ISDA Safe, Efficient Markets

October 31st, 2017

Request for quotations for data analysis and production of digital artefact for ISDA Common Domain Model

The International Swaps and Derivatives Association, Inc.[1] ("ISDA") is seeking an approach and quotations from qualified parties to conduct data analysis and production of a digital artefact in relation to the ISDA Common Domain Model[2] ("ISDA CDM") for its ISDA CDM design working group which is developing said model.

The primary goal of the ISDA CDM design working group (henceforth the "group") is to define a standard representation of derivatives trade events, that are asset class and product agnostic, and develop a common domain model ("ISDA CDM" or the "model") across transaction and legal agreement data required for processing of such events.

To achieve the proposed goal, the model will be defined as a collection of events with product data elements expressed in a hierarchical structure. This structure will be validated across variations in product classes, reinforcing the model in the process.

The standardized model will be realized as a single, shared artefact across impacted parties with process automation of embedded events. The shared artefact will encompass data and process standards being defined as part of the domain model standardization.

On course to develop the conceptual version 1.0 of the model, the group has completed an initial collection and analysis of events and defined the initial event model (these events are gathered under Independent and Dependent Events sections of Appendix), now ISDA would like to engage a third party (the "vendor") to perform the analysis exercise to collect product data elements into the hierarchical product models proposed in the conceptual verison 1.0 of the ISDA CDM (see Products section of Appendix for more information). The FpML data standard has been identified as a reliable source of product data elements to build the initial hierarchical models from. The focus of the group so far has been specifically on the interest rates and credit asset classes, ergo the interest rates and credit FpML schemas will be the initial focus of the analysis work but the work is not limited to those asset classes.

[1] Since 1985, ISDA has worked to make the global derivatives markets safer and more efficient. Today, ISDA has more than 875 member institutions from 68 countries. These members comprise a broad range of derivatives market participants, including corporations, investment managers, government and supranational entities, insurance companies, energy and commodities firms, and international and regional banks. In addition to market participants, members also include key components of the derivatives market infrastructure, such as exchanges, intermediaries, clearing houses and repositories, as well as law firms, accounting firms and other service providers. Information about ISDA and its activities is available on the Association's web site: www.isda.org.

[2] ISDA CDM documents are published by the International Swaps and Derivatives Association, Inc. (ISDA) and are protected by copyright and other proprietary intellectual property rights.

In tandem with the product data analysis and modelling work, the vendor will provide ISDA with a digital artefact, an executable digital representation (e.g. using JSON objects or similar) of version 2.0 of the ISDA CDM, including both the hierarchical product model which it has built, and also the event model.

Generally, the vendor will be expected to operate in agile manner fully engaged with the group and structure work to have weekly (or similarly frequent) deliverables in line with suggested requirements and deliverables below.

(*Please treat requirements and deliverables as indicative for the purposes of vendor selection, final plan and deliverables to be agreed when vendor is selected.*)

Requirements and deliverables for this approach and quotation:

I. Digital representation[3] of ISDA CDM in a digital artefact,
consisting of a, b and c:
   a. Hierarchical product model based on FpML Schemas and ISDA Definitions
      - Composable product models from FpML (under auspices of FpML Standards Committee) based on hierarchical approach detailed under Products section of Appendix using JSON objects or similar.
      - Digitizing the necessary standardized ISDA definitions (found in ISDA's documentation) for product intrinsic events such as schedule, rate, interest , calculations, and so on, to build out the product models
      - Approach - proceeding as follows:
         1. Firstly provide a digital process to build product models from FpML schema for interest rates and credit default swaps (CDS).
         2. CDM design & FpML Standards Committee decides how to model product (following concepts presented initially in ISDA CDM version 1.0 definition document & detailed under Products section of Appendix) then the vendor codes the product model building from FpML schema (i.e. mapping FpML to new persistence model objects)
   b. Event model initially based on primitive events in ISDA CDM version 1.0 conceptual definition document which are listed below and detailed in Appendix
      - Independent Events
         - New
         - Terminated for Cash
         - Amend
         - Split (Allocation)
         - Partial Termination
         - Full Assignment
         - Partial Assignment
         - Cancel
         - Clear
         - Intermediation (Prime Brokerage)
         - Aggregation
         - Tear-up/Portfolio Compression

[3] Extensible framework for the model in digital form (e.g. using JSON objects or similar)

- Dependent Events
  - Observations
  - Exercises
- Approach:
  1. Produce functional definitions (non-implementation specific, using JSON objects or similar) to represent the events listed above and event processing approach found in ISDA CDM version 1.0 conceptual design and for reference as detailed in Appendix which will be used to model basic business use cases

c. Model of container for aggregation/portfolio processing
   - Propose approach to model to support aggregations by transaction attributes within model (see *Fractal Symmetry - Product Example* in Appendix)

II. Proposed pricing
   a. The project is expected to iterate through existing product definitions across asset classes. Responses should include cost of delivery for initial product/asset set and estimates replicating the process across other products.
   b. To allow expansion of scope quickly – a series of proposed milestones and deliverables with proposed payment terms related to each from the vendor is preferred.

II. Resources and engagment plan
   a. In defining expected approach the vendor should provide details on the following aspects of their plan
      - The resources the vendor expects to deploy on the project, including, the resource profile, roles they will play on the project, and summary of relevant experience.
      - The software tools which will be employed and whether those tools are open sourced or proprietary.
      - If the analysis and model production is to be automated by software.
      - The vendors' expectations for engagement with ISDA, FpML and their members and resources they are expected to make available to the vendor.

III. Proposed timeline
   a. 1 month to develop a working prototype of model (e.g. digital form of the interest rate swap example from FpML interest rates schema and some core events: *New,Terminate for cash*, *Split/Allocate;* as detailed in Appendix)
   b. Concurrently, 3 months to complete foundational elements of model (i.e. the product model I. a and event model I. b.) for interest rates cleared, non-cleared, and credit derivatives from the interest rates and credit schemas respectively.
   c. Other asset classes will also be completed concurrently if resources allow

The vendor will be subject to appropriate non-disclosure provisions with respect to all aspects of its work with ISDA, including, but not limited to, the digital artefact/representation of the ISDA CDM delivered by the vendor, the data and materials provided by ISDA members, the ISDA CDM Design working group, and ISDA. The vendor would be required to execute ISDA's standard intellectual property and confidentiality agreements. Please note that all intellectual property in the work conducted by the vendor will be owned by or assigned to ISDA.

To aid development of approach and quotations, ISDA would invite prospective vendors to read , review and provide comments and questions on the ISDA CDM version 1.0 conceptual model document [found

here on ISDA's website] sections of which are found in Appendix. Additionally, ISDA will host open information sessions with prospective vendors to allow vendors the opportunity to ask questions or obtain additional information which will aid their response to this request. To be involved in these information sessions, please contact ISDA at MarketInfrastructureandTechnology@isda.org as soon as possible.

Finally, if your firm would like to be considered by ISDA to conduct this work, please provide any relevant information regarding your firm's knowledge of ISDA CDM and specific qualifications to perform this exercise, along with an approach and quotation for your fees MarketInfrastructureandTechnology@isda.org no later than November 28th 2017.

Appendix

Below sections are taken from ISDA CDM version 1.0 conceptual design definition document (Pages 9 - 26)

THE ISDA CDM

The ISDA CDM is built up in stages.

- First, the concept of independent events is introduced (ie, negotiated/advised events/actions).
- Second, the concept of dependent events is introduced. It is shown that the results of dependent events are the same as independent events without the negotiation (the terms are defined elsewhere, in contracts, etc).
- Third, the concept of exchange of value is introduced.
- Finally, the definition of products is introduced and expanded upon.

It is then shown that 'event', 'exchange' and 'product' are tightly related, if not identical. This is the basis of the fractal symmetry – ie, identical structures/processes at different scales. This minimizes the code that needs to be deployed by re-using the code for historically different processes.

Independent Events

The objective of this section is to define a primitive set of operations that exist on S= [P_1, P_2, Q, (E)]. The key point is the before and after events are a collection in space S.

The first set of events are independent in that they have to be negotiated (ie, priced/quoted) or advised.

Although an interest rate swap (IRS) is shown for illustrative purposes, these operations are independent of the economics (E), and are therefore are applicable to all asset classes.

The events considered are:

- Single events (one-for-one state transition, between before and after);
  - New;
  - Terminate for cash;
  - Amend;
  - Cancel;
- Single events (one before but multiple after);
  - Split (also known as allocation);
  - Partial termination for cash (also known as a decrease; an increase is the logical opposite);
  - Full assignment for cash (full novation);
  - Partial assignment for cash (partial novation);

- Clear*;
- Intermediation* (prime brokerage);

- Multiple events (many to one);
  - Aggregation*;
- Multiple events (many to many);
  - Tear-up*.

** NB: In these events, the re-use of very similar primitive state transitions that have been used in previous events becomes evident.*

New

	Event Identifier	Party	Party	Quantity	Economics	Comments
New						
Before	-o-	-o-	-o-	-o-	-o-	
After	3fb9	P1	P2	Q	IRS(5dc4)	

	Item	Description	Comments
1	Before	Nothing exists '-o-'.	
2	Event Identifier	3fb9 is a hash function result that identifies the event – for example, on a DL.	
3	Economics	IRS(5dc4) is a pointer to an item on the DL that defines the economic terms, dates, etc of the contract.	The definition and example of economics is considered later in this document[10]. Assume here the IRS has no value at inception.

Terminate for Cash

At some point in the future, the parties negotiate to terminate the contract for cash.

	Event Identifier	Party	Party	Quantity	Economics	Comments
Full Term for Cash						
Before	3fb9	P1	P2	Q	IRS(5dc4)	IRS replaced by a termination fee
After	2ef3	P1	P2	c,ccc.cc	Cash	

[10] See Fractal Symmetry

	Item	Description	Comments
1	Before	IRS(5dc4) exists.	
2	Event Identifier	2ef3 identifies the termination event The DL infrastructure joins the before and after events 3fb9 and 2ef3.	
3	Economics	IRS (5dc4) has been replaced by a cash flow of quantity 'c,ccc.cc'. Once the cashflow has settled, there are no remaining contractual obligations between P1 and P2.	This is a negotiated termination – ie, both parties have to agree on cash value.

Amend

The economic terms are changed in some way. However, there is no negotiated cashflow.

There are necessary constraints on this operation that need to be explored further – ie, the intention[11] is to amend the transaction to correct an error. Consequently, it should probably not be possible to change an IRS to an FX option, for example.

	Event Identifier	Party	Party	Quantity	Economics	Comments
Amend						
Before	3fb9	P1	P2	Q	IRS(5dc4)	
After	82ef	P1	P2	Q'	IRS(7dj5)	Economic details of trade are changed

	Item	Description	Comments
1	Before	IRS(5dc4) exists.	
2	Event Identifier		
3	Economics	Q→Q' and IRS(7dj5) represent the change to the IRS contract. DL infrastructure joins the before and after events 3fb9 and 82ef.	There should be restrictions on what can be changed. Also, it is believed, the event should capture intention.

Note: The distinction between 'Amend' and 'Cancel/Correct' does not exist in this definition of before/after states. This is because the linkage (addressing) on a DL is the same for both[12].

[11] The concept of tying intention to events is to be explored further in subsequent versions of the document. Comments on implementations of such event processing would be welcome input to further development of this event model

[12] In conventional relational database management system (RDBMS) technology, the addressing is in terms of elements in a table. This is the root of much of the complexity when multiple RDBMSs have to be kept in sync or events have to be extracted and reported. For example:

- An amend changes a version number but not a trade ID
- Cancel/correct changes trade ID, and therefore there needs to be an explicitly programed mechanism to join the distinct trade IDs

Split (Allocation)

A block trade is executed with a fund manager P2. P2 decides to allocate this trade across two funds controlled by the fund manager.

	Event Identifier	Party	Party	Quantity	Economics	Comments
Split (a.k.a. Allocation)						
Before	3fb9	P1	P2	Q'	IRS(5dc4)	
After	3k9s	P1	P2/a	q1	IRS(5dc4)	Where P2/a and P2/b are 'funds' of P2
After	3k9s	P1	P2/b	q2	IRS(5dc4)	Where q1+q2 = Q

	Item	Description	Comments
1	Before	IRS(5dc4) exists.	
2	Event Identifier	3k9s identifies the event that splits the notional.	
3	Party P2	P2 is a manager of two funds, A and B.	See later for definition of party hierarchy[13].
4	Quantity	The original trade quantity Q is split across the two funds.	
3	Economics	IRS(5dc4) does not change.	

Partial Termination

	Event Identifier	Party	Party	Quantity	Economics	Comments
Part Term						
Before	3fb9	P1	P2	Q	IRS(5dc4)	
After	3k9s	P1	P2	q1	IRS(5dc4)	Only change is quantity
After	3k9s	P1	P2	c,ccc.cc	Cash	Partial termination fee

	Item	Description	Comments
1	Before	IRS(5dc4) exists.	
2	Event Identifier	3k9s identifies the event that splits the notional.	
3	Economics	There is no change in the terms IRS(5dc4).	
4	Quantity	The original quantity is reduced from Q to q1.	
3	Cash	A cash quantity c,ccc.cc is exchanged in for the decrease in quantity of economics (IRS(5dc4)).	The cash consideration for the reduction Q→q1 is a negotiated event.

Note:

- *On a strict delta definition, this is a decrease in one asset (the IRS) and an increase in another asset (cash).*
- *An increase is logically the same but reversed (quantity increases and cash reverses).*

[13] See Fractal Symmetry

Full Assignment

An existing contract is transferred to a new party and a fee is paid.

	Event Identifier	Party	Party	Quantity	Economics	Comments
Full Assign						
Before	3fb9	P1	P2	Q	IRS(5dc4)	An IRS
After	3k9s	P1	P3	Q	IRS(5dc4)	Change of party (P2 --> P3) on IRS
After	3k9s	P2	P3	c,ccc.cc	Cash	Fee between P3 and P2

	Item	Description	Comments
1	Before	IRS(5dc4) exists.	
2	Event Identifier	3k9s identifies an event that records the assignment and associated fee.	
3	Economics	There is no change in the terms IRS(5dc4).	
4	Party	The contract is assigned from P2 to P3.	
4	Quantity	As this is a full assignment, there is no change in quantity.	
3	Cash	A cash quantity c,ccc.cc is exchanged between P2 and P3 to compensate for the change in ownership of the contract.	The cash consideration for the reassignment P2→P3 is a negotiated event.

Partial Assignment

An existing contract is partially transferred for a negotiated fee.

	Event Identifier	Party	Party	Quantity	Economics	Comments
Partial Assign						
Before	3fb9	P1	P2	Q	IRS(5dc4)	An IRS
After	3k9s	P1	P2	q1	IRS(xxxx)	Where Q=q1+q2
After	3k9s	P1	P3	q2	IRS(xxxx)	Change of party (P2 --> P3)
After	3k9s	P2	P3	c,ccc.cc	Cash	Fee between P3 and P2

	Item	Description	Comments
1	Before	IRS(5dc4) exists.	
2	Event Identifier	3k9s identifies an event that records the assignment and associated fee.	
3	Economics	There is no change in the terms IRS(5dc4).	
4	Party	The contract is assigned from P2 to P3.	
4	Quantity	As this is a full assignment, there is no change in quantity.	
3	Cash	A cash quantity c,ccc.cc is exchanged between P2 and P3 to compensate for the change in ownership of the contract.	The cash consideration for the reassignment P2→P3 is a negotiated event.

Cancel

A cancel event should be unusual in normal transactions. However, it is required as part of portfolio events (particularly tear-up transactions).

Cancel doesn't mean that the trade has never existed. It means that it has ceased to exist now.

	Event Identifier	Party	Party	Quantity	Economics	Comments
Cancel						
Before	3fb9	P1	P2	Q	IRS(5dc4)	
After	-o-	-o-	-o-	-o-	-o-	Trade is 'cancelled' - no corresponding cashflow

Clear

	Event Identifier	Party	Party	Quantity	Economics	Comments
Clear						
Before	t73j	P1	P2	Q	[E]	Where P3 is a CCP - Simultaneous novations and removal of any contract terms ([E] -->[E]) offensive to CCP (eg, early termination)
After	t73j	P3	P2	Q	[E]'	
After	t73j	P3	P1	(Q)	[E]'	

May be combined with allocation/split process.

Intermediation (Prime Brokerage)

	Event Identifier	Party	Party	Quantity	Economics	Comments
Intermediate						
Before	t73j	P1	P2	Q	[E]	Where P4 is a prime broker – simultaneous novations and removal of any contract terms ([E] -->[E]) offensive to PB (eg, early termination)
After	t73j	P4	P2	Q	[E]'	
After	t73j	P4	P1	(Q)	[E]'	

Intermediation is basically the same as clearing.

Aggregation

	Event Identifier	Party	Party	Quantity	Economics	Comments
Aggregation						Logically the reverse of a split/ allocation above
Before	3fb9	P1	P2	q1	IRS(5dc4)	
Before	3k9s	P1	P2	q2	IRS(5dc4)	
After	3k9s	P1	P2	Q	IRS(5dc4)	Where Q=q1+q2

Aggregation is logically the reverse of allocation process above.

Tear-up/Portfolio Compression

	Event Identifier	Party	Party	Quantity	Economics	Comments
Tear-up/ Portfolio Compression						This is a set of changes to a portfolio that is risk neutral OR change in risk is compensaed for by a fee (CCY) Bilateral shown – multilateral is logically no different to 'disappear'
Before	gfd4	P1	P2	Q1-99	[E1-99]	
Before	gfd4	P1	P2	Q100	[E100]	
Before	gfd4	P1	P2	Q101	[E101]	
Before	gfd4	P1	P2	Q102	[E102]	
After	gfd4	P1	P2	Q100	[E100]	No change
After	gfd4	P1	P2	Q101-x	[E101]	Decrease
After	gfd4	P1	P2	Q102+y	[E102]	Increase
After	gfd4	P1	P2	Q103	[E103]	New
After	gfd4	P1	P2	c,ccc.cc	CCY	Fee

A tear-up is a portfolio process that aims to reduce the notional value of a portfolio without materially changing the net risk.

The majority of trades are cancelled – there may be a few increases or decreases or the odd new trade. If the risk replication is not exact, then there will be a fee associated with the tear-up/ compression process.

Independent Events Summary

- All events can be expressed in terms of the simple space S=[P_1,P_2,Q,(E)].
- The events are a collection of before and after states.
- The events are agnostic to the definition of economics in (E).
- There are very few events, as the simple space only contains four 'addresses' (strictly three in examples illustrated so far, as P1 does not change in any of the examples above).
- There are three change types (P2→Pn, Q1→Q2 and -o-→ inclusion of a negotiated cashflow).
  - Therefore, the examples logically further reduce to a set of primitive operations.
- Events are symmetrical[14].
  - And therefore are simpler to code and to incorporate an 'un-do' of the event. This implies that the underlying event solution should be very simple and generic.

#	Model event name	Note
1	o New	Single events (one-for-one state transition, between before and after)
2	o Terminate for cash	
3	o Amend	
4	o Cancel	
5	o Split	Single events (one before but multiple after)
6	o Partial termination for cash	
7	o Full assignment for cash (full novation)	
8	o Partial assignment for cash (partial novation)	
9	o Clear	
10	o Intermediation (prime brokerage)	
11	o Aggregation	Multiple events (many to one)
12	o Tear-up	Multiple events (many to many)

[14] This statement may be further explained in a subsequent version of this document

Dependent Events

Derivatives are contingent claims and, as such, have reference to future events. As time passes and these events become present, the crystallization of these events need to be recorded (observed) and the appropriate actions need to be taken.

Generally, observations are currently split into two types:

- Observation of data defined in the contract (eg, a floating rate set, dividend declaration, observation of temperature, etc)[15].
- Observation of a human action required in a contract (eg, exercise notice served on a generic-type option (see below)).

This distinction is not helpful. In a DL paradigm, there is no difference. Both result in an observation that is logically a number (rate is a decimal number, exercise is a yes/no – 0/1 binary observation[16]). Both have same constraints: 'who is allowed to do it' or 'who is the authoritative source?'

The definition above is important, as the same primitive operations are used in all limit and review type controls. For example, if a firm has a policy that 'all transactions above 1,000,000 need a review action', then this is logically no different to the terms of a derivative contract. In other words, there is some pre-defined policy that triggers a human to have to do something and evidence that the review has taken place (and any subsequent actions as part of the review[17]). This is 'evidencing the application of professional judgement' that is at the heart of BCBS 239.

Observations

Observations record 'events' defined in the contract. They may lead to subsequent actions (eg, setting of a cashflow or change of contract type).

	Event Identifier	Party	Party	Quantity	Economics	Comments
Numeric Observation						
Before	xxxY	P1	P2	Qty(xxxA)	IRS(xxxx)	
After	xxxZ	P1	P2	Qty(xxxA)	IRS(xxxx).Numeric	Eg, observation of a floating rate on an IRS or an MV on a position
Action Observation						
Before	xxxY	P1	P2	Qty(xxxA)	OPTION(xxxx)	
After	xxxZ	P1	P2	Qty(xxxA)	OPTION(xxxx).Action	Eg, a person exercising an option

[15] Note: We have deliberately not said 'market data' here, as this is an unhelpful historic definition and leads to the separation of physical systems that we have in the current environment, which may not be the case in future implementations

[16] Note: There is a subtlety here, in that there is the tristate of {'yes', 'no', 'no response yet'}

[17] For example, the classic control of 'review all reconciliation breaks over x days old or greater than y' is not usually evidenced and, more subtly, not followed up to ensure that the break cleared in a way that was 'valid'. Exploitation of these 'controls', and the lack of checking that the clearance was valid, has been at the root of multiple unauthorized trading incidents and market abuse. That said, a key benefit of DLs should be to eliminate reconciliations – the policy and follow-up controls will remain

Numeric Observation

Examples include:

- The economics of a trade may require a floating rate (eg, federal funds rate) to be observed each day;
- A trade is valued each day and the value stored.

An observation may lead to a subsequent action (eg, calculate next cashflow based on federal funds rate observation).

Action Observation

Examples include:

- An option contract may require notice of exercise to be evidenced. This is a yes/no/not advised observation.
- A policy (eg, review all trades with a day-one value above 'value').

Exercises

These are events that are defined by the economics of a contract. Such contracts are all types of option – ie, where the final state depends on whether a defined choice (option) in the contract is taken up (exercised).

	Event Identifier	Party	Party	Quantity	Economics	Comments
Exercise (Cash)						
Before	3fb9	P1	P2	Q	Option(5dc4)	Cashflow is defined by economics of position and market data
After	3fb10	P1	P2	c,ccc.cc	Cash	Eg, credit derivative, option, swaption etc. This is termination without negotiation
Exercise (Physical, Knock In)						
Before	4fy4	P1	P2	Qty(xxx)	Option(5dc4)	Position (xxY) is defined by Position (xxx) and market data
After	4fy5	P1	P2	Qty(xxY)	Option(8wtx)	Eg, FX option, credit derivative, physical swaption etc. This is an amendment without negotiation
Exercise (Physical, Knock Out)						
Before	4fy4	P1	P2	Qty(xxx)	Option(5dc4)	The contract disappears
After	4fy5	-o-	-o-	-o-	-o-	

Cash Exercise

In a cash exercise, the option contract turns into a cashflow that is calculated from terms in the contract, and data observed after the contract is executed. The exercise results in a termination event (as defined previously). There is no negotiation of terms, as the terms have already been defined in advance. The exercise may require the holder of the optionality to 'advise' the other party. This is a type of observation (also see above).

Physical Exercise

This is where the event changes the form of the contract in a pre-defined way.

For example:

- A swaption when exercised changes into an interest rate swap;
- A knock-in FX option changes into a vanilla FX option;
- An FX option changes into an FX trade.

In summary, if there is value in an option contract, then it will turn into cash or an asset – where the ownership is transferred on a settlement system. For example, the contract may require the delivery (transfer of ownership) of a security (eg, bond, equity) or a commodity (eg, metal, oil, etc).

Knock-out Exercise

A knock-out is where the contract ceases to exist as a result of an observation (other than time passing[18]).

Dependent Events Summary

- Dependent events are defined by the contract terms.
- Dependent events cause the same underlying changes as independent events (eg, the exercise of an option for cash results in a cashflow, as does an independent event (ie, negotiated termination).
- They can therefore also be considered 'contracted' events.

Transfers and Exchanges

This section shows how products are built up out of primitive events in the same space [P1, P2, Q, (E)] – ie, how the economics set (E) in this space is defined. In order to show how this is done, it is useful to start with cash, then bonds/securities, and then derivatives[19].

[18] Note: The concept of maturity/expiry of a contract is where the contract goes past a time, defined as the end of the contract. It is debatable if this is an event at all

[19] In fact, mirroring the way such products developed over history

Transfer

This represents a transfer of cash between two parties[20]. Cash is defined by an identifier (in this case, an ISO currency code[21]). Cash could move for any number of reasons (settlement of a trade, a coupon, dividend, collateral, account transfer, etc).

The quantity needs to be defined in terms of units – eg, sterling is in pounds and pence. This design removes the rounding problems encountered when settlements are calculated at a precision that is meaningless (ie, it is impossible to have a £2,456.432525 settlement, whatever any system calculating settlement values thinks. There are therefore finite precision issues that need to be designed in at the beginning.

	Event Identifier	Party	Party	Quantity	Economics	Comments
Transfer						
Cash	6re1	P1	P2	Q	GBP	Where GBP is the ISO currency code

Exchange

	Event Identifier	Party	Party	Quantity	Economics	Comments
Exchange						
FX Trade						Exchange of cash. FX rate is calculated from cashflows at 1.25
Cash	6re1	P1	P2	100	GBP	
Cash	6re1	P1	P2	(125)	USD	

An exchange (of 'things') is the fundamental concept of any individual contract. The example shows the simplest form of financial contract – an agreement to exchange one currency for another. The two cashflows are connected by a common event identifier.

When the FX trade comes to settle, two transfers (as defined above) are processed[22].

Key points:

- In a DL, the same mechanism for event identification is used – ie, an exchange is a collection of things that is identified on the underlying ledger.

[20] Implementation details of how this happens are not important (ie, if there are one or two records that are linked)

[21] At this point, it is not necessary to distinguish between central bank and commercial money. The point is the transfer is recorded on a ledger

[22] Note: The settlement may be independent or through a cash versus cash process. Either can be implemented conventionally or on a DL, although both are easier on a DL

- An FX trade is defined as the exchange of two cashflows. The rate is computed from the cashflows. This is important, as it means that any number of any size FX trades in the same currency pair can be simply added without loss of precision. If the rate is defined in terms of a finite precision (five decimal places), then it is not possible to add large and small FX trades together with confidence. Similarly, it is possible to have aggregations of similar size trades that will produce a rate that cannot be expressed in a finite precision number.
- Some further notes:
  - The exchange of two cashflows is embedded in the ISO/SWIFT messaging protocols.
  - Implemented well, there is no need for standard settlement instructions and all the overhead that goes into maintaining them.
  - Likewise, implemented well, netting is implicit in the ledger (see original aggregation event above).

Products

Bond Processing as an Example (Definition, Transfer, Sale)

	Event Identifier	Party	Party	Quantity	Economics	Comments
Bond Definition						P5 issues a bond with the following economics
Cash	hx72		P5	1,000,000,000	USD,s	The principle cashflow at the start of the bond
Cash	hx72		P5	(1,000,000,000)	USD,e	The principle cashflow at the start of the bond
Coupon	hx72		P5	1,000,000,000	Coupon(rate,s,e,d,h)	And the coupon in between
Transfer						
Bond	54gt	P1	P2	5,000,000	hx72	Where the bond is defined above and identified as hx72 on the ledger
Exchange						
Bond Trade						
Bond	esft	P3	P4	10,000,000	hx72	Where the bond is defined above
Cash	esft	P3	P4	(9,727,000)	USD	Price is again computed at 97.27

Definition

A bond is defined as a collection of terms (initial and final cashflows and coupon). The collection is tracked on a DL as an event hx72.

Coupon is a function (smart contract) defined on the ledger.

There are additional contractual terms to a bond that can be stored with the base economics defined here. These don't impact the processing of bond transactions through its normal life[23].

There are other notably possibilities – for example, registration of bond securities becomes an approval process by the relevant authority.

Similarly:

- A bond template could be defined and then re-used on each issue of a bond[24].
- Interest amounts are easy to strip from the principal.

Transfer

The bond hx72 can then be transferred between two parties P1, P2 (eg, in a collateral pledge). The mechanism for doing this is identical to transferring cash (ie, the ledger tracks the thing identified by an address, and that address could contain a cash contract, a bond contract or something else). There is therefore no physical difference between the settlement infrastructure for a bond or for cash.

Exchange

The exchange (purchase/sale of a bond) transaction is exactly the same structure as for an FX trade. When due for settlement, the individual elements turn into transfers and are processed on same settlement functionality.

Implications of Bond Processing Example

- The definition of a bond can be conducted on the same infrastructure that processes them – ie, no separate product data systems.
- 'The processing of cash and bonds (or any other security or asset) is logically identical to processing cash. On a DL, it can be physically identical.'
- Definition of a 'thing' and transactions in a 'thing' are tracked by the same addressing mechanism on a DL.
- Some further notes:
  - Consider how complicated this is on conventional infrastructure.
  - Cross-currency processing (eg, an investor buys a US dollar bond for sterling) is a simple composition of an FX and bond trade, as defined above.

[23] A bond contract may contain a lot more, including terms relating to interest cover (really an option trigger), and collateral (ie legal liens). All these may fall into the same structure

[24] For example, every Treasury or gilt issuance is fundamentally under the same legal framework with amount, coupon and maturity added

Simple Derivative Contracts

Derivatives contracts are fundamentally agreements to exchanges of asset streams (usually cash) into the future.

	Event Identifier	Party	Party	Quantity	Economics	Comments
Derivatives						
IRS	53g3					An IRS is an exchange of fixed and floating coupons
Coupon	53g4	P1	P2	10,000,000	Coupon(Q,float,s,e,d,h)	Assumed entered into at zero value (ie, no cash at inception)
Coupon	53g5	P1	P2	(10,000,000)	Coupon(Q,fix,s,e,d,h)	
CDS Single Name	gy4j					
Security	gy4j	P1	P2	5,000,000	hx72	Underlying security defined above
Coupon	gy4j	P1	P2	5,000,000	Coupon(rate,s,e,d,h)	Either 100 or 500bp
Coupon	gy4j	P1	P2	67,435	USD,s	Calculated at inception
Swaption	hw34					
Option	hw34	P1	P2	10,000,000	Strike(float)	Where strike refers to the floating rate in the IRS below
Coupon	hw34	P1	P2	10,000,000	Coupon(Q,float,s,e,d,h)	
Coupon	hw34	P1	P2	(10,000,000)	Coupon(Q,fix,s,e,d,h)	

An IRS is the exchange of two coupon streams (ie, a fixed leg and floating leg). The event to identify an IRS is no different to any other on a DL – it is the address 53g3 in this example.

A single-name credit default swap (CDS) connects together a bond (as defined previously) with a coupon flow and a fee at inception (as the coupons are standardized).

A swaption wraps an optionality term around an IRS.

Index Derivatives Contracts

	Event Identifier	Party	Party	Quantity	Economics	Comments
Derivatives						An index is defined as a standardized collection
Index Definition	ued6					Define an index in terms of previously defined bonds
Constituent 1	ued6		P5	01	hx72	The bond defined above
Constituent 2	ued6		P43	02	j9rs	Another bond
etc.	ued6					
Constituent n	ued6		P34	On	7eds	Another bond
Execute a trade in an INDEX						
Security	t6c8	P1	P2	5,000,000	ued6	Refer to the index defined above
Coupon	t6c8	P1	P2	5,000,000	Coupn(Q,fix,s,e,d,h)	
Cash	t6c8	P1	P2	67,435	USD,s	

The example above shows the definition of an index and a trade in that index in the same format.

The index is defined in terms of quantities of previously defined bonds (eg, hx72 above). The creation of the index has an identifier (ued6).

Once the index has been created, there is no difference between transactions in an index (ued6) to a transaction in any other 'thing' already defined.

Notes:

- The fundamental function is the ability to store collections of things.
- An index is merely a collection of things. It is usually defined by a single entity (eg, FTSE (SE100), Dow (DJIA), IHS Markit (iTraxx), etc) and is referenced and used by multiple participants for different purposes.
- The underlying mechanism that is important is the ability to create an index identifier and then add/modify the elements of an index independently.
- This same mechanism can be used to create other collections:
  - A basket trade is a non-standard index;
  - A structured derivative/note is a collection;
  - More subtly, a trading book is a collection that changes every day;
  - Indeed, a private client portfolio is also a collection that changes every day.
- The general point is picked up in the fractal-symmetry design section. All elements/instruments of the financial markets are collections of simpler terms.

Sophisticated Derivatives

More complex derivatives are hierarchies of simple derivatives – ie, they are collections of simpler derivatives. Their lifecycle is to change from more complex derivatives into simpler derivatives as time progresses. This suggests an elegant way of defining the contracts to simplify their lifecycle.

	Event Identifier	Party	Party	Quantity	Economics	Comments
Knock In Option Lifecycle						
Execute Trade						
Knock In	y76j	P1	P2	Q	f1(rate)	A knock in (if rate=KI in the period)
Option	y76j	P1	P2	Q	f2(rate)	The strike of option (if rate = S in the period)
FX Trade	y76j	P1	P2	Q1	USD	The underlying FX
FX Trade	y76j	P1	P2	Q2	GBP	
Trade Knocks In						
~~***Knock IN***~~	~~y76j~~	~~P1~~	~~P2~~	~~Q~~	~~f1(rate)~~	The knock In is exercised
Option	y76j	P1	P2	Q	f2(rate)	The underlying option is now active
FX Trade	y76j	P1	P2	Q1	USD	
FX Trade	y76j	P1	P2	Q2	GBP	
Trade Knocks In						
~~***Knock In***~~	~~y76j~~	~~P1~~	~~P2~~	~~Q~~	~~f1(rate)~~	
~~***Option***~~	~~y76j~~	~~P1~~	~~P2~~	~~Q~~	~~f2(rate)~~	The underlying option is excercised
FX Trade	y76j	P1	P2	Q1	USD	Underlying option FX is now active
FX Trade	y76j	P1	P2	Q2	GBP	

This example shows a knock-in FX option (KIFXO). A KIFXO is an FX option that comes into existence if a certain condition is met. It is a compound option.

Starting from the inside or underlying and working out:

- There is an underlying FX trade.
- There is an option on that FX trade.
- The option only exists if a certain condition exists.

If defined this way, then the lifecycle events consist merely of deleting certain contract terms if the conditions are met:

- If the knock-in (KI) conditions are met, then the KI conditions disappear (strike through) and the FXO remains.
- If the FX options (FXO) conditions are met, then the FXO conditions disappear and a simple FX trade is left.

Defining contracts in this way simplifies lifecycle processing[25]. It should allow an option to be defined on any underlying and all exercise events to be processed the same way, removing terms/ conditionality as each of the conditions are met.

(Found on Page 37)

Fractal Symmetry – Product Example

Further levels - Legal entities, etc.		
Aggregate (Level 6)		
	Net value	25,365
Aggregate (Level 5)		
	Valued Portfolio (Portfolio, Market Data, Model)	
	IRS Executed	54,363
	IRS Executed	4,545
	IRS Executed	(33,543)
Aggregate (Level 4)		
	Portfolio	
	IRS Executed	
	IRS Executed	
	IRS Executed	
Aggregate (Level 3) - Trade is executed - Template is populated		
	IRS Executed (dr54)	
	Coupon(USD,100M,3M,20170824,20270824,1.7653,A/360,NY,MF)	
	Coupon(USD,(100M),3M,20170824,20270824,LIBOR,A/360,NY,MF)	
Aggregate (Level 2) - Constructed out of Level 1 Elements		
	IRS "Template"	
	Coupon(CCY,Quantity,Frequency,Start,End,Fixed,DayCount,Holidays,Convention)	
	Coupon(CCY,(Quantity),Frequency,Start,End,Float,DayCount,Holidays,Convention)	
Aggregate (Level 1) - constructed out of BASE elements		
	Coupon(CCY,Quantity,FrequencyStart,End,Rate,DayCount,Holidays,Convention)	
BASIC ELEMENTS (Level 0)		
	DayCount["A/360","A/365","30/360", etc.)	
	Convention["ModFollowing", etc.]	
	Dates[ ]	
	Holdays[cities:Dates]	
	CCY["USD","GBP", etc.]	
	Rate[Fixed, (Float)]	