Simulation of Derivatives Post-Trade Services using an Authoritative Data Store and the ISDA Common Domain Model

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Abstract

In this paper, we present a summary of the design and implementation of a simulation of post-trade services for interest rate swaps, from execution to maturity. We use an authoritative data store (ADS) and the International Swaps and Derivatives Association (ISDA) Common Domain Model (CDM) to simulate a potential future architecture. We start by providing a brief overview of the CDM and the lifecycle of an interest rate swap. We then compare our simulated future state architecture with a typical current state architecture. Next, we present the key requirements of the simulated system, several suitable design patterns, and a summary of the implementation. The simulation uses the CDM to address the industry problems of inconsistent processes and inconsistent data, and an authoritative data store to address the industry problem of duplicated data.

1 Introduction

The post-trade industry has gradually evolved over time, with its core infrastructure increasing in complexity as new functionality is added. There is an opportunity to rationalise this infrastructure and potentially reduce costs by 50 to 80 percent by adopting newer standards and technologies [6]. In a previous paper [18], we highlighted that there exists “a perfect storm of industry inefficiency in post-trade processing, fuelled by duplicated inconsistent processes operating on duplicated trade data in inconsistent data formats”. We also identified a potential industry solution in the widespread adoption of the ISDA Common Domain Model (CDM) [15], alongside the adoption of authoritative data stores (ADSs). The former provides common standards for both data and processes, and the latter addresses the problem of data inconsistency and duplication.

Here we aim to provide a summary report of relevance to financial institutions. We set the scene by presenting the scope, aim and structure of the CDM, as well summarising the lifecycle of an interest rate swap. Our paper then provides an overview of the design and implementation of a simulation of post-trade processing for interest rate swaps, from execution to maturity. We compare our simulated future state architecture for trade services with a typical current state architecture. We also present the key requirements of the system, several suitable architectural and software design patterns, and key implementation details. Finally, we briefly analyse the simulated architecture, including how it addresses the three industry problems of inconsistent processes, inconsistent data, and duplicated data.

This trade services simulation builds upon Barclays’ existing engagement with the CDM, including participating in association working groups, hosting industry hackathons [6, 9], and producing an architecture report [18]. We hope this paper will contribute to the design landscape for post-trade infrastructure and look forward to continuing industry collaboration on suitable architectures and the CDM.
2 The ISDA Common Domain Model

In this section, we provide an overview of the structure of the CDM with the intention of providing relevant background knowledge for the subsequent implementation.

2.1 Scope and Aim of the CDM

ISDA, the International Securities Lending Association (ISLA), and the International Capital Market Association (ICMA) signed a memorandum of understanding [16] in August 2021 “to strengthen collaboration on the future development of the CDM” with the aim of establishing a “single, common digital representation of trade events and actions across the lifecycle of financial products”.

The scope of the CDM has expanded from its initial focus on OTC derivatives in 2018 [17] to a much larger remit including “OTC derivatives, cash securities, securities financing, and commodities” [21]. The CDM remains an open collaborative standard with the expectation that other standards setters and associations will join with ISDA, ISLA and ICMA in future.

2.2 Structure of the CDM

The CDM is defined in a domain specific language (DSL) called Rosetta [22]. Code generators are available to convert source code (written in the Rosetta DSL) to other computer languages (such as Java, Go, and DAML) so that users can adopt the CDM and build applications on top of it in the language of their choice. CDM data structures largely mirror their corresponding types in FpML but, in some cases, the model has been amended following the advice of ISDA working groups.

The goal of a single domain model is an ambitious objective, so it is important that the CDM’s structure be flexible enough to accommodate the diversity of the financial products in scope. In the following subsections, we briefly summarise the seven modelling dimensions of the CDM, comprising three main dimensions (Product, Event, Process) and four other dimensions (Legal Agreement, Reference Data, Namespace, Mapping) [21, 24].

2.2.1 Product Model

In the CDM product model, the TradableProduct type represents an executable financial product. It contains all of the associated data required for a trade including Counterparty information, details of the Product itself, the PriceQuantity, etc.

In the CDM, the qualification of a Product occurs by inferring its type from its constituent components. For example, a Product containing two InterestRatePayout objects could be inferred to be a vanilla swap, whereas if it contained an InterestRatePayout and an EquityPayout then it could be inferred to be an equity swap instead.

The composition of CDM components permits a high level of component reusability and qualification by inference provides flexibility (because the product model does not necessarily need to be coupled to a specific naming convention or taxonomy).

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1The Legend platform, hosted by the Fintech Open Source Foundation (FINOS), can also be used for CDM development [10].

2The Java distribution of the CDM is complete. Other distributions capture the data types and data structures of the whole model but, in some cases, do not contain all the functional specifications. [21].
2.2.2 Event Model
The CDM event model provides data structures to represent all possible lifecycle events for a trade. It is organised into a four level hierarchy:

- **Workflow.** Represents a set of actions that are required to trigger a business event. Applications can trigger business events directly or use workflows.

- **Business Event.** Represents an atomic lifecycle event of a trade, comprising one or more primitive events which must either all occur or none occur. For example, a partial novation business event must have both a ContractFormationPrimitive and a QuantityChangePrimitive occur. The qualification of the type of a business event is inferred from the primitive events it contains, similar to the process for products.3

- **Primitive Event.** Defines an atomic change of state for a trade and is a building block component intended to form part of a business event. Each primitive event contains a “before” and “after” TradeState permitting tracking of the lineage of the trade’s state.

- **TradeState.** Represents the state of a trade throughout its entire lifecycle. The TradeState itself contains a TradableProduct, linking the event model to the product model.

2.2.3 Process Model
The CDM process model provides standardised representations of industry processes such as trade execution, confirmation and settlement.4 For each process, the CDM leverages the function component of the Rosetta DSL to provide executable code for: (i) validation, (ii) calculation (where applicable), and (iii) event creation.

Each function takes a CDM object as input and returns a CDM object as output.5 This results in a standardised application programming interface (API) for automating trade processing and increases the interoperability of components built using the CDM.

2.2.4 Legal Agreement
The CDM provides a digital representation of all types of ISDA documents (including Master Agreement and Credit Support documentation) and business events are defined so that they can reference the legal agreement(s) that govern them. Although not used in our implementation, it should be noted that, by having digital representations of the ISDA legal agreements, there is opportunity to increase efficiency in future legal and collateral workflows that adopt the CDM.

2.2.5 Reference Data
The reference data component contains definitions for parties and legal entities.

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3In some cases, it may also be necessary to specify a relevant “intent” qualifier to aid qualification.
4For the full list of processes in scope, see the “coverage” section of the CDM documentation [20].
5Some functions may also have additional basic types as input/output such as numbers, boolean values, etc.
2.2.6 Namespace
The Rosetta DSL files are organised into a hierarchy of namespaces intended to provide greater modularity to the CDM. Components can reference each other from anywhere in the model and the partitioning of components into namespaces has the added benefits of shielding them from changes to each other and aiding understandability.

2.2.7 Mapping (Synonym)
The CDM defines synonym mappings between itself and existing standards, such as FpML, FIX, and ISO 20022. These mappings aid in supporting both legacy applications and newer “CDM native” applications, as well as increasing interoperability.

3 Lifecycle of an Interest Rate Swap
In this section, we provide a high level overview of the lifecycle of a fixed versus floating interest rate swap from execution to maturity, as an introduction to the use case selected for our simulation. We chose an interest rate swap over other types of derivatives, because it is a simple, well understood product that comprises the majority of the over-the-counter (OTC) derivative market.

A vanilla fixed versus floating interest rate swap is an agreement to exchange future cash flows based on a fixed rate of interest with future cash flows based on a floating rate of interest, with the main purpose being to support risk management by institutions such as banks, brokers, dealers and corporations. The condensed lifecycle summary which follows is drawn from the descriptions found in [4], [5], [2], [26], and [3].

3.1 Execution
The execution of a swap occurs when the trade’s economic terms (and, optionally, specific non-economic reference data) are agreed between both parties. Executions largely occur through telephone calls (voice) or through an electronic communication network (ECN).

The typical economic terms that are required to be captured include: (i) the notional amount, (ii) the trade execution and termination dates, (iii) the fixed interest rate, and (iv) the floating rate index plus its tenor. In the case of a vanilla interest rate swap, many of the additional economic terms are inferable using market conventions.

The additional step of allocation, where the trade is assigned to the legal entity (or sub-account of the legal entity) which will actually own it, takes place either with the execution or afterwards during the post-trade process.

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6 The namespace hierarchy can be viewed graphically by browsing the CDM using the Rosetta portal [23].
7 We ignore pre-trade activities such as counterparty onboarding and compliance checks as well as issues related to margin and collateral.
8 In 2019, interest rate swaps were reported to account for approximately sixty percent of the total gross notional volume of OTC derivatives [11].
9 An execution could potentially occur using other methods such as post, email, or in person meetings but these occur less frequently.
10 Specific economic terms (such as the day count conventions, holiday calendars, and the spot lag) can be inferred by market conventions [13].
3.2 Post-Trade

3.2.1 Trade Capture

A “trade ticket” is created in the relevant post-trade processing system following the successful execution of a trade. If the execution took place on an ECN then the ticket details could potentially be populated automatically, whereas a voice executed trade would usually require some form of manual input. Following the initial trade capture, the trade will also be validated against a known set of rules and enriched with additional details (such as settlement instructions) which are necessary for further processing.

3.2.2 Matching and Confirmation

For a bilaterally executed trade, once the trade details have been captured, both parties must then attempt to match their respective views of the trade against each other on an electronic matching platform. After matching takes place, they must then confirm that the recorded terms are accurate between them. In contrast, when a trade has been executed on an ECN platform, the platform will use its straight-through processing systems to handle the matching and confirmation automatically.

The confirmation is the agreement of both parties to the terms of the trade. The interest rate swap will have an associated schedule of dates on which floating rate resets and payments (discussed below) are triggered and its lifecycle continues until termination.

3.2.3 Floating Rate Reset

The payment amount for each cash flow is calculated using the economic terms for the relevant “leg” of the trade, with one of the key details being that particular period’s associated interest rate. For the fixed leg, this rate is established when the trade is executed and the value remains constant. For the floating leg, the rate is reset to the value which is observed on the dates specified in the trade’s schedule. Once reset, the rate remains fixed for the next period.11

3.2.4 Clearing and Settlement

The trade’s schedule dictates the dates on which payment obligations are due and must be settled between the parties in the swap. “Clearing” denotes the process of performing all of the required activities prior to the settlement and “settlement” refers to the actual discharge of the contractual obligation (the payment) which, once performed, is irrevocable.

Depending on the agreement between the counterparties, the clearing process could potentially involve, among other things, the netting, transmission, reconciliation and in some cases the confirming of payment order instructions prior to the establishment of the final positions for settlement.

Clearing is either “bilateral” or “central” with the former referring to the process being performed directly between the parties to the trade and the latter referring to the process in which the original trade is replaced by two new trades which contain the same economic terms but with the parties now facing off to the central counterparty instead.12

11 The terms “reset” and “fixing” are sometimes used interchangeably to refer to this process.
12 In practice, the term “clearing”, unless explicitly qualified, typically refers to central clearing.
3.3 Maturity

In the case where one of the parties to the trade would like to exit their position prior to the maturity date (an “early termination”), they could potentially elect to perform an amendment, cancellation, offset or unwind of the trade. Otherwise, at the point of the final payment of the swap, all contractual obligations are discharged and the interest rate swap is matured/terminated.

4 Design

In this section, we start by comparing a typical current post-trade services architecture with the proposed future state architecture that we simulated. We then discuss the key requirements for our simulation and the design patterns that were adopted.

4.1 Comparison of Post-Trade Services Architectures

![Current State Diagram]

**Figure 1:** Current state - a typical post-trade services architecture.

![Future State Diagram]

**Figure 2:** Future state - a central utility post-trade services architecture using the CDM.
Figure 1 illustrates a typical current post-trade services architecture in which a broker-dealer interacts with a financial market infrastructure (FMI). Both parties utilise their own data models internally and therefore they must convert messages to a data interchange format prior to sending them and also convert to their own internal data format subsequent to receiving them.

The broker-dealer’s applications can communicate with multiple trade stores containing data that may be partitioned or replicated, and therefore may require reconciliation. Additionally, reconciliation is also typically required between between the trade stores of the FMI and the broker-dealer to ensure consistency.

In contrast, Figure 2 illustrates the central utility architecture in which both the FMI and broker-dealer utilise the CDM and, as a result, there is no requirement for translations between data formats. The FMI hosts an ADS that contains all of the associated lifecycle event data for trades. Broker-dealers can replicate the relevant authoritative data from the ADS into their own local store, which can then be read by local applications.

4.2 Requirements

Our simulation adopted the architecture illustrated in Figure 2 and simulates the lifecycle of an interest rate swap from execution to maturity. It comprises a central utility (hosting an ADS) and broker-dealers, with all components using the CDM natively. Given that the processes in post-trade services will be simulated, we refer to our complete system as a “trade services simulator”. The following components are required:

- A centralised utility which acts as the FMI of the network, providing services for trade submission (execution) and consent (confirmation), as well as performing the actions required during the trade lifecycle (rate fixing and payments). Additionally, the FMI hosts the ADS containing the definitive record of the history of all trades.

- A network operator which manages the processes of onboarding and offboarding participants on the network, and an associated identity registry of counterparties. The network operator functionality can be performed by the FMI, or an alternative entity.

- A simulator “harness” containing a virtual network clock, whose time can be adjusted, and an associated scheduler which can trigger business events. A interest rate swap can be active for many years and, as such, the simulator harness is a key component which allows the full trade lifecycle to be performed on demand and within a practical time period.

- A user interface allowing users to issue commands and queries to components in the system. For example, confirming that trade details are accurate or querying the FMI for the latest details of a trade.

Note that netting and collateral management are out of scope for this trade services simulator.

\[\text{This architecture was introduced in our previous paper as “scenario 4” [18].}\]
4.3 Design Patterns

A simulation of the lifecycle of an interest rate swap within a network of market participants is a complex system. To tame this complexity, we adopted several suitable architectural and software design patterns, which are discussed in the subsections below.

4.3.1 Domain driven design (DDD)

DDD\(^{14}\) is a software development approach in which the structure of the software matches the business domain \([8]\). Developing software using DDD requires continually evolving your *domain model* such that it always remains an accurate representation of the real-world processes in your domain.

A *ubiquitous language* which is unambiguous and well understood within the domain is used by both business experts and developers. Additionally, significant actions which can occur within the domain are modelled as *domain events*.

There is an explicit distinction made between *value objects*, which are defined by their attributes, and *entities*, which are defined by their identifier.\(^{15}\) Value objects and entities can be bound together to form an *aggregate*, and other domain objects can only refer to them through the identifier of the entity which is designated as the *aggregate root*.\(^{16}\) The aggregate itself is the boundary for consistency, and changes in state are applied such that invariants of the aggregate are always maintained. Retrieval of aggregates occurs through the use of *repositories* which fetch them from a store based on their unique identifier.

In our case, our domain is that of post-trade processing and a significant amount of the representation of the domain model is already provided by the CDM itself. As discussed in section 2.2, not only does the CDM provide representations for financial products and business events, it goes further and provides representations of post-trade processes as well. As a result, the CDM and DDD together make a complementary pairing for our design and implementation.

4.3.2 Event sourcing (ES)

Event sourcing is a data storage pattern in which changes to an application’s state are captured as events which are committed to an append-only event store \([14]\). The store is always the authoritative source of truth for the system and provides a complete audit trail of all events. The events can also be reprocessed at anytime to recreate the current state of the system.

The CDM already implements a form of event sourcing by tracking the effects of applying business events in a “before” and “after” lineage contained within the event itself. This provides the benefits of both traceability and visibility of state changes. By adopting the event sourcing pattern more widely, we can reap the associated benefits throughout the entirety of the system and not just those parts which utilise the CDM.

\(^{14}\)*DDD terms are *italicised* in the following description.*

\(^{15}\)An example of a value object is a date - it is uniquely identifiable by its attributes (year, month, day) and two variables containing the same date can be considered to be equal. An example of an entity could be a book in a library - two instances of the exact same book would not be considered as equal because they will have separate inventory identifiers/asset tags.

\(^{16}\)An example of an aggregate could be a trade within the CDM - the trade itself could be made up of several value objects and entities (e.g. payouts, parties, etc), and all other objects can only refer to the trade through its unique identifier (the root).
4.3.3 Command and query responsibility segregation (CQRS)

CQRS is an architecture pattern which separates the handling of commands, which write data and mutate state, and queries, which read data and do not mutate state [12].

Events which are published by the command side are processed by the query side, which maintains its own relevant “projections” of them into the desired view model. This introduces complexity because two models (command/query) must be maintained instead of one, and the synchronisation of projections results in an eventually-consistent query side.

However, the benefits of using CQRS outweigh the drawbacks, especially given the complicated domain of post-trade services. CQRS gives us the ability to: (i) develop components which are optimised for a single purpose (command/query side), (ii) separately deploy and scale the command and query sides based on their respective demand, (iii) select the most appropriate storage solution for the command and query sides,¹⁷ and (iv) develop queries and projections for reports or other data on an ad-hoc basis instead of requiring their specification in advance.

4.3.4 Message driven architecture (MDA)

A message driven architecture is a pattern in which components within a system communicate with each other asynchronously through three types of message: commands, events, and queries. A command message is a request for the system to perform some action (usually to mutate state), an event message is a notification of an action having occurred (state having been mutated), and a query message is a request for data to be returned to the sender.

Commands must be routed in a point-to-point manner from the component which is requesting the state change directly to the DDD aggregate which it targets. The aggregate itself must define a valid command handler for that particular command. The handler can then either fail (for whatever reason) and raise an exception, or succeed and publish one or more events which are then persisted on the event log and distributed to any event listeners.

In contrast to commands which are routed point-to-point, events follow the publish-subscribe routing pattern where listeners receive published events without necessarily knowing anything about the publisher itself. This allows us to specialise parts of our system to follow an event driven architecture with loose coupling as required.

5 Implementation

In this section, we describe the technology stack, the architecture, and implementation details for each of the four components of the system described earlier in section 4.2.

5.1 Technology Stack and Architecture

The simulator is a loosely coupled system capable of managing the entire interest rate swap lifecycle to maturity. It coordinates this through the mechanics of command processing and event listeners, together with simulating moving forward through time.

We chose Java [19] as the main programming language (together with the open-source Spring Boot [28] and Axon [1] frameworks) for development of our backend services because of its complete integration with the CDM and our team’s existing familiarity with the language.

¹⁷For example, in the CQRS architecture we adopted for the FMI we used an event store for the command side and a relational database for the query side.
Spring Boot provides a rich environment of pluggable components for testing, database connectivity and creating web endpoints, while the Axon framework provides building blocks for the DDD, ES, CQRS, and MDA design patterns previously described in section 4.3.

For the simulation, the backend data stack includes PostgreSQL [27], an open-source relational database, and Axon Server\textsuperscript{18} [1], which acts as an event store. Axon Server also acts as a message router for the system, simplifying the architecture by removing the need for additional message-broker/queue infrastructure.

The frontend user interface uses the Vue.js [29] JavaScript framework, which was selected over alternatives (such as Angular and React) because of its relative simplicity.

Figure 3 illustrates the component architecture of the post-simulator and the implementations of each of the constituent components are summarised below.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{componentarchitecture.png}
\caption{Component architecture of the post-trade services simulator.}
\end{figure}

\textsuperscript{18}Our simulation uses the open-source standard edition of Axon Server.
5.2 Network Operator

In the network operator, a “registry manager” service exposes public interfaces to create, read, update, and delete (CRUD) counterparties on the network, and a traditional relational database (PostgreSQL) stores the counterparty data.

Users can utilise the Web UI to perform the required CRUD operations to ensure that their required counterparties are present on the network. In a real-world network, it is likely that the FMI would act as the network operator, including hosting and managing the relevant services.

5.3 Web Based User Interface (UI)

The web based UI contains four webpages which can be used to query the current state of the system and to issue commands: simulator harness, network, interest rate swap execution, and blotter. The UI allows the user to, for example, take the role of a broker-dealer via the execution and blotter pages.

The simulator harness webpage provides functionality to start a new simulation, erasing any pre-existing data. It can also be used to create a new clock for the current simulation and initialise its date and time. The network webpage allows the user to interact with the registry manager CRUD service to create, read, update, or delete parties from the network. The interest rate swap execution webpage allows the user to submit a new trade execution to the FMI.

The fourth and final webpage, the blotter, communicates with the FMI’s public query service and displays key trade data including economic terms, open actions, and cashflow details. If an open action exists, for example the need to confirm an execution, then the webpage gives the user the option to respond and close the action.

The header on the blotter webpage displays three widgets, as shown in Figure 4. The first widget, the clock, interacts with the simulation clock backend service to: display the current simulator time, provide a “forward” button which moves time forward to trigger the next open deadline, and provide a “play” button which continues moving time forward until no open deadlines remain.

A “deadline” is the term used within the simulator to refer to a point in time when a trade business event should be triggered. The second widget displays the name and time that the next open deadline should be triggered. In this example, on the 17th December, there is a floating leg payment which needs to be triggered, and clicking the forward button on the clock widget would move time forward to this date.
The final widget is the event stream which shows the last twenty-five events which have occurred in the current simulation run. In this particular case the filter is selected so that only CDM events are displayed and other simulation events, such as the clock moving forward in time, are not shown. The first column is the number of the event in the stream, the second column is the name of the simulator event, and the last column is the underlying CDM event which it represents. The underlying CDM event is wrapped into a simulator event so that it is in a form which can be routed to other event listener components within the system. A description of each of the different types of CDM events is provided in Table 1.

5.4 Simulator Harness

The harness component of the simulator comprises two services which persist their data to a PostgreSQL relational database. The first service, the simulation clock, exposes public CRUD endpoints which are then utilised by the UI to set the time and date of the simulation clock.

The second service, the scheduler, registers itself as a listener for all events which require an action to be scheduled in the future and also as a listener for any clock change events so that the scheduler can remain synchronised with the simulation clock. At the point when the clock’s time advances on or beyond the same time as a scheduled action, it publishes an event to indicate that the scheduling threshold has been breached and the action should take place. The lifecycle event initiator service in the FMI listens for these types of events and reacts by triggering the relevant trade lifecycle event.

5.5 Financial Market Infrastructure

The FMI provides the key trade services within the simulator. Its use of the CQRS pattern can be seen in Figure 3 with each of the FMI’s subcomponents segregated into either the command side or the query side. A newly executed trade can be submitted to the FMI’s submission service using the interest rate swap execution webpage in the UI. The user can then view the trade on the blotter webpage and issue a command (that is routed to the FMI’s consent service) to confirm or reject the accuracy of the trade details. These two services, submission and consent, manage the trade’s execution and confirmation lifecycle steps respectively.

Each of the commands that are issued are placed on the command bus which routes them to the correct instance of the interest rate swap aggregate based on the trade identifier. The aggregate contains the core business logic that validates that the command is executable, and publishes event(s) indicating that the state has been successfully changed.

A number of events are published when the trade is confirmed, including those indicating the dates on which future rate fixings and payments should be scheduled. Published events are placed onto the event bus which persists them in the event store and then routes them to any simulator component which is listening for those types of events.

The query side projector service listens for relevant events and reacts to them by maintaining its materialised views\(^1\) in the PostgreSQL projection store. Additionally, the simulator harness scheduler listens for any specific scheduling events which it will need to manage. The scheduler remains synchronised with the clock and each time the clock crosses a time threshold it publishes an event to trigger the occurrence of the relevant business event by the FMI.

The FMI’s lifecycle event initiator service listens for these types of events and triggers either a rate fixing or payment to be made as a response. The rate returned from a rate fixing

\(^{1}\)A materialised view is a logical data view which is persisted to a database table.
is currently set to be a randomly generated number, and settlement of a payment is managed by a payment aggregate which currently only simulates the action. However, the interfaces for these actions are clearly defined and the current implementations could potentially be swapped in future for ones which perform the genuine action.

5.5.1 CDM usage

The FMI manages the interest rate swap aggregate and makes extensive use of the CDM. The CDM product model, with the root component being the TradableProduct type, is used to define an interest rate swap and its EconomicTerms.

Table 1 describes the four business events (from the CDM event model) which occur during the lifecycle of the interest rate swap and are used by the FMI.

| CDM Business Event       | Description                                                                 |
|--------------------------|-----------------------------------------------------------------------------|
| Execution                | Contains a trade whose EconomicTerms are waiting to be confirmed by the two parties. |
| ContractFormation        | Contains an executed trade which has been confirmed by the two parties.       |
| Reset                    | Contains a trade whose last event was a reset of the associated rate within the floating rate payout. |
| CashTransfer             | Contains a trade whose last event was a transfer of a cash amount between the two parties. |

Table 1: CDM business events for an interest rate swap.

Integrating the CDM process model is not straightforward because it is necessary to determine whether the default function implementation(s) in the CDM distribution will suffice for the given use case or whether further customisation is required.

For our simulator, the FMI contains a customised implementation of a business event creation function for each business event described in Table 1. These in turn make use of the default CDM implementations for generating the event primitives that are contained within the final business event. When the specific point in the trade’s lifecycle is reached, the correct function is invoked and a validated and qualified business event of that type is created.

Additionally, the FMI contains a custom implementation of the ResolveObservation function which is invoked when an observation of the underlying reference rate for the floating leg needs to be made.

6 Architecture Analysis

The three fundamental problems facing the post-trade industry were summarised in [18] as being inconsistent processes, inconsistent data, and duplicated data. Developing a working implementation of the system illustrated in Figure 3 has provided insights on how these industry problems could be addressed by using an authoritative data store with the CDM.

In our simulation, processes cannot be inconsistent because they are defined by the CDM and implemented by the FMI, which drives adoption by the broker-dealers, thereby removing any potential for variation. Similarly, data cannot be inconsistent because the CDM provides common definitive representations of business events and data, and all market participants use
the same authoritative data store. This authoritative data store also removes inefficiencies, such as reconciliation, resulting from trade data being duplicated across multiple locations.

The simulated future state architecture is also less complex than a typical current state architecture, as can be seen by comparing Figures 1 and 2. The encapsulation of almost all of the trade processes within a single entity (the FMI utility) is more efficient than each of the broker-dealers performing those processes themselves. This provides an opportunity for rationalisation of hardware/software infrastructure and cost reduction.

By utilising the CDM throughout the system, we avoid issues associated with standards proliferation, such as the need to maintain mappings, the challenges with interoperability, and the potential risk of data loss. In contrast, note that a typical trade flow could currently be “executed using the pre-trade FIX protocol (with an FpML payload representing the product), confirmed electronically using FpML as the contract representation, and reported to a Trade Repository under the ISO 20022 format” [21].

7 Summary and Further Work

This paper provided an overview of the design and implementation of a simulation of post-trade services for interest rate swaps, from execution to maturity. We began by presenting the scope, aim and structure of the CDM. We then summarised the lifecycle of an interest rate swap including the stages of execution, matching, confirmation, floating rate reset, clearing, settlement and maturity.

We then moved on to compare our simulated future state architecture for trade services with a typical current state architecture. Next, we presented the key requirements of the system and several suitable design patterns which we adopted. We then summarised the implementation including the technology stack, the architecture, and details of for each of the components of the system.

Finally, we briefly analysed the simulated architecture by considering how it addressed the three fundamental problems facing the post-trade industry. This included using the CDM to address the industry problems of inconsistent processes and inconsistent data, and using authoritative data stores to address the industry problem of duplicated data. We also highlighted the opportunity for this less complex architecture to rationalise infrastructure and reduce costs in the post-trade industry.

We have demonstrated that the CDM is capable of modelling the entire lifecycle of a trade from execution to maturity and can report that our exploration of the central utility architecture has validated the opportunity for simplification of the post-trade industry.

Potential further work includes incorporating legal agreements into the simulation’s workflows, storing supplementary private data for a trade in the ADS, and providing digital regulatory reporting. We look forward to continuing industry collaboration on the CDM and opportunities to improve the post-trade industry.

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References

[1] AxonIQ. Axon Reference Guide. https://docs.axoniq.io/reference-guide/, 2021.

[2] Robert P Baker. The Trade Lifecycle: Behind the Scenes of the Trading Process. John Wiley & Sons, 2015.

[3] Bank for International Settlements (BIS). A glossary of terms used in payments and settlement systems. 2013.

[4] Bank of England. The Future of Post-Trade: Findings from the Post-Trade Technology Market Practitioner Panel, 2020. https://www.bankofengland.co.uk/-/media/boe/files/report/2020/the-future-of-post-trade-report.pdf.

[5] J.H.M. Darbyshire. The Pricing and Trading of Interest Rate Derivatives: A Practical Guide to Swaps. Aitch & Dee Limited, 2016.

[6] Deloitte. Future of post trade - shifting the cost curve, 2019. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/financial-services/future-of-post-trade.pdf.

[7] Michael Durbin. All about derivatives. McGraw-Hill, 2nd edition, 2011.

[8] Eric Evans. Domain-driven design: tackling complexity in the heart of software. Addison-Wesley Professional, 2004.

[9] EY. How financial services can accelerate the adoption of the ISDA Common Domain Model (DerivHack 2019). https://www.ey.com/en_gl/banking-capital-markets/how-financial-services-can-accelerate-the-adoption-of-the-isda-common-domain-model, 2019.

[10] Fintech Open Source Foundation (FINOS). The FINOS Legend Studio Pilot: an Open Source Success Story in Financial Services (Case Study). https://www.finos.org/hubfs/FINOS/assets/FINOS%20Legend%20Case%20Study%202021.pdf, 2021.

[11] Silvia Dalla Fontana, Marco Holz auf der Heide, Loriana Pelizzon, and Martin Scheicher. The anatomy of the euro area interest rate swap market. https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2242-b1f459eb90.en.pdf, 2019.

[12] Martin Fowler. CQRS. https://martinfowler.com/bliki/CQRS.html, 2011.

[13] Marc Henrard. Interest rate instruments and market conventions guide. OpenGamma Quantitative Research, 2013.

[14] IBM. An introduction to event sourcing. https://developer.ibm.com/articles/event-sourcing-introduction/, 2019.

[15] International Swaps and Derivatives Association. ISDA CDM Factsheet, 2018. https://www.isda.org/a/z8AEE/ISDA-CDM-Factsheet.pdf.

[16] International Swaps and Derivatives Association (ISDA). ISDA, ICMA and ISLA Sign MoU on the Common Domain Model. https://www.isda.org/2021/08/02/isda-icma-and-isla-sign-mou-on-the-common-domain-model/, 2021.
[17] ISDA. ISDA Publishes Digital Iteration of the Common Domain Model. https://www.isda.org/2018/06/05/isda-publishes-digital-iteration-of-the-common-domain-model/, 2018.

[18] Aishwarya Nair and Lee Braine. Industry Adoption Scenarios for Authoritative Data Stores using the ISDA Common Domain Model. 2020. https://arxiv.org/pdf/2007.06507.pdf [To appear in the Journal of Financial Market Infrastructures].

[19] Oracle Corporation. Java 16 Release Notes. https://www.oracle.com/java/technologies/javase/16-all-relnotes.html, 2021.

[20] REGnosys. CDM Process Model - Coverage. https://docs.rosetta-technology.io/cdm/documentation/source/documentation.html#coverage, 2021.

[21] REGnosys. Overview of the ISDA CDM. https://docs.rosetta-technology.io/cdm/readme.html, 2021.

[22] REGnosys. Rosetta DSL. https://docs.rosetta-technology.io/dsl/index.html, 2021.

[23] REGnosys. Rosetta Portal. https://ui.rosetta-technology.io/, 2021.

[24] REGnosys. The Common Domain Model - Modelling Dimensions. https://docs.rosetta-technology.io/cdm/documentation/source/documentation.html, 2021.

[25] Jana Sacks. Elementary financial derivatives: a guide to trading and valuation with applications. John Wiley & Sons, 2015.

[26] Khader Shaik. Managing derivatives contracts: A Guide to derivatives market structure, contract life cycle, operations, and systems. Apress, 2014.

[27] The PostgreSQL Global Development Group. PostgreSQL: The World’s Most Advanced Open Source Relational Database. https://www.postgresql.org/download/, 2021.

[28] VMware, Inc. Spring Boot. https://spring.io/projects/spring-boot, 2021.

[29] Evan You. Vue.JS Guide. https://vuejs.org/v2/guide/, 2021.