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What happens when government, industry and investors seek common digital ground?

Withholding tax distributed ledger report

A look inside the testing of an innovative application of distributed ledger technology to solve a costly and decades-old tax problem

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Executive summary

As financial markets have become more globalized over the past 20 years, governments and industry have been grappling with a challenge that centers on cross-border investment, the practical application of tax treaties and withholding taxes (WHT) on passive income. Processing taxable events such as dividends and interest and determining the correct withholding taxes requires synchronized data collection and reporting across a complex network of financial intermediaries and tax authorities. Although statutory WHT rates can be as high as 35%,¹ they can be reduced or even eliminated by tax treaties or domestic law provisions if the investor meets certain requirements and provides the required evidentiary proof.

The withholding tax challenge

Proving that financial markets investors are entitled to tax treaty relief and making sure that the correct amount of withholding tax is paid can involve complicated, cumbersome, often inefficient paper-based manual processes with risk of human error and fraud. Coordinating the timely exchange of information across an extensive and complex network of intermediaries, while meeting contractual and regulatory requirements, is very difficult.

Without timely information being available, providing treaty relief at the time of the payment (relief at source) creates a risk for withholding agents and governments. As a consequence, treaty benefits are often provided after the payment has taken place, through a reclaim system that could result in administrative costs, opportunity costs and costs related to the time value of money. In certain instances, access to treaty benefits is unavailable in practice.

This, in short, is “the global WHT challenge.” The financial impact was estimated by the European Commission (EC) at €8.4 billion annually in the EU alone.² COVID-19 has exacerbated the issue for financial markets given the difficulty to process paper documents, making it clear that a solution is needed.

On the pathway to a solution

July 2020 saw the kick-off of a project designed to test an innovative technology, developed over multiple years with input from government and industry representatives across the tax ecosystem. The objective was to demonstrate the technology’s potential for private and confidential data sharing to apply relief at source at the time of the taxable event while maintaining or even improving tax compliance. The complex and multi-faceted nature of the challenge called for a core group of private and public sector participants who understood the fact patterns of the challenge and the disparate demands of a workable solution for government and industry.

Participants in the group included Her Majesty’s Revenue and Customs (HMRC), the Netherlands Tax Authorities (NTA), Norwegian Tax Administration, BNP Paribas Securities Services, Citibank, N.A., JP Morgan Securities Services, Northern Trust and EY, with invited academics Vienna University of Economics and Business (Austria) and the Tax Administration Research Centre (TARC, University of Exeter), observers APG Asset Management N.V. and PGGM Investment Management and others. This was a cooperative effort among representatives of participant financial intermediaries and tax authorities to test a new distributed ledger technology within the

context of the use case of the withholding tax challenge.

The work took place against the backdrop of the global pandemic, relying upon phone calls, online meetings and virtual workshops. The project goal was to demonstrate, test and evaluate the feasibility of leveraging new technology for administering withholding tax that could:

- ▶ Evidence cross-border investors’ entitlement to tax treaty relief
- ▶ Help make sure the correct amount of tax is paid
- ▶ Substantially lower the vulnerability to fraud
- ▶ Provide a reliable, confidential and user-friendly way to share information and documentation on a (near) real-time basis across a complex network of intermediaries: registrars, transfer agents, local and global custodians, fund managers, distributors, withholding agents and tax authorities
- ▶ Improve the sustainability of the process and reduce the carbon impact of the existing practices

Demonstrating the solution at work

To facilitate the testing of distributed ledger technology, the project used a WHT solution developed by EY, designed to create a “shared record book” of all dividend transactions occurring in the distributed network. It leveraged distributed ledger technology to automate, decentralize and securely share tax and financial information between financial institutions and government agencies and across the network of intermediaries and relevant stakeholders. With a strong focus on maintaining data privacy throughout, the solution aggregates results across the network of intermediaries, including the flow along

¹ E.g. Switzerland https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/tax/tax-pdfs/ey-wctg-web-final-11-december-2020.pdf#page=1667?download

² European Commission, “Non-paper on the withholding tax for discussion at the Expert Group on barriers to free movement of capital”, 28 September 2016. Available at: [https://ec.europa.eu/transparency/documents-register/detail?ref=COM\(2017\)147&lang=en](https://ec.europa.eu/transparency/documents-register/detail?ref=COM(2017)147&lang=en) (last accessed March 17, 2021).

complex investment structures, to support a roster of critical features and functionality:

- ▶ **Multi-party data sharing**, enabling near real-time data exchange of data and documentation
- ▶ **Smart contracts³ and tokenization⁴ of dividend events** to facilitate and automate the identification of investors and their treaty entitlements
- ▶ **Automation via systems integration** that allows parties to extract key information from their systems to confirm the WHT treatment on dividend events
- ▶ **Privacy and trust**, so that sensitive information is protected and never stored on chain, while distributed transactions use the enhanced privacy of zero knowledge proof (ZKP) technology
- ▶ **Audit and verification**, for near real-time validation of dividend events and their WHT treatment
- ▶ **Document exchange** between parties in near real-time

Participants ran five testing scenarios using synthetic data to simulate the occurrence of dividend events based on fact patterns abstracted from real-world dividend events. The main objective was to test whether the WHT solution would allow relevant parties to share and exchange pertinent tax data in near real-time to determine the correct withholding treatment on the simulated dividends. Each of the test scenarios was successfully completed, with results verified against expected outcomes. This included validation of retaining commercial confidentiality, while allowing multiple participants to each control their own node on a multi-cloud secure network.

One major achievement of the project was the testing and deployment of zero knowledge proof technology (ZKP) to enable additional protection of investors' sensitive information (such as country of residence and type of investor) that could otherwise be inferred without ZKP. This was the first known test involving industry and government that directly compared ZKP against a

non-ZKP "control" scenario. The project also proved that the WHT solution can support a high volume of investors, be scaled horizontally to accommodate more complex scenarios and demonstrates an architecture that could be extended to other use cases.

From technology testing to real-world deployment

The technology testing resulted in positive and promising outcomes, demonstrating private and confidential data being shared in near real-time to support the determination of treaty entitlements in a reliable manner while providing access to investor identities and related documentation on a need-to-know basis. The technology has the potential to take a significant step towards introducing a solution to the WHT challenge and other similar use cases.

However, non-technology related issues will need to be addressed before widespread deployment with tax authority adoption and support is feasible. Two key questions concern whether the introduction of distributed ledger technology to support relief at source requires legal changes and the nature and level of cooperation that is needed between government and industry.

On the first issue, in parallel to the technology testing, Vienna University of Economics and Business (Austria) and the Tax Administration Research Centre (TARC, University of Exeter) undertook an analysis to identify the tax legal issues from a sample of six countries to understand which legal issues may need to be addressed before the technology solution can be fully adopted (e.g., adoption of relief at source by more governments, acceptance of digital/electronic documentation, etc.).

On the second issue, participants discussed the cooperation needed to fully realize the benefits and positive network effects of a distributed ledger solution,

where ecosystem and value creation are closely linked. Growing and sustaining the ecosystem requires a governance framework fit for purpose that covers both the terms of cooperation between the network participants and the underlying technology. It must be able to assign and manage the responsibilities of ecosystem participants, addressing who is responsible for holding and providing the data, who is liable for any tax payments that may arise in the event of an incorrect WHT being applied, and many other details. The solution also needs to have the flexibility to evolve and adapt to changes in the tax legal systems as the ecosystem expands over time.

Distributed ledger technology as a solution to the WHT challenge is no longer merely a concept. This project has provided tangible evidence of a near future in which technology can assist industry and governments to reconcile legal and technical issues and also could flex to address different demands and requirements of taxpayers and tax authorities. With the potential for enabling a global solution, this could support the European Commission's proposal to begin building (starting in 2022⁵) a common, standardized, EU-wide system for withholding tax relief at source.

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Distributed ledger technology as a solution to the WHT challenge is no longer merely a concept.

³Software functions that define and control the shared state of the distributed ledger. They are invoked by transactions sent to the blockchain and can emit events to trigger off-chain actions.

⁴Digital representation of real (physical) assets on distributed ledgers, or the issuance of traditional asset classes in tokenized form.

⁵EUR-Lex - 52020DC0590 - EN - EUR-Lex (<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:590:FIN>)

01 Inside the withholding tax challenge

Dividend withholding taxes

Cross-border payments of dividends are often subject to WHT. Although some jurisdictions do not levy WHT on dividends, most jurisdictions do. Withholding taxes are *prima facie* levied according to the tax rates set forth under local law, which can be as high as 35%. A WHT agent, typically located in the country where dividends are sourced or originated (source country), is generally responsible for administering the withholding process.

Tax treaties

WHT rates under local law can be reduced or eliminated under tax treaties in the case of cross-border investments.⁶ Tax treaties are typically signed between the country where the item of income (e.g., dividend, interest) is originated or sourced (i.e., the source country) and the country where the investor is located (i.e., the residence country). In general, dividends are sourced based on the tax residency of the issuer. The ultimate purpose of tax treaties is to foster cross-border investments by eliminating double taxation on income and capital and prevent tax evasion and avoidance. Typically, this is accomplished by reducing the WHT to be levied at the source country and allowing it to be credited against the investor's income tax in the residence country.

Whether the investor is entitled to tax treaty relief needs to be determined under the rules set by the relevant tax treaty. Among other matters, it is key to determine if the

investor is, in fact, a tax resident of the treaty country and is the beneficial owner⁷ of the dividend/interest income. Depending on the source market's requirements, the investor may need to provide to the WHT agent evidence of: (1) a certificate of residence issued by its local tax authority, and (2) documents that provide facts and assertions certifying the investor's beneficial ownership to that dividend/interest income and any other requirements provided for under the law of the source country.

The WHT agent must receive sufficient documentation to reduce or even eliminate WHT under the treaty (relief at source), or investors will need to initiate a reclaim process to get reimbursed for the excess WHT levied.

Barriers created by complexity

When there is a network of intermediaries between the WHT agent and the investor, the complexity of the tax treaty relief process dramatically increases. Such networks are common, as different financial institutions are responsible for different steps in the investment chain. Typically, a bank may have the relationship with the investor. That bank will appoint a global custodian to manage the safekeeping of financial assets and also perform the relevant asset servicing (i.e., income collection, processing of corporate actions and tax services). In turn, the global custodian will typically appoint a local custodian in the source market to interface with the local financial infrastructure. That local custodian may also operate

⁶Organisation for Economic Co-operation and Development, 2020, Centre for Tax Policy and Administration, "Glossary of Tax Terms, 'Withholding Tax'". Available at: <https://www.oecd.org/ctp/glossaryoftaxterms.htm> (last accessed March 17, 2021).

⁷The tax resident investor to whom the dividend is paid has the right to use and enjoy the dividend income and is both legally and economically entitled to receive the dividend, unconstrained by a contractual or legal obligation to pass on the dividend payment to another person - https://read.oecd-ilibrary.org/taxation/model-tax-convention-on-income-and-on-capital-condensed-version-2017_mtc_cond-2017-en#page237

as the WHT agent or interface with another local party that is the WHT agent.

The required paperwork must flow through multiple parties before the WHT agent could consider granting relief at source. The paper-based nature of this process along with issues of account structure, commercial confidentiality and investor privacy between different financial institutions in the chain create practical barriers to sharing documentation in a secure and timely fashion.

Another source of complexity can be investment vehicles that are treated as transparent by the source country, meaning that in order to obtain treaty benefits, sufficient documentation to look through to the end investors is required. Where there are a large number of investors, there is significant complexity involved in the WHT agent obtaining the requisite documentation to allow relief at source.

In these cases, the investor's only alternative may be to file for a tax reclaim with the source country. This process is cumbersome, expensive and time-consuming. Faced with considerable delays and costs, some investors will initiate the process and eventually abandon it, or simply not even bother to seek the refund, thus paying more taxes than are legally due.

To quantify the issue, the European Commission estimated the cost of the WHT challenge in the European Union alone to be €8.4 billion, annually.⁸

This cost breakdown indicates €6.03 billion in foregone tax relief, €1.21 billion in costs related to relief-related procedures, and €1.16 billion in opportunity costs, as cash trapped in the tax relief process cannot be deployed elsewhere. The issue is not confined to the EU, so the real cost of the WHT challenge is likely to be significantly greater globally.

WHT-related fraud

The paper-based process and the lack of visibility and transparency in the WHT process have opened the door to major cases of WHT-related tax abuse and fraud, resulting in billions of euros in lost tax revenues and significant political and media attention (e.g., in relation to cum-ex and cum-cum transactions).⁹ In an effort to manage these risks, some tax administrations are introducing additional tests or requiring higher levels of documentation¹⁰ (which may include information from both the investor and financial intermediaries in the chain). In some cases, tax authorities in both source and investor countries have found it necessary to increase the number and intensity of WHT audits.

This results in further increasing the costs and complexities faced by investors and financial intermediaries in pursuing legitimate claims for tax relief. Against this individual country backdrop is also the interest of the regulators such as the European Securities and Markets Authorities in developing best practices and solutions to prevent, detect and prosecute WHT reclaim schemes.¹¹

Document flow

The flow of documentation across all the parties involved in the network is illustrated in Figure 1.1. It also highlights how COVID-19 has magnified some of the existing challenges in this process, particularly around the requirements for physical paper and wet ink signatures in a remote working environment.

Efforts to solve the WHT challenge

The search for a solution to the WHT challenge has been ongoing. OECD's Treaty Relief and Compliance Enhancement Implementation Package (2013¹²) (TRACE) provided for a set of forms, procedures and contracts to introduce a standardized approach to make and grant WHT claims. Finland on 1 January 2021 became the first jurisdiction to implement TRACE.

In 2017 the EC launched a Code of Conduct on Withholding Tax to address inefficiencies in the system.¹³ European Union (EU) institutions also expressed increasing concerns about WHT fraud.¹⁴ More recently, the EU's High-Level Forum on Capital Union invited the EC to set out in EU law common definitions, common processes and a single form, relating to WHT at source procedures and their streamlining.¹⁵

In response, the EC committed to proposing a legislative initiative for introducing a common, standardized, EU-wide system for WHT at source, accompanied by an

⁸European Commission, "Non-paper on the withholding tax for discussion at the Expert Group on barriers to free movement of capital", 28 September 2016. Available at: [https://ec.europa.eu/transparency/documents-register/detail?ref=COM\(2017\)147&lang=en](https://ec.europa.eu/transparency/documents-register/detail?ref=COM(2017)147&lang=en) (last accessed March 17, 2021).

⁹<https://www.europarl.europa.eu/news/en/press-room/20181120IPR19552/cum-ex-tax-fraud-meps-call-for-inquiry-justice-and-stronger-tax-authorities>

¹⁰https://www.ey.com/en_gl/webcasts/2021/05/global-withholding-tax-update-emeia-and-us

¹¹<https://www.esma.europa.eu/press-news/esma-news/esma-delivers-statement-cum-excum-cum-ep-subcommittee-tax-matters>

¹²https://www.oecd.org/ctp/exchange-of-tax-information/TRACE_Implementation_Package_Website.pdf

¹³https://ec.europa.eu/taxation_customs/sites/default/files/code_of_conduct_on_withholding_tax.pdf

¹⁴E.g. European Parliament Resolution of 29 November 2018 on the cum-ex scandal: financial crime and loopholes in the current legal framework (2018/2900(RSP)),

See http://www.europarl.europa.eu/doceo/document/TA-8-2018-0475_EN.html

¹⁵High Level Forum on Capital Markets Union, A new vision for Europe's capital markets, June 2020, https://ec.europa.eu/info/sites/info/files/business_economy_euro/growth_and_investment/documents/200610-cmu-high-level-forum-final-report_en.pdf, p. 112.

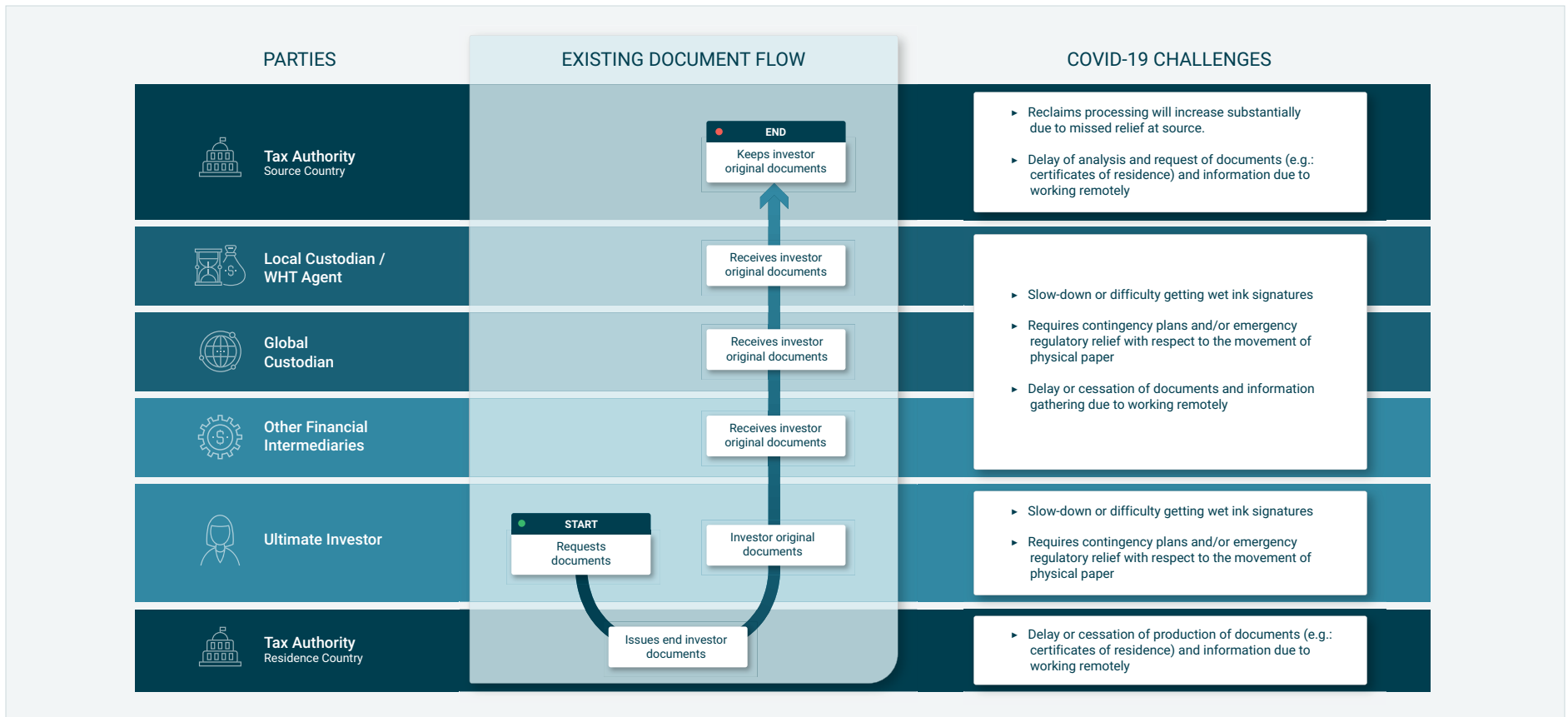


Figure 1.1 Document flow

exchange of information and cooperation mechanism among tax administrations. The Commission's Action Plan on Fair Taxation¹⁶ and its Capital Markets Union Action Plan¹⁷ have attracted the support of the Member States.

In December 2020, the Council asked the Commission to submit proposals "(...) to simplify the withholding tax relief procedure for cross-border investments, while taking into

account the existing work, such as the discussions at FISCALIS or on the OECD TRACE initiative, and preventing tax fraud".¹⁸

This project tested a new technology that could lead to a more efficient global implementation of the objectives defined by TRACE and the EC initiative mentioned above.

¹⁶European Commission, An action plan for fair and simple taxation supporting the recovery strategy, COM(2020) 312 final, https://ec.europa.eu/taxation_customs/sites/taxation/files/2020_tax_package_tax_action_plan_en.pdf, p. 10, and European Commission, Capital Markets Union for people and business-new action plan, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:590:FIN>, action 10. The Commission notes that, in addition, it will assess the need for exchange of information and cooperation between tax authorities and financial markets supervisory authorities.

¹⁷European Commission, A Capital Markets Union for people and businesses-new action plan, September 2020, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:590:FIN>

¹⁸<https://data.consilium.europa.eu/doc/document/ST-12898-2020-REV-1/en/pdf>



02 WHT solution

Leveraging breakthrough advances in technology, the WHT solution can address material elements of the global WHT problem, which, in practice, cannot be solved using traditional methods and approaches.

The complexity of the process to manage dividend withholding taxes across a network of intermediaries has resulted in an inefficient patchwork of siloed point-to-point data links with very little cross-visibility and often limited transparency. This network could be transformed with the adoption of a WHT solution that creates a “shared record book” (i.e., distributed ledger) of all transactions occurring in the network, while protecting investor data privacy and commercial confidentiality.

This WHT solution, developed by EY, is an integrated distributed ledger-based system that allocates investor dividend entitlements and associated withholding tax across multiple tiers of financial intermediaries. All participants, including tax authorities are supported as peer nodes on the distributed network, allowing near real-time transmission of tax data while carefully controlling commercial confidentiality and investor privacy.

This WHT solution tracks complex investment structures across the network to support a roster of critical features and functionality:

- ▶ **Multiparty network for data sharing and efficiency.** It allows the secure sharing of tax and financial data across the parties participating in the network in near real-time.
- ▶ **Smart contract and tokenization.** Smart contracts tokenize dividend entitlements and their distribution across the various financial intermediaries’ network nodes via a distributed ledger. Once the investors

are identified, the tokens¹⁹ provide the investment information needed to calculate the appropriate WHT on the dividend event.

- ▶ **Automation via systems integration.** It automatically interacts with financial intermediaries’ enterprise systems to extract key financial data needed to identify investment ownership.
- ▶ **Privacy.** Investors’ sensitive information is kept private (not shared on the distributed ledger) and on-chain data is encrypted to protect confidentiality of sensitive business and commercial information.
- ▶ **Audits and verification.** This enables tax treaty entitlement and income data to be checked and reconciled in near real-time between financial intermediaries and tax authorities in an encrypted, secure manner without compromising investment confidentiality across the network.
- ▶ **Document exchange:** The WHT solution supports exchange of relevant documentation between financial intermediaries and tax authorities in near real-time. The solution can also support proactive sharing of tax documentation that could be accessed on a need-to-know basis according to the participant’s role in the system.

Tokenization of dividend entitlements

Digital representations of dividend entitlements are tokenized and exchanged through the distributed ledger to properly allocate the entitlements across the financial intermediaries until each investor is identified. This means that for each dividend event, all the dividend entitlements can be accurately tracked and accounted for, reconciled to the investor level.

¹⁹Digital representation of assets, access rights, entitlements, etc.

In a process called minting, the system creates, validates or stores on the ledger a collection of fungible tokens²⁰ for each dividend event, with each token representing a dividend entitlement for one share (or part thereof) of the security. These fungible tokens are then distributed across the network of financial intermediaries through a cascading set of token splits and transfers corresponding to the ownership positions in the security with respect to that dividend event. Each token split and transfer is managed through smart contracts, providing assurance that tokens are not subject to “double spend” (i.e., the same token can’t be assigned to two different parties) and that the total number of tokens is fully accounted for at each step in this cascading process.

For any given dividend event, the pattern of token splits and transfer transactions reflects the custodial account relationships among the financial entities for that security. WHT agents (located in the source country of the security) transfer tokens to multiple global custodians, and the process continues through the various distribution networks of financial intermediaries that hold securities on behalf of the investors. Distribution channels can include funds and other CIVs. In some cases, the CIV or fund is considered to be transparent for withholding tax purposes, where the system can “look through” the fund to allocate dividends and withholding tax based on the fund’s holdings in the underlying security.

This process is illustrated in Figure 2.1.

Exchange for non-fungible tokens (NFT)²¹

The cascading sequence of token splits continues until the investors, also known as beneficial owners for WHT purposes, have been identified. This is done by querying the local databases of each financial intermediary

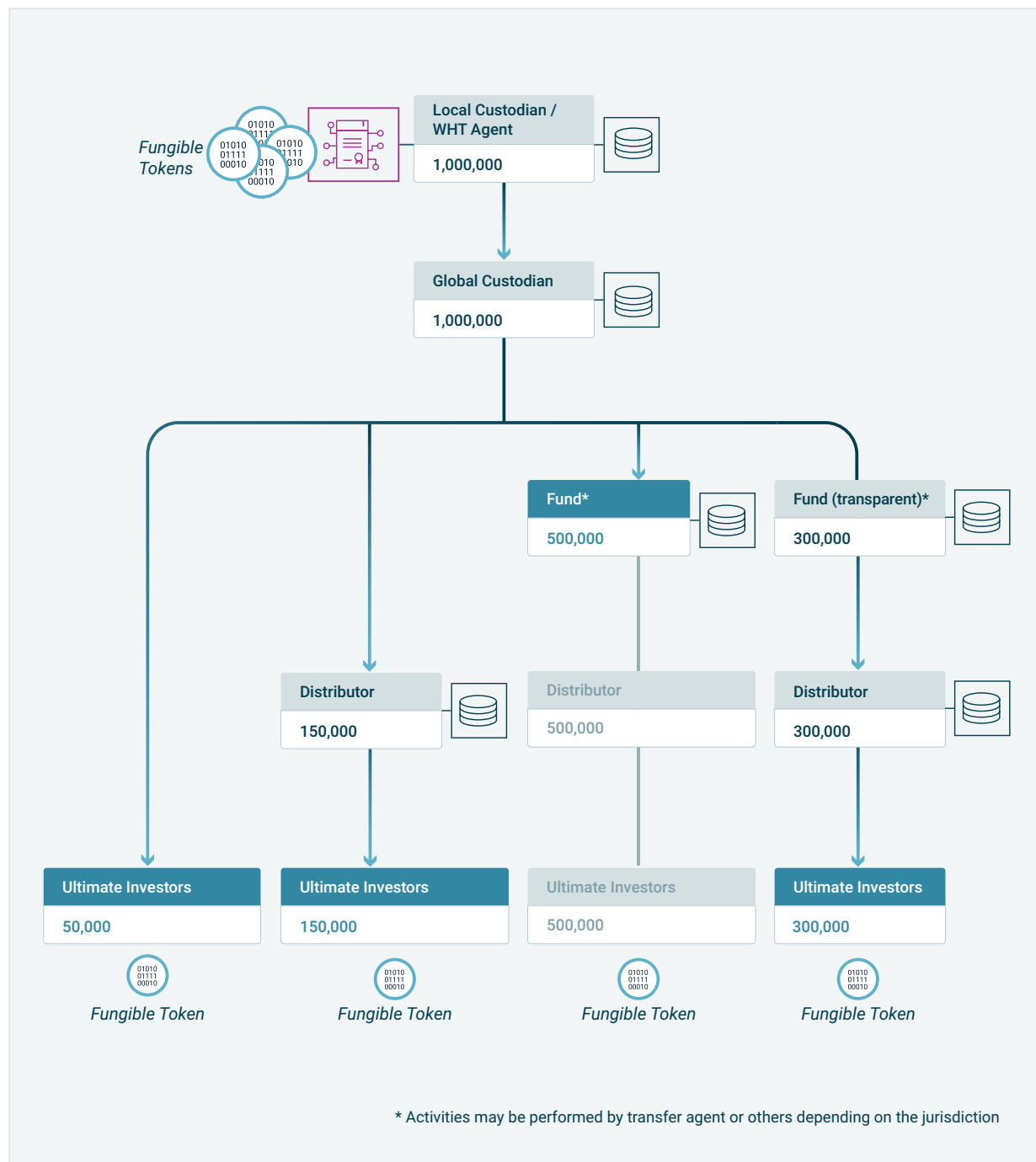


Figure 2.1 Fungible token distribution process

²⁰Tokens indistinguishable from one another and divisible.

²¹Tokens uniquely identifiable from one another and non-divisible.

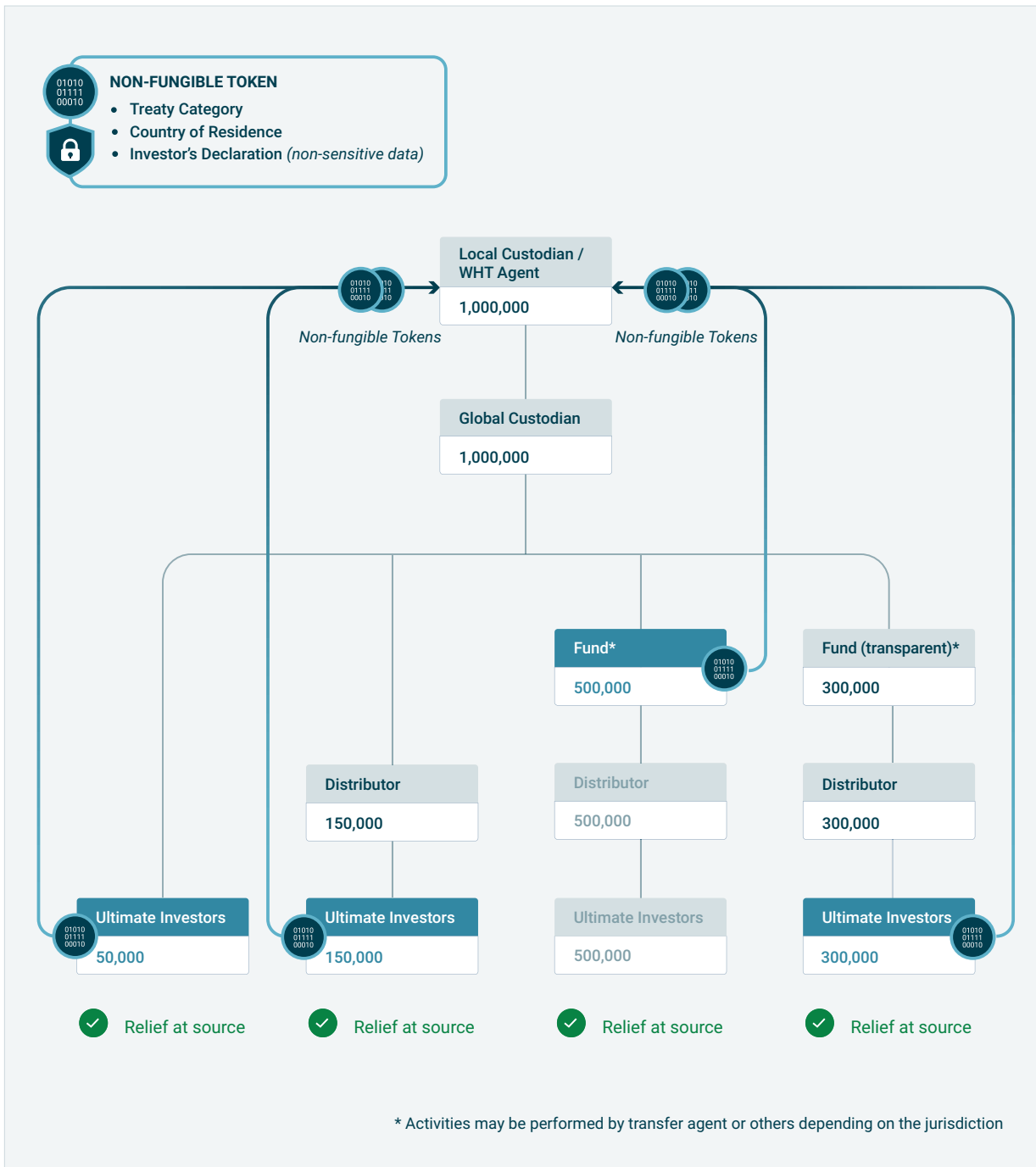


Figure 2.2 Non-fungible token distribution process

through a set of enterprise application programming interfaces (APIs²²).

When a beneficial owner is identified, the fungible tokens representing the entitlement for that beneficial owner are exchanged for a single non-fungible token. The NFT has a value equal to the number of fungible tokens that were exchanged. The fungible tokens are “burned,” which means they are no longer valid. All shares are accounted for, with no possibility of “double spend” (Figure 2.2).

The NFT provides enough information to properly assign the appropriate WHT without revealing the investor’s identity. Information includes the country of residence and category of investor (e.g., pension fund, individual, corporation, etc.) for purposes of determining tax treaty eligibility for a reduced WHT rate. On a need-to-know basis, tax authorities or other authorized parties can access the investor’s identity.

Supporting incremental adoption of the technology

To support incremental adoption of this technology, the WHT solution has a built-in mechanism for handling situations where a financial intermediary is not yet part of the network, or a node is “down” and not responding, or an investor has decided to “opt out” of the process. When the cascading process completes, any remaining fungible tokens are automatically converted into a special type of non-fungible token called a “grey token.”

A grey token has a value equal to the number of fungible tokens that were exchanged but does not identify a specific investor and will likely be assigned the maximum withholding rate by the WHT agent. Grey tokens help safeguard the fundamental accounting of the system. All the original fungible tokens are accounted for, either

²² “Application Programming Interface” (API) acts as connectors of networks allowing applications to “talk” with each other, like a common language between software programs.

through uniquely identified non-fungible tokens or as grey tokens. Whether the WHT solution or similar technology is adopted, tax authorities could run parallel systems to provide relief at source.

Private data stays off chain

Each NFT uses a unique investor identifier. It is assigned by the financial intermediary that has the direct relationship with that investor and is known only to that financial entity. Sensitive data such as the investor name, address and taxpayer identification number are not included in the NFT and are never present in any distributed system transactions, safeguarding confidentiality of private information under regulations like General Data Protection Regulation (GDPR) and other privacy laws.

On a need-to-know basis, tax authorities and/or WHT agents will be able to access taxpayer identities and additional documentation through a parallel set of secure messages and point-to-point secure communication channels that run entirely off-chain. Requests for additional information are made by specifying the unique identifier; and the financial entity that has the direct relationship with that investor can respond to the request. It is also possible to automatically flow encrypted copies of taxpayer identities and documentation to tax authorities or other authorized parties over the parallel off-chain channels and control access to decryption keys based on legal and contractual requirements.

Zero knowledge proof technology

The WHT solution also offers an additional layer of privacy and encryption through the use of **zero knowledge proof (ZKP) technology**.²³

ZKP makes it possible to retain the commercial confidentiality of data on the distributed ledger while still providing cryptographic assurance that the data has been transferred correctly. The counterparties to a ZKP transaction have full visibility into the transaction and the data being transferred. Third parties will see that a transaction has occurred, but the identities of the transacting parties and the data being exchanged are not revealed. However, a third party can rely on the validity of a ZKP transaction, and the “correctness” of the associated proof can be verified on the distributed ledger.

This is how ZKP works: it allows a token's private data to be replaced with a cryptographic “hash” of the data producing a unique, fixed-size string of bytes. The token is sent anonymously from the sender to the recipient and encrypted proof of this transaction is recorded on the distributed ledger. The sender notifies the recipient that the token is available through an encrypted message. The recipient can then retrieve private data from the sender via off-chain data exchange (outside of the distributed ledger). Only the recipient can decrypt the encrypted proof and use it to prove ownership of the token without having to reveal any of the private data.

The same test scenarios can be run in either ZKP mode or non-ZKP mode, with full functionality in each. The WHT solution is among the first in the world to demonstrate a practical application of ZKP technology applied to both fungible and non-fungible tokens. For more details see “Technology details” section.

Privacy, security and confidentiality safeguards

The solution pays strong attention to privacy and commercial confidentiality that extends beyond ZKP. This includes the use of private key management

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The WHT solution is among the first in the world to demonstrate a practical application of ZKP technology applied to both fungible and non-fungible tokens.

²³This WHT solution uses a ZKP protocol called Nightfall, which EY contributed into the public domain in 2019.

for both authentication and transaction signing. APIs are protected by requiring secure socket layer (SSL) certificates²⁴ for all user interface APIs and authentication protocols for point-to-point server APIs.

User authentication and role-based access control is managed independently by each node.

Enterprise application programming interfaces (API)

Connections to existing enterprise systems are facilitated through a set of enterprise application programming interfaces. The APIs are used to query each financial intermediary's data sources for the shareholder positions, investor information and related data such as fund allocations. These APIs are implemented using secure message queues, with data cached in each node using a local database. The technical solution includes a prototype of a simulated enterprise server that implements the enterprise side of the message queue.

Benefits of leveraging a WHT solution

The WHT solution allows parties to determine in near real-time whether a reduced (or zero) WHT rate applies under a tax treaty.

This provides benefits across the WHT solution ecosystem, as shown in Figure 2.3.

Even the environment realizes a positive impact with the reduction of millions of pieces of paper that are currently flow from country to country during this process.

Investors	Governments / Tax Administration	Financial Intermediaries
<ul style="list-style-type: none"> ▶ Applies correct withholding tax rate through fund investments ▶ Reduces administration cost to process paperwork to achieve treaty relief at source or reclaims ▶ Minimizes time spent obtaining reclaims 	<ul style="list-style-type: none"> ▶ Increases tax transparency ▶ Reduces administration cost to process paperwork supporting treaty relief at source or reclaims ▶ Reduces instances of fraud 	<ul style="list-style-type: none"> ▶ Increases tax transparency ▶ Reduces financial and reputational risk ▶ Improves tax auditability and accuracy

Figure 2.3 Benefits

²⁴Secure Sockets Layer (SSL) certificates are protocols that provide secure data transmission and communications over a network. They are a form of digital certificate that authenticates and encrypts any given connection. They assist with data privacy and data transmission between two endpoints.



03 Testing results

In testing the WHT solution, participants simulated the occurrence of dividend events using hypothetical data and fact patterns based on historical information from real-world dividend events. They validated whether the WHT solution would help the relevant parties to determine the correct WHT treatment on the simulated dividends, comparing the results with the expected outcome.

Scope

The scope of the project was based on the hypothetical facts in Figure 3.1.

The project testing was performed based on hypothetical dividend events. Actual dividend payments were out of scope. Other types of securities including corporate debt and government debt and other types of corporate actions such as interest income and capital gains were also out of scope.

Project testing scenarios

The project scenarios considered synthetic but realistic data to simulate real-world dividend scenarios on the WHT solution and compare expected results on those dividends against results generated through the WHT solution. For purposes of this testing, the project leveraged the realistic information in Figure 3.2.

Based on this information, participants tested five different scenarios (see participants and their roles in the testing scenarios in Figure 3.3), comparing the outcomes against expected results that tested WHT solution ability to:

- ▶ Host multiple parties
- ▶ Exchange data and documentation in near real-time
- ▶ Demonstrate that the same scenario could be successfully tested with and without ZKP technology
- ▶ Support a large number of Investors

- ▶ Support horizontal scalability (i.e.: various numbers and levels of parties involved in a complex scenario)

A look at the results

The technology testing was successful, with all scenarios deployed and their objectives accomplished.

No errors or software issues were reported during the testing. For each test scenario, the participants documented the results and downloaded output reports from the WHT solution (e.g., WHT reports and payment reconciliations reports) as evidence of testing completion.

In order to test ZKP technology, the same scenario was run with and without ZKP. The results were identical, proving that ZKP provided reliable results while offering real-time information to the participants with an enhanced level of privacy. This is the first known test involving industry

Security Type	Yield on Security	Investor Types	Source Countries	Residence Countries
Local shares issued by a Security Issuer located in any of the source countries	Dividends paid by Security Issuer to Investors located in any of the residence countries	<ol style="list-style-type: none"> 1. Pension fund 2. Collective investment Vehicle (CIV) 3. Corporate body 4. Sovereign wealth fund 	<ol style="list-style-type: none"> 1. Norway 2. The Netherlands 3. France 4. Japan 	<ol style="list-style-type: none"> 1. Norway 2. The Netherlands 3. United Kingdom 4. Finland 5. Canada 6. Australia 7. Ireland 8. Luxembourg 9. Cayman Islands 10. France 11. Italy 12. Germany 13. Sweden 14. Japan

Figure 3.1 Hypothetical facts

Security issuer	Security type	Country of security issuer
Oil company	Shares	Norway
Consumer products company	Shares	The Netherlands
Insurance company	Shares	France
Telecommunication company	Shares	Japan

Figure 3.2 Project testing scenarios realistic information

Participant	Role in the testing	Node hosted?
Her Majesty's Revenue and Customs (HMRC)	Project leader and auditor**	Yes
Netherlands Tax Authorities (NTA)	Source country Tax Authority	No*
Norwegian Tax Administration	Source country Tax Authority	Yes
EY	Local custodian / WHT agent / Distributor	Yes
BNP Paribas Securities Services	Global custodian / Distributor	Yes
Citibank, N.A.	Global custodian / Distributor	No*
JP Morgan Securities Services	Global custodian / Distributor	Yes
Northern Trust	Global custodian / Distributor	Yes

* The Netherlands Tax Authorities (NTA) and Citibank, N.A. nodes were hosted on EY's cloud infrastructure.
 ** The role of the auditor had the full oversight of the system. This was a full-visibility role, which would likely not exist in a production deployment.

Figure 3.3 Participants and their roles in the testing scenarios

and government of which the participants are aware that directly compares ZKP against a non-ZKP "control" scenario. Detailed inspections were held to show how transactions on the ledger differed between the ZKP and non-ZKP runs, with ZKP restricting visibility to only the two parties directly transacting while ensuring that the overall results were reliable and could be trusted by all parties.

In terms of security and confidentiality of investor-related information, the ZKP mode offered additional protection beyond the non-ZKP mode. This is what that looked like:

- ▶ **Non-ZKP mode:** When participants investigated one specific dividend event by using such tools as block explorers²⁵ and decoders,²⁶ they could see potentially sensitive investor data in clear text, including investor country and the type of investor (e.g., pension fund, sovereign wealth fund, collective investment vehicle, etc.). Based on this information, competitors could guess or speculate about the investor's identity, creating confidentiality concerns for participating investors while giving competitors an edge in the market. The same scenario was tested in a ZKP mode.
- ▶ **ZKP mode:** For this circumstance, ZKP technology was overlaid on the same dividend event. Using the same block explorers and decoders as in the non-ZKP mode, sensitive investor-related data could no longer be seen. This data was encrypted, resulting in greater confidentiality and security than those under a non-ZKP mode. In a ZKP mode, however, there is still enough information on chain for authorized parties to properly verify the accuracy of specific transactions and the relevant tax treatment, thus preserving the key functionalities of the WHT solution. For tax authorities, the system can be extended to provide encrypted access to investor's tax identifier numbers as required.

²⁵Search engine that allows users to search for a particular piece of information on the blockchain.

²⁶Tool that decodes the raw blockchain transaction using the smart contract to make it readable.

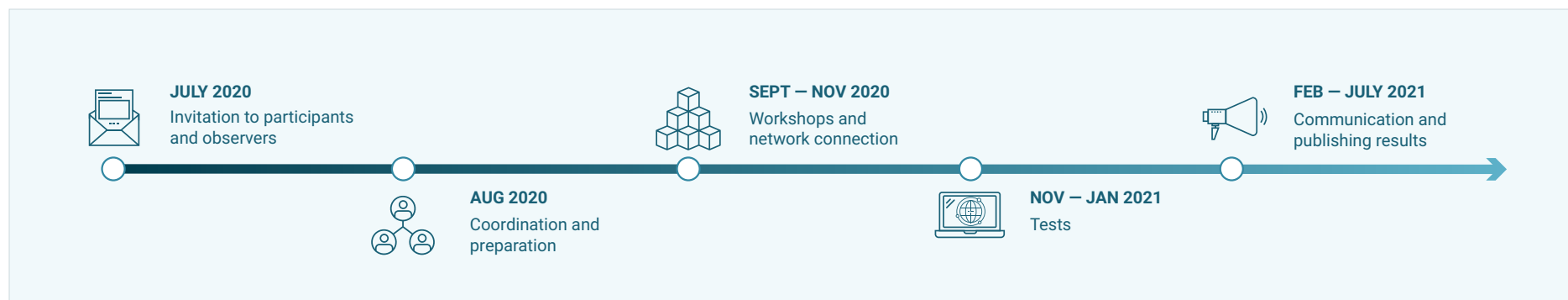


Figure 3.4 Timeline

Out of scope

The following considerations were out of scope of the WHT solution tested during the project:

Functional

- ▶ Residence country tax authority role
- ▶ Automated calculation of withholding taxes
- ▶ Actual payment of dividends
- ▶ Data analytics insights

Non-functional

- ▶ System integrations (with custody and trading system)
- ▶ Use of any production data
- ▶ Interoperability between blockchain protocols

Project survey

At the end of this phase of the project, all the participants responded to a survey about the distributed ledger technology. There was unanimous agreement that the technology met all its objectives (as set at the outset of the project) and that the WHT solution could be a catalyst for digital/electronic document adoption by tax authorities, to the extent permitted by applicable law.

The survey also indicated strong support by both governments and industry participants for the potential of the WHT solution to:

- ▶ Improve efficiency and effectiveness of WHT operations by reducing the time of WHT processing, e.g., reduce response time of dividend event completion, reduce time to receive payment information, amend WHT reports
- ▶ Provide more visibility and transparency into the WHT processes for the tax authorities, thereby enhancing reporting and allowing for more efficient compliance verification
- ▶ Help tax authorities to concentrate on key risk areas and reallocate their resources efficiently, supporting their ability to identify tax fraud cases and manage tax leakage
- ▶ Increase the possibility of getting relief at source for investors, reduce operational costs and risks, and potentially reduce time and costs of specialized resources spent on mundane, repetitive WHT processes
- ▶ Promote and support reduction of the manual paper-based processes, which could lead to reduced time for document request and sharing across relevant parties
- ▶ Improve the documentation process via automated

near real-time document request and receipts for relevant investor (e.g., request and receipt of certificate of tax residence (CoTRs) and other tax forms)

- ▶ Increase confidence and trust among the market participants and governments and even could reduce reputational and legal risks of failure to meet WHT obligations for WHT agents and financial intermediaries



04 Considerations beyond technology testing



Technology is just one part of the equation for addressing the global WHT problem. Government acceptance of digital documentation and adoption of relief at source would deliver maximum benefits of the technology. Successfully deploying the WHT solution in production also means creating a strong ecosystem of participants to fully realize the benefits and positive network effects. This is true not only for the WHT challenge use case, but also for other distributed system use cases as well.

Relief at source

Although introducing the technology would create benefits if adopted in the context of the current environment, governments' adoption of relief at source systems should lead to significant mitigation of the challenges connected to the current WHT system and processes, including costs associated with the time value of money.

The WHT solution could allow governments and other ecosystem participants to move to such a system without being subject to higher risk of errors and tax abuse. It could provide near real-time access to the relevant WHT data for all ecosystem participants. In addition to more timely data, it provides the ability for fundamental accounting of WHT to support more efficient and effective reconciliation of WHT payments, auditing of the WHT collected, and the amount of any reductions in WHT from tax treaty benefits.

Accordingly, if governments were to move to a relief at source system in combination with a system such as the WHT solution, there is the potential for a significant reduction in the risk compared to the current situation. On the other hand, moving to a relief at source system without timely and comprehensive data may not deliver the benefits in risk reduction and may subject tax administrations to higher risks than providing treaty benefits on

application for reclaims. The WHT solution could become an incentive for governments to align with broader policy objectives for moving collectively to more efficient WHT systems such as relief at source.

Introducing the solution as tested will not mitigate all risks for tax administrations. For example, assessments of beneficial ownership will still be needed. However, the technology does create more transparency and makes it significantly easier and more efficient to risk assess different scenarios and treaty claims to focus audit attention on higher risk scenarios in near real-time. In addition, the technology is a step to achieving further innovation such as automatic checks and validation of investor's tax residency rather than today's cumbersome paper-based process of applications and generation of certificates of tax residency.

Building an ecosystem

Like many other distributed technologies, the success of the WHT solution will be closely linked to its ability to create and amplify network effects. For example, the value of using the WHT solution for investors as a means to access relief at source will largely depend on the participation of relevant WHT agents and financial intermediaries in the network.

The same is true for tax authorities, which will benefit substantially from other participants in the network and the subsequent increased transparency, with the expected result of reducing the risk of tax fraud and the costs related to tax audits. Tax authorities will also derive further incremental value as many of them join the network, as they can exchange information for tax audit or compliance purposes.

Network formation and value creation are closely linked and interdependent. Leveraging existing commercial relationships is a critical part of successfully bootstrapping the ecosystem of WHT solution participants and generating mutual benefits. The greater the number of participants, the stronger the WHT solution network effects are likely to be.

Ecosystem governance

Setting up and sustaining the ecosystem requires a fit-for-purpose governance framework. This framework should cover both the terms of cooperation between the network participants and the underlying technology. Proper governance is key to a fair and balanced model focusing on expected benefits for the participants. It helps minimize risks and incentivize participants to join and trust the WHT solution. Although participants did not explore specific governance models for the WHT solution during this project, they did distil key governance matters deserving further study:

- ▶ **Explore the need for a decentralized, neutral institution** that governs the development, deployment and maintenance of the WHT solution. This could be, for example, a governing body like a consortium or foundation involving financial intermediaries and tax authorities.
- ▶ **Explore the need for a separate legal entity and funding** to build and operate the WHT solution and ecosystem, pooling supply and demand around it and allocating funds for more efficient development, deployment and maintenance across jurisdictions.
- ▶ **Design risk management protocols**, to properly identify, manage, mitigate or recover from ecosystem-wide risks and participant-specific risks, so that the WHT solution is resilient and can withstand potentially extreme events.
- ▶ **Explore the need for advisory councils** to capture input from a wide range of stakeholders and domain experts, across sectors, around the WHT solution. Advisory councils can also play a meaningful role in the design of interoperability standards to allow the WHT solution to seamlessly interact with other



Figure 4.1 Ecosystem

systems, while factoring in specific needs of low-capacity jurisdictions.

- ▶ **Design flexible data and intellectual property governance frameworks**, so that each category of participant has access to critical data needed for tax compliance or business purposes and retains it if the participant leaves the WHT solution network. The WHT solution, by design, should also explore intellectual property strategies, so that the value derived is properly captured and protected.
- ▶ **Create an open environment to allow participants to build business applications on top of the WHT solution** to solve adjacent and other problems.

Figure 4.1 illustrates some of the potential parties to this ecosystem.

Select tax procedural matters

A key question that needs to be answered before the WHT solution can be deployed is whether the introduction of the distributed ledger technology requires changes to the existing tax legislation. This issue was the subject of academic research undertaken by the Global Tax Policy Center of the Vienna University of Economics and Business (Austria) and Tax Administration Research Centre (TARC, University of Exeter). Researchers surveyed the tax procedural frameworks of the following countries: the Netherlands, Norway, the United Kingdom, Austria, Germany and India.

In principle, all countries surveyed provide for the possibility of relying on both relief at source and reclaim mechanisms to achieve preferential WHT treatment under a tax treaty. Despite certain advancements such as those by the Dutch system for filing bundled refund requests for portfolio investments, most procedural frameworks are time-consuming and paper-based, with heavy and variable documentation requirements. Under most frameworks, tax authorities carry the ultimate burden of deciding on any reduced WHT entitlement, whether through a relief at source or a reclaim process.

The systems surveyed generally provide for the possibility to hold parties other than the taxpayer accountable for the inaccurate application of WHT. The academic research found that the standard of the duty of care, however, varies. Under the Dutch system, intermediaries authorized to submit bundled requests are unconditionally liable in case of excessive refunds. In Austria, the standard is the one related to the activity in question, e.g., banking. In Germany, if an inaccurate amount of tax is withheld, there is a rebuttable presumption of fault on the side of the WHT agent. In turn, the WHT agent may rebut the presumption by demonstrating that they acted neither intentionally nor with gross negligence.

Given the diversity of legal and administrative frameworks, there is no one-size-fits-all approach around tax procedural matters associated with the WHT challenge and solution. Instead, researchers have come up with some hypothetical scenarios to help answer the question of whether reform is needed at the local country level if a WHT solution were to be used. Here are some examples:

Scenario 1: the WHT solution simply enhances local-country tax relief processes and, thus, no major tax procedural reform may be needed. In this scenario, the WHT solution is introduced to simply enhance the existing WHT relief processes (i.e., either relief at source or via reclaim process). As a result, there would be no changes to the mode of relief; the statutory timeframe (although the more efficient WHT solution could compress the timeframe); documentation requirements; the position of intermediaries and other parties in the network; and their legal responsibility in the process. The WHT solution is simply a tool to make an already existing process more efficient. In this hypothetical context, no major reform would be needed, provided that tax authorities accept digital documentation.

Scenario 2: the WHT solution changes the local country tax relief process, which may trigger the need for tax procedural reform. In this scenario, the WHT solution

is deeply integrated with the systems of the relevant parties to the network. For example, the WHT agent and the source-country tax administrations would rely on information provided through the WHT solution to determine the applicable withholding tax, which then would be automatically calculated and levied without pre-approval by the tax authorities. This automatic WHT determination (subject to audit by the tax authorities if necessary) may not be allowed in all countries and, thus, reform may be needed.

If a jurisdiction currently requires the WHT agent to physically hold or even supply copies of all relevant documentation supporting the reduced WHT rate (e.g., certificates of residence), reform may be needed as well, potentially accompanied by automated movements of electronic documentation between parties.

Additional reform may be required to create the legal basis for the relationship between tax authorities and other parties on the WHT solution, or to define the formal requirements of such relationships. For example, on cross-border exchange of information, existing rules may limit the extent to which a tax authority can communicate with third parties outside its country. Local legislators may also consider additional reform to make sure, for example, that local tax authorities can claim a reimbursement for an automatically provided relief to an investor, from local intermediaries involved in the transaction.



05 Technology details

Architecture layers

At the heart of the WHT solution is a specific technology (called TaxGrid™) based on a distributed ledger architecture. This solution is comprised of multiple layers connected through a set of open APIs (Figure 5.1):

- ▶ User layer
- ▶ Application/integration layer
- ▶ Core layer
- ▶ Infrastructure

User layer

An implementation of the user layer is provided to each party according to their user personas (Figure 5.2).

The features and functions of the WHT solution were determined by the functional role(s) assigned to that participant (i.e., node) for a given test scenario (Figure 5.3).

The architecture also demonstrates the capability to integrate with the financial intermediaries' legacy system

(e.g.: custody/trading system) and share securities and tax relevant data among the relevant participants.

As the system evolves over time, additional application software such as withholding tax calculation engines, data analytics, audit/risk management engines could be integrated through the User layer.

Application / integration layer

The application/integration layer provides connectivity and operational software. It contains the server and user

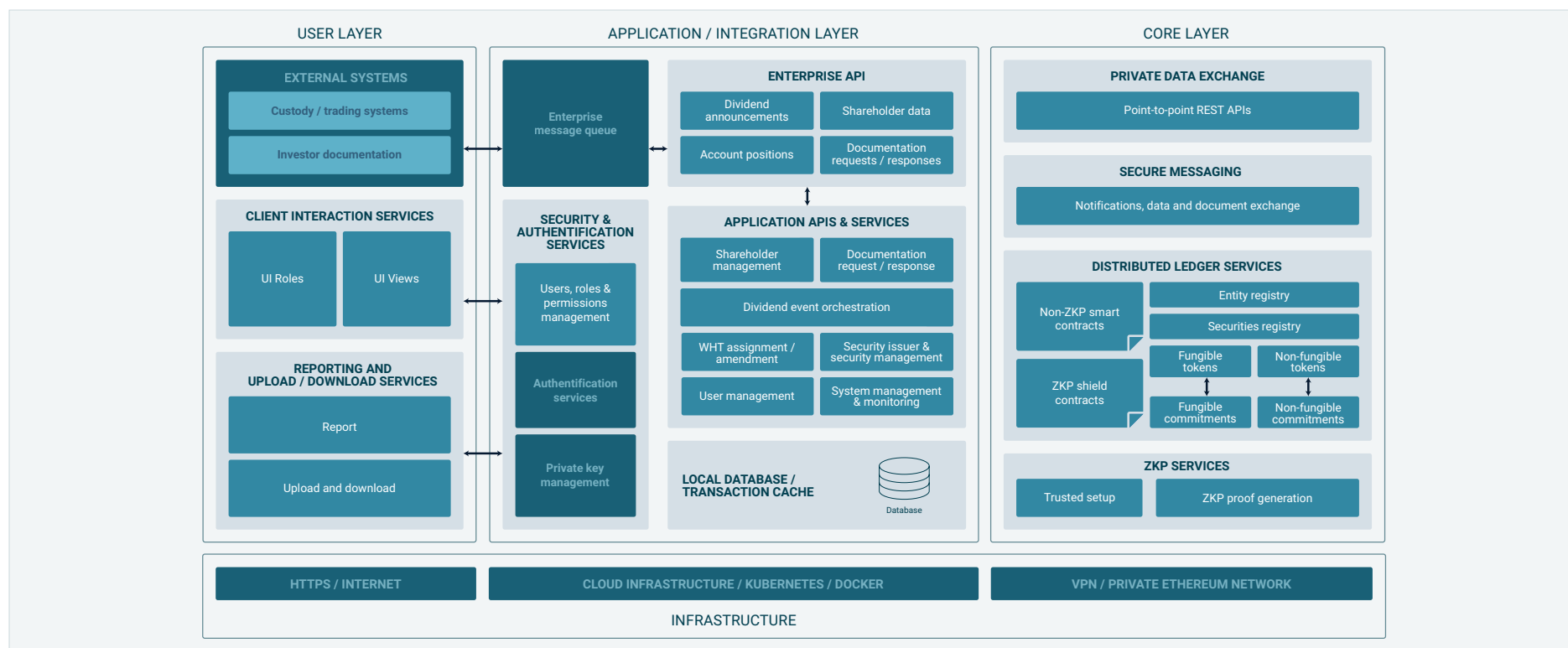


Figure 5.1 WHT solution architecture

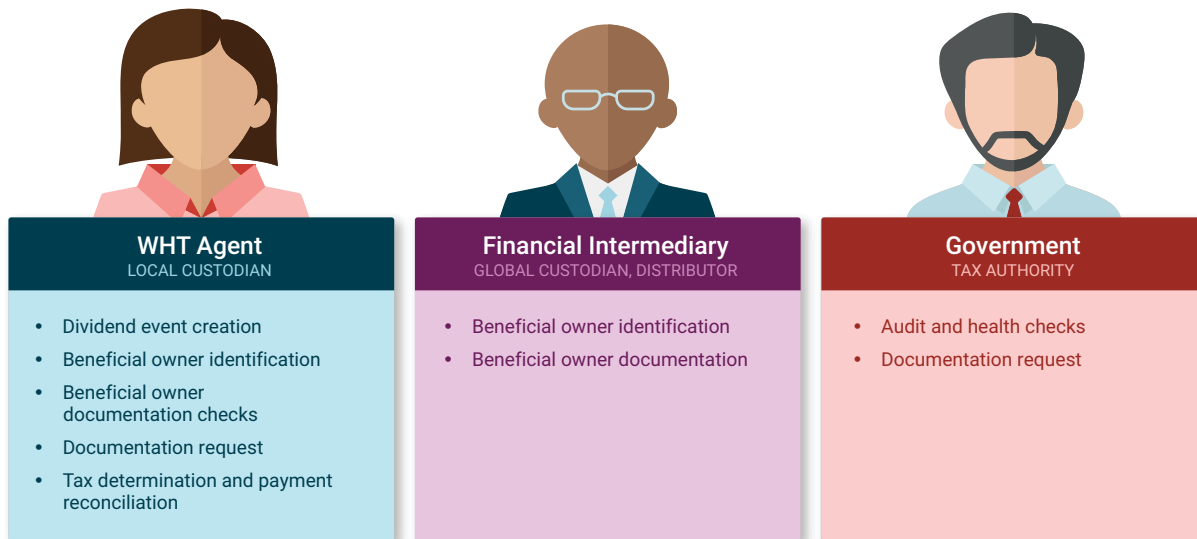


Figure 5.2 User personas

interface software to operate a production node on the WHT solution. Since this layer is built on the open APIs provided at the core layer and integrates into existing financial systems through a separate set of open Enterprise APIs, it is technically possible for other vendors to build their own proprietary software and services that act as the application/integration layer. This technology approach enables future widespread adoption of the WHT solution reducing the risk of vendor lock-in.

Enterprise APIs and enterprise message queue

In order to connect the WHT solution to existing systems managed and maintained by the financial intermediaries, there is a set of Enterprise APIs. These are used to query the account and investor data required to process dividend events and to update the financial intermediary's systems with information generated and exchanged through the solution. Requests for additional documentation

are also forwarded through the Enterprise APIs, along with the responses to those requests.

To provide a layer of isolation between the WHT solution and each financial intermediary's proprietary system, the Enterprise APIs are implemented as request/response messages.

The Enterprise API defines the "payload" carried in each message. The contents and format of each payload and its intended usage form the open API for enterprise connectivity. For each API, there is a request message (the query) and a corresponding response message (the results of the query).

Application APIs

In addition to these Enterprise APIs, the various components of the application/integration layer are connected

through application APIs. For example, there is a set of REST APIs²⁷ that connect the user interface web application to the server application. Access to these application APIs is secured through the use of a Web Application Firewall (WAF).

These application APIs are not needed to connect to either the core layer or the enterprise systems, so they are not included in the open APIs.

Application services

The WHT solution has a set of data management features to define and maintain the key data elements required to process the dividend events: the security issuers, securities, income/dividend events, and shareholders. This includes data schemas, database APIs, user interfaces and means to transmit and share this data throughout the network through the Core Layer communications facilities (blockchain transactions, secure messages, point-to-point data exchange).

The Application Services support display of dividend events in real-time including its status and downloads of key reports from the WHT solution (WHT reports and payment reconciliations). Data entry, review and amendment of WHT rates are provided for WHT agents. Management of investor documentation, and workflows associated with processing documentation requests, are also provided through the application/integration layer.

Security and authentication services

Each entity on the network runs its own copy of the application/integration software layer on a system under its control. This means that each entity has full control over its own data, the interfaces to its enterprise systems (using the Enterprise APIs), and its users and their access rights.

²⁷Representational State Transfer (REST) is an architecture style and approach commonly used on web-based applications.

These are the main mechanism and architectural components that underpin security and authentication:

- ▶ User, roles and permissions management: A role-based access control (RBAC) facility determines each user's capabilities and interfaces, requiring login with their username and password.
- ▶ Authentication services: An authentication API provides a standard method of authenticating users, securing APIs, and signing distributed ledger transactions.
- ▶ Private key management: Private keys, managed by cloud hosted secure key management services, are used to authenticate the APIs and sign the distributed ledger transactions.

Local database and transaction cache










To support the operations performed by the application/integration layer, each node was configured with its own local database. The local database stores configuration information and data files required by each node. It also acts as a transaction cache and buffer between the application layer and each of the major external interfaces: distributed ledger services, Enterprise APIs and user interface. The transaction cache provides efficient access to the state of the blockchain from the perspective of that entity, avoiding the need to continuously query the blockchain directly.

Core layer

The core system architecture is built on a private permissioned network based upon the Ethereum blockchain.

The system architecture includes a robust mechanism to protect data privacy and confidentiality through a secure messaging system, point-to-point data exchange protocols and zero-knowledge proof (ZKP) protocol.

A core layer made widely available through a combination of licensing, open source and/or release into the public domain could enable the migration of technical governance and future roadmap to a neutral institution as discussed in the "Ecosystem Governance" section.

USER INTERFACE		CAPABILITIES	LOCAL CUSTODIAN / WHT AGENT	FINANCIAL INTERMEDIARY	TAX AUTHORITIES
	Entity registration and management		✓	✓	✓
	Security issuer data management	▶ Manages security issuer data	✓		
	Security data management	▶ Manages security data	✓		
	Income event (e.g.: dividend distribution) data management	<ul style="list-style-type: none"> ▶ Manages income event data ▶ Trigger income event (e.g.: total shares, gross amount, payment date, etc.) ▶ Withholding taxes determination process ▶ Payment reconciliation process 	✓		
	Shareholder data management	<ul style="list-style-type: none"> ▶ Sends shareholder's information ▶ Receives shareholder's information 	✓	✓	
	Withholding tax and payment reports	<ul style="list-style-type: none"> ▶ Access to WHT report (gross dividend and WHT per beneficial owner) ▶ Access to payment reconciliation report 	✓	✓ ⁽¹⁾	✓ ⁽²⁾
	Investor documentation provision	▶ Manages final investor documentation (beneficial owner)	✓	✓	
	Audit and documentation request	<ul style="list-style-type: none"> ▶ Request documents ▶ Receive and respond to documents request 	✓	✓	✓
	System management and monitoring		✓	✓	✓

(1) Only access to reports concerning investors with which the financial intermediary has a direct relationship
(2) Only access to reports from income events originating from tax authority's country (source country)

Figure 5.3 Functional roles

Distributed ledger services

The distributed ledger is a decentralized database where several computers or nodes maintain the ledger across a network. Every party in the network keeps a copy of all the transactions. As new transactions are submitted and validated, the ledger will be updated on each node. Transactions are secured through cryptographic and algorithmic techniques to prevent tampering and support the consistency and integrity of the distributed ledger at each node.

The core layer leverages smart contracts to tokenize dividend²⁸ event entitlements and provides these main function and features:

- ▶ Register and query entities
- ▶ Execute dividend event
- ▶ Return dividend data to WHT agent
- ▶ Support audit queries by tax authorities (via peer-to-peer secure data transfers)

This includes managing dividend events, fungible and non-fungible tokens, the shared entity registry, and ZKP-related functions.

The token architecture uses a combination of ERC20 fungible tokens (FT) and ERC721 non-fungible tokens (NFT), the Ethereum open standards.

ZKP services

The ZKP services are based on open-source and public domain libraries. The foundation for these services is the Nightfall library, which EY contributed into the public

domain in 2019.²⁹ This library supports ZKP-enabled fungible (ERC20 compatible) and non-fungible (ERC721 compatible) token operations on an Ethereum network.

The proofs are generated off-chain, with results recorded into a combination of an on-chain shield smart contract and off-chain Merkle tree database; verification is done on-chain.

In the ZKP implementation, the properties of the non-fungible tokens (including unique investor identifier, number of shares, and category of investor) are transmitted off-chain rather than being recorded in the on-chain non-fungible token mint transaction. Instead, the NFT has a hash of these properties, which is an algorithm that takes a data input and produces a unique, fixed-size string of bytes as output. With the hash recorded on the distributed ledger (i.e., blockchain), the off-chain properties can be validated against the hash without allowing third parties access to these properties.

All ZKP transfers (fungible and non-fungible) are accomplished in a way that masks the identities of the sending and receiving parties while providing mathematically provable means for on-chain verification of the validity and accuracy of the transaction. For fungible tokens, the amounts being transferred are hidden from third parties through off-chain transmission of the values with on-chain verification. This uses the same secure messaging and off-chain point-to-point facilities used in ZKP transfer of non-fungible token properties.

Secure messaging

The software uses secure messages to send notifications and acknowledgements from one node to another node without using distributed ledger transactions. This avoids having the contents of these messages being permanently and immutably stored on the blockchain. The messages are secured by encrypting the entire message contents using the public key of the intended recipient node. Only the intended recipient can decode this message using its closely guarded private key.

Its secure messages are limited to a small number of specialized purposes. The first is to initiate a private point-to-point data exchange between two nodes on the network. The second is for an authorized party to request investor documentation from a financial intermediary. In both cases, the actual data being exchanged is not contained in the message itself, just the request to initiate a separate point-to-point data exchange.

Private data exchange

Private point-to-point data exchange is used when data needs to be exchanged outside of the distributed ledger. For example, in ZKP transactions certain data elements that would normally be included in the transactions for fungible and non-fungible tokens are instead moved privately. Similarly, investor documentation and other confidential investor data are transferred privately from one node to another. Each private data exchange is initiated by a secure message, conducted through an encrypted REST API, and secured using a JSON Web Token (JWT).

²⁸Other corporate actions like interest and capital gains could also be tokenized.

²⁹<https://github.com/EYBlockchain/nightfall>

Infrastructure

The infrastructure used varied among the participants. A shared VPN³⁰ connected environments from IBM cloud, Azure cloud and AWS cloud. The testing was deployed on 11 nodes hosted by a combination of tax authorities, EY and financial intermediaries.

Data standards

Adoption of common standards for representing data elements is one major step towards interoperability. With that in mind, the WHT solution was built considering existing data standards on its system such as ISO 20022³¹ – corporate actions (SWIFT), ISO 6166³² – international securities identification numbering system (ISIN), OECD: Treaty Relief and Compliance Enhancement (TRACE)³³ Schema and OECD: Common Reporting Standard (CRS).³⁴

The adoption of these standards can enable tax authorities and governments to efficiently communicate and share global tax data among themselves.

³⁰Virtual Private Network (VPN) is a secure connection of nodes (i.e.: participants' computers) across the public internet so traffic among them is protected and encrypted.

³¹<https://www.iso20022.org/>

³²<https://www.iso.org/standard/44811.html> and <https://www.isin.net/iso-6166/>

³³<http://www.oecd.org/tax/exchange-of-tax-information/trace-xml-schema-user-guide.htm>

³⁴<https://www.oecd.org/tax/automatic-exchange/common-reporting-standard/>



06 Discussions and learnings during the project

During the course of the project, a series of coordination calls were held at three levels: a steering committee, tax and business calls, and IT technical. This provided a temporary governance structure for the project and offered a potential template for transitioning to on-going governance of a solution based on distributed ledger technology.

As the project evolved, the topics of discussion gradually shifted from logistical/technical issues toward the implications of adopting and adapting this type of technology for transforming the cross-border WHT process.

To understand the nature of the discussions, it is important to recognize that the technical solution was designed to increase the potential for granting relief at source in the near future, while also providing a new level of privacy and commercial confidentiality using a state-of-the-art system based on distributed ledger technology.

While the project made this future state quite tangible and directly experienced by the participants, it drew attention to the gaps between the future state being envisioned and current practices and regulatory structures. From the start, it was always assumed that adjustments would be needed to the technology (as demonstrated) to provide a smoother transition and more flexible options. The feedback, discussions and learnings from the project pointed to some areas for the next version to enhance the user experience and value of the solution to the users, both industry and governments.

The other major focus of discussions and learnings were non-technical in nature. The need to advance the formation of the ecosystem and address issues of governance are covered elsewhere in this report. With the testing proving that many of the technology hurdles have been greatly reduced or eliminated, it highlights the urgency of resolving these ecosystem and governance issues by finding ways to advance the mutual interests of government, industry and taxpayers.

“

Many of the technology hurdles have been greatly reduced or eliminated.



07 Next steps

Having completed the project, the logical question that arises is what should be done next. As the project had a narrow scope and focused on technology testing, next steps can be divided into the following categories:

- Raising market awareness
- Technology
- Legal and regulatory

Raising market awareness

The general consensus of the participants was that the WHT solution or another solution using similar technology could help solve significant aspects of the global WHT challenge. A logical next step is to raise market awareness of the WHT solution and its capabilities among interested parties in the private sector (e.g., financial intermediaries, investors, industry bodies, etc.) and the public sectors (e.g., governments, multilateral organizations, etc.).

There are different viewpoints as to whether successful adoption should be driven by industry or governments. While industry is looking to government for leadership, further government action may depend on the identification and quantification of the policy case for such adoption, in addition to any positive conclusions reached about the technology.

Direct and clear leadership from one or more multi-stakeholder organizations could provide a path to adoption. To help achieve that goal, public and private sectors can coalesce around the problem, working with internal and external stakeholders to raise awareness and help remove current barriers that may be preventing an advanced technology WHT solution from moving forward.

This could include discussions on the legal, governance

and regulatory frameworks that may be required and, from a technology perspective, how other parties may want to participate in the further exploration of this technology and its potential for solving the global WHT challenge.

Technology

The technology development will continue taking into account the feedback from the project participants with a view to take the next steps toward production deployment. In particular, participants expressed the need for additional flexibility and alternative workflows for handling documentation based on differences in markets and variations in legal requirements and contractual arrangements. One area of great interest, subject to regulatory approvals, is to directly replace entire paper-based documentation workflows with digital equivalents.

These developments could then be tested, which would include testing the automated gathering of data from custody/trading systems and production-level workloads to demonstrate continued progress in system performance and scalability.

One area of focus for performance and scalability improvements will be the computation of ZKP proofs. Although these proofs are computed off-chain, the process is resource intensive and could present a performance bottleneck in a production deployment. There are a number of opportunities to make improvements. That includes next generation algorithms for computing proofs, which are expected to substantially reduce the computational requirements for each proof. Also, proofs can be executed in parallel across multiple processors using techniques similar to those used in “big data” applications. By executing dozens or even hundreds of proofs in parallel, the elapsed time to execute a dividend event should be able to meet production requirements.



Legal and regulatory

This project focused on the technology testing. It did not seek to explore in detail or address any potential legal and regulatory changes that might be needed in order to widely adopt the WHT distributed system to solve the global withholding tax challenge. In parallel, an academic analysis by Vienna University of Economics and Business and the TARC, University of Exeter looked to identify legal and regulatory issues that might need to be addressed in further stages of the project involving this technology. The framework of next steps will need to include examining such issues as acceptance of digital documents/certificates (e.g., CoTR) by governments, beneficial ownership assessments and liability related questions.

Other use cases

One of the objectives of the project was to identify other use cases that could benefit from distributed system-based platforms such as the WHT solution. Successful testing of the WHT use case proved that the distributed system technology could share data between taxpayers and governments while respecting relevant permissions and data privacy regulations.

This could pave the way for considering this technology for other tax and wider use cases such as exchange of information (e.g.: CBCR,³⁵ CRS³⁶) and global trade. By adopting a network and ecosystem approach, there is the potential to solve some of the practical challenges around data flows and single source of data for global tax data sharing.

³⁵Country-by-country reporting - <https://www.oecd.org/tax/beps/beps-actions/action13/>

³⁶Common reporting standards - <https://www.oecd.org/tax/automatic-exchange/common-reporting-standard/>



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