TOKENIZED ECONOMIES

In collaboration with

Caisse des Dépôts GROUPE

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Unlocking Scalability and Interoperability in Tokenization Systems

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Ecosystem Cases For Scalable, Interoperable Tokenization

FEVERTOKENS

tokenizedeconomies.org

Foreword

The rise of tokenization marks a transformative shift in the management, trading, and security of financial assets. At the heart of this revolution lies the adoption of open-source, composable, and secure architectures, which form the essential building blocks of this evolution. This report, the first in the series "Unlocking Scalability and Interoperability in Tokenization Systems," sets the stage for reimagining and redesigning tokenization systems beyond the traditional confines of single-stakeholder approaches.

FeverTokens and Caisse des Dépôts (CDC) share a unified vision of integrating all ecosystem players and breaking down the barriers that hinder the development and deployment of scalable tokenization systems. Through their collaboration within the Tokenized Economies Institute, they aim to establish scalability and interoperability as achievable benchmarks. Addressing the cost and technical obstacles that have long constrained next-generation infrastructure for capital markets will empower innovators to focus on what truly matters: data standardization, seamless interconnectivity, advanced financial engineering, and robust governance frameworks, all of which are critical to unlocking the full potential of tokenization.

In Chapter 1, we laid the foundational framework for the future of tokenization systems, emphasizing the critical importance of open-source, modular, composable, and secure architectures. We explored the barriers to scalability and interoperability and underscored the need for collective innovation to reduce entry costs and enable an inclusive ecosystem.

Chapter 2 takes this foundational vision forward by diving into practical ecosystem use cases and industry perspectives. With real-world cases and collaborative projects, we illustrate how the principles discussed earlier are being implemented to drive tokenization at scale. The chapter highlights how key players, including financial institutions and technology providers, are adopting modular and interoperable frameworks to transform tokenization from a theoretical possibility to a market reality. These cases also serve as a platform for gathering feedback and fostering dialogue among stakeholders, ensuring that the next steps in tokenization development are informed by shared experience and insight. As we turn to these ecosystem-driven approaches, we continue to move closer to a financial infrastructure that is interconnected, efficient, and accessible to all.

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1. Interoperability from Standards to Industry Frameworks to Protocols

Robust tokenization systems and thereby a robust tokenized ecosystem must leverage and align with existing industry standards and frameworks to ensure interoperability, which is also foundational for adoption and scalability. The challenge lies in how one elaborates these high-level specifications and guidelines and adopts them in low-level implementations. The current chapter presents leading examples of this process by ecosystem players.

Before we begin, it is important to clarify three closely related and interdependent concepts: industry standards, frameworks, and protocols. These concepts do not exist in a strict hierarchy but rather interact at different levels, often overlapping and influencing each other in practical applications.

Standards typically define data formats, interfaces, and practices that ensure consistency, interoperability, and trust within an industry ecosystem. Developed by recognized standardization bodies, standards serve as agreed-upon benchmarks that provide a foundation for collaboration. They are generally more rigid and, in many cases, mandatory, offering the stability needed to align diverse players and systems.

Frameworks, in contrast, provide a broader structure that integrates end-to-end processes with specific guidelines for achieving particular objectives. While frameworks often incorporate and adhere to standards, they are inherently more flexible and adaptable. This flexibility allows frameworks to address a wider range of use cases and support customization to meet industry-specific or organizational needs.

Protocols operate at a more detailed and procedural level, implementing the rules and processes outlined by standards and frameworks for specific use cases. They tend to be more rigid and precise by design, ensuring that operational details are effectively executed within the broader structural guidance provided by the framework.

In practice, these concepts frequently intersect and influence one another. Standards might guide the data and interfaces used by a framework, while frameworks define the overarching processes that protocols implement. This interdependence underscores the importance of understanding how each element contributes to the creation of cohesive, scalable, and interoperable industry solutions.

Crucially, a complete tokenized solution consists of a range of protocols, directly or indirectly applied, that implement several industry frameworks, which in turn complies with all pertinent industry standards. It is incumbent upon the technical architecture serving the ecosystem to act as a flexible, scalable, and secure vehicle for ecosystem players to fulfil their respective roles in elaborating the continuum from industry standards to frameworks and protocols. To that end, FeverTokens' package-oriented technical framework is an end-to-end companion to tokenized ecosystems, as cases in this chapter will illustrate.

In this section, we focus on two cases at the standard and framework levels.

In Section 2, we delve into the implementation of frameworks into protocols. Lastly, we explore the development of standard-abiding frameworks, with an emphasis on the meta-layer tooling that greatly smoothens the introduction and evolution of industry frameworks that ensure interoperability and scalability.

ICMA Bond Data Taxonomy (BDT) and FINOS Common Domain Model (CDM): Harmonising Data and Processes Across Ecosystems

Introduced in March 2023, the Bond Data Taxonomy (BDT) is a common language developed by a broad range of global bond market constituents to promote automation and reduce the risk of fragmentation across issuance, trading, settlement and distribution of debt securities. The BDT is technology agnostic and designed both for traditional debt securities as well as tokenised bonds.

In essence, the BDT provides a standardised, machine-readable language for key bond information typically contained in a bond term sheet. This includes terms such as issuance amount, currency, maturity date, interest, but also governing law, applicable selling restrictions and, if applicable, DLT-related information such as the DLT platform operator and LEI, for example. By defining these data elements unambiguously, the BDT promotes straight-through processing (STP) and interoperability between different systems and stakeholders where data is exchanged during a debt security's lifecycle.

To facilitate trade processing and reporting of derivatives, repo and securities lending transactions – including a broad range of complex and operationally cumbersome lifecycle events, the Common Domain Model (CDM) was developed jointly by ICMA, the International Swaps and Derivatives Association (ISDA), and the International Securities Lending Association (ISLA). Hosted by the FinTech Open Source Foundation (FINOS) since 2023, the CDM provides a machine-readable, and machine-executable data and process model that represents how financial products are traded and managed throughout their lifecycle. The CDM seeks to facilitate automation, enhance compliance and lower operational costs.

In the context of tokenisation, these standards are crucial for ensuring cross-system interoperability and avoiding fragmentation between traditional securities markets and the 'new world' of tokenised assets. The BDT's standardised data definitions enable different systems to interpret and process bond information consistently, while the CDM's comprehensive process models help ensure that complex lifecycle events are managed uniformly across platforms.

Due to their technology agnostic and standardised nature, both BDT and CDM lend themselves to implementations of smart contracts for tokenised securities. FeverTokens demonstrated at the "CAST challenge", organised by Société Générale FORGE's in 2023, how the BDT and CDM functions can be integrated modularly within larger tokenisation systems, utilizing its open-source package framework. In the Guardian Fixed Income Framework (GFIF), published by the Monetary Authority of Singapore (MAS) in November 2024, ICMA outlines different BDT implementations for tokenised debt securities, including FeverTokens' proposal "Integrating BDT into so|bond v2.0: A Modular Approach to Enhancing Bond Tokenization". This complements the adoption of the BDT in early 2024 by Hong Kong SAR in its multi-currency digital green bond issuance.

Raising awareness of such implementations as well as continued collaboration across the ecosystem are key to facilitate broader adoption of standards and foster the development of tokenised bond markets as a reliable source of funding.

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A note to keep in mind in understanding this pair of concepts is that some initiatives encompass elements of both standard and framework.

In such cases, the standard aspects usually set specifications that other frameworks can build on, while the framework aspects are adaptable implementations of industry standards including, but usually not limited to, standards set out by the initiative.

Incorporating international financial standards into tokenization protocols is ultimately a cornerstone for advancing secure, efficient, and compliant digital asset markets. These standards provide the foundation for transparency, interoperability, and streamlined market operations. FeverTokens and Caisse des Dépôts (CDC) advocate for a progressive, modular approach to integration—one that supports ecosystem development through flexibility and composability.

DASCP Principles: The Foundation for Access Control in Smart Contract Implementations

The Digital Asset Securities Control Principles (DASCP), collaboratively developed by industry leading FMIs, Euroclear, DTCC, and Clearstream, established a comprehensive framework for the adoption and management of digital asset securities. These principles are instrumental in addressing regulatory compliance and in mitigating operational risks, thereby fostering a secure and efficient digital assets' ecosystem.

The six core DASCP principles encompass:

1. Legal Certainty: Ensuring that digital asset operations are firmly grounded within existing legal frameworks.
2. Regulatory Compliance: Aligning digital asset activities with current and evolving regulatory standards.
3. Resilience and Security: Developing robust infrastructures capable of withstanding disruptions and safeguarding sensitive data.
4. Safeguarding Customer Assets: Implementing governance mechanisms, including smart contracts, to manage assets securely.
5. Connectivity and Interoperability: Facilitating seamless transactions and flexible settlements across diverse networks.
6. Operational Scalability: Striving for efficiency and cost-effectiveness through standardization.

To smart contract implementations, the DASCP principles provide a foundational framework for establishing robust access control mechanisms. By adhering to these guidelines, tokenization systems can ensure that their smart contracts are secure, compliant, resilient, and interoperable. This alignment is essential for fostering trust among market participants and for supporting the sustainable growth of digital asset markets. Technology specialists, such as FeverTokens with its ecosystem-driven, open package framework and hub technology, play a critical role in championing the integration of DASCP principles in a scalable fashion by way of access control modules, modular and composable, that enable the development of secure and scalable smart contract solutions.

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2. Industry Frameworks and Protocols for Modular Implementations

While new frameworks and protocols may have one-to-one relationships, this is usually unnecessary and often insufficient. Rather, we should see frameworks and protocols as networks with many-to-many relationships that constitute an ecosystem.

In this section, we delve into two leading examples of modular tokenization frameworks and protocols. In the first example, an innovative implementation of Common Domain Model (CDM) functionalities as interoperable modules demonstrate how modular frameworks can operationalize industry standards. The implementation paves the way for scalable and adaptable solutions. In the second example, a modular implementation of the CAST framework at the protocol level (so|bond V2) addresses critical challenges in green financial instruments. Under the auspices of growing collaboration between FeverTokens and Swift, Delivery versus Payment (DvP) modules are under development with the goal of incorporating international standards via external components that are compatible with all protocols built on FeverTokens' package-oriented technical architecture, including so|bond V2.

Attention should be paid to how the technical architecture enables protocols to implement frameworks while incorporating elements of other frameworks to integrate international standards as well as external components that extend the protocol. The transformative potential to drive innovation lies in the composable, open nature that compatible frameworks inherit from such technical architecture, thereby underpinning a cohesive, scalable digital asset ecosystem.

2.1 CAST Framework: Native Compatibility with Global Standards

The CAST framework represents a significant step toward establishing open, standardized, and interoperable architectures for the tokenization of financial instruments. Developed through industry collaboration led by Société Générale Forge, the CAST initiative focuses on creating a compliant architecture for security tokens. Its ultimate goal is to foster a global ecosystem of financial systems that integrate seamlessly with international standards and operate efficiently at scale.

As part of this vision, the CAST challenge, organized by a consortium of industry leaders among prominent financial institutions and organizations such as Société Générale Forge, CACIB, Swift, ICMA, ISDA, and others, seeks to identify robust open-source solutions that align with the framework and adhere to international standardization processes. The challenge posed an essential question: how can attributes, functionalities, and definitions be implemented to ensure compatibility with standards such as the Common Domain Model (CDM), ICMA's Bond Data Taxonomy (BDT), and ANNA's digital asset taxonomy? The use case was centered on integrating these ongoing standardization processes into CAST-compatible smart contracts.

FeverTokens emerged as a key contributor to this endeavor with an innovative approach to creating natively BDT- and CDM-compatible CAST smart contract implementations. Leveraging its open-source, package-oriented framework, FeverTokens showcased a modular architecture capable of addressing the challenge's multifaceted requirements. First, it mapped the BDT into smart contracts by standardizing their parametrization through a dedicated package that enables precise representation of bond data. Second, it implemented CDM packages in Solidity to guarantee standard interfaces for common lifecycle functions, thereby ensuring consistency and compliance with international standards.

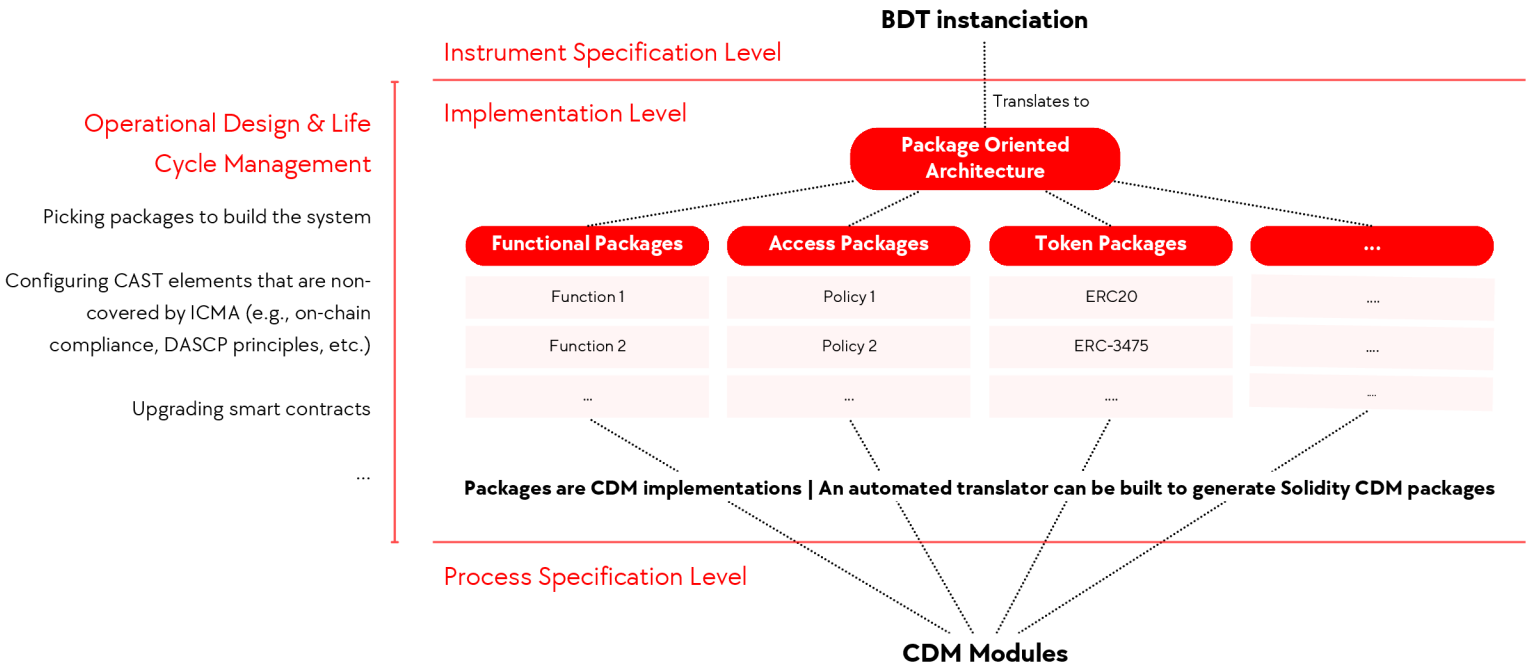

Figure 1. CAST Challenge Winning Proposal by FeverTokens

This modular, package-oriented approach developed by FeverTokens highlights the transformative potential of scalable, interoperable smart contract architectures. By enabling native interoperability, FeverTokens provides a blueprint for advanced smart contract implementations that are ready for deployment across diverse financial ecosystems. Its solution not only addresses the immediate requirements of the CAST framework but also sets the stage for the broader adoption of global financial standards, ensuring the scalability and harmonization needed for next-generation tokenization systems.

The work presented by FeverTokens during the CAST challenge exemplifies how modular architectures can drive standardization and interoperability, reinforcing the CAST's goals of creating a unified and efficient global financial ecosystem. Technology-wise, it underscores the importance of open-source collaboration in advancing tokenization standards and integrating international best practices into scalable, functional systems.

2.2 so|bond V2: Modular Design for Ecosystem-Driven Expansion

The introduction of so|bond v2.0 marks a significant leap forward in the evolution of tokenization systems at the protocol level, offering a robust, scalable, and modular architecture tailored to the needs of an interconnected digital finance ecosystem.

Building upon the foundations of its predecessor, so|bond v2.0 leverages FeverTokens' innovative Package-Oriented Framework to drive scalability, composability, and interoperability. This approach streamlines the tokenization and settlement of financial instruments, making these processes more efficient and accessible to a broader range of solution builders and market participants.

A Comprehensive Ecosystem Approach

so|bond v2.0 is more than just a technical upgrade to the so|bond protocol—it represents a fundamental shift toward a collaborative and integrated ecosystem. Utilizing open-source smart contract packages, it creates opportunities for financial institutions, regulators, and other stakeholders to work seamlessly within a unified system. This ecosystemic approach mitigates the risks of fragmentation and operational silos, ensuring that the digital finance landscape remains cohesive and scalable.

By prioritizing interoperability and flexibility, so|bond v2.0 provides stakeholders with tools to customize their implementations while adhering to international standards. This ensures that the framework is not only forward-looking but also inclusive, thereby accommodating the diverse needs of participants across the financial ecosystem.

Modular Integration with External Packages

A defining feature of so|bond v2.0 is its capacity to integrate external packages that further enhances its flexibility and utility. Key examples of such integrations include:

- SWIFT's Settlement Packages: Integration with settlement modules enables seamless Delivery versus Payment (DvP) functionality that bridges traditional and tokenized financial systems for secure and efficient settlement processes.
- Access Control Packages: Incorporating sophisticated access control mechanisms ensures that the protocol remains compliant with regulatory requirements while maintaining high security and operational integrity.
- Specialized Packages for Green Bonds: so|bond v2.0 also supports innovative packages such as those developed for coupon management in the context of green bonds. These capabilities were demonstrated during the COP28 TechSprint, a global competition organized by the Bank for International Settlements (BIS) in collaboration with the COP28 Presidency and the Central Bank of the United Arab Emirates (CBUAE), where FeverTokens showcased how modular smart contracts can be tailored to meet the specific requirements of data integrity and compliance with green bond standards.

Enabling Scalability and Interoperability

With its modular design, so|bond v2.0 not only enhances the efficiency of tokenization processes but also fosters greater scalability and interoperability. By allowing external packages to be seamlessly integrated, the framework empowers market participants to innovate within a standardized yet adaptable ecosystem.

Through creating a scalable and open ecosystem, so|bond v2.0 enables market participants to build on a shared foundation while maintaining the flexibility to address their unique needs. This vision aligns with the broader goal of creating a cohesive digital finance landscape where fragmentation is minimized and interoperability is maximized.

Swift Can Help Financial Institutions Unlock the Potential of Digital Assets

For 50 years, Swift has played a vital role in increasing global interoperability and enabling fast, frictionless and secure transactions. And we're continuing to expand on our ability to interoperate new systems, technologies, assets and currencies in line with our company strategy.

We believe the Swift network and infrastructure is a community asset that can help financial institutions unlock the benefits of digital assets and currencies.
Recent experiments have proven our capacity to connect public and private blockchains, interlink central bank digital currencies (CBDCs) on a global scale, and integrate multiple digital asset and currency networks.

Now we're moving beyond experimentation.

This year we are collaborating with our community to pilot an advanced version of our infrastructure that is capable of orchestrating digital asset and currency transactions across networks. This move will mark an important milestone as we progress towards achieving our ultimate vision of giving financial institutions a single point of access to multiple digital asset classes and currencies.

This year's trials aim to address a key challenge in the continuously evolving digital asset market: the rise of disconnected digital platforms, or 'digital islands', that could hinder more widespread adoption and ease of use for new forms of value.

A further priority, aligned with Swift's traditional role, is the need to define community driven global standards for digital assets and thereby improve the ecosystem as a whole. The need for standardisation was explored in more detail in our recent white paper, Unlocking the Potential of Digital Asset Securities.

As part of these efforts, we will explore how Swift can enable its community to create and foster adoption of global standards. This aims meet the broader industry's demand for scalable, interconnected solutions capable of supporting a dynamic and evolving financial landscape.

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3. Bridging Industry Standards and Frameworks for Interoperability and Scalability

As a framework must adhere to all pertinent standards while being adaptable, and since standards are by nature rigid, the development and evolution of a framework are challenging tasks. Done well, the framework offers flexibility and compatibility with ever-growing features that let builders and entrepreneurs loose in pursuit of innovation while ensuring interoperability and scalability, and vice versa.

In terms of interoperability and scalability, the rigid, rule-based layer of standards provide the foundation for data formats, operational consistency, and regulatory compliance, while the adaptable, functional layer of frameworks define the broader structure and processes that implement these standards in a practical, scalable way. Knitting them into a cohesive, adaptable, extendable, and maintainable network is critical for fostering interoperability.

An emerging approach that has demonstrated technical superiority and captured the industry's imagination is based on smart contract packages using FeverTokens' open-source technical architecture. It excels in being framework-agnostic, i.e. an operationalization of an industry standard can be reused across industry frameworks. As standards evolve, it also allows seamless, interruption-free updates.

3.1 MAS Fixed Income Group: FeverTokens' BDT Implementation Proposal

The collaboration between the Monetary Authority of Singapore (MAS) Fixed Income Group and the International Capital Markets Association (ICMA) produced a compelling example of bridging standards and frameworks.

The Bond Data Taxonomy (BDT), developed by the International Capital Market Association (ICMA), standardizes how bond data is represented and processed. While the BDT ensures a consistent language for bond data, integrating it into frameworks requires adapting these rigid definitions into dynamic, modular systems that can support varied financial instruments and lifecycle processes.

To that end, FeverTokens proposed an innovative approach to integrating ICMA's BDT into token frameworks and distributed ledger platforms, which was detailed in a report by ICMA, that uses its package-oriented technical framework to operationalize the BDT.

By mapping the BDT's rigid data definitions into smart contract modules, FeverTokens enabled standardization at the smart contract level. These modules are designed to capture the taxonomy's data elements—such as bond terms, payment structures, and identifiers—while allowing composability with other lifecycle components.

This modular approach ensures that data integrity and consistency are maintained while offering flexibility for extensions and customizations.

Additionally, FeverTokens also introduced interfaces that use the Common Domain Model (CDM) to define lifecycle functions such as bond issuance, coupon payments, and maturity processing. These interfaces serve as bridges between the standardized BDT data layer and the operational framework, enabling seamless interoperability across frameworks and implementations.

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