R3 Reports

Building Blocks for Better Compliance:

Can Blockchain Ease the Burden of Financial Regulations?

Gabriella Zak

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Building Blocks for Better Compliance: Can Blockchain Ease the Burden of Financial Regulations?

Gabriella Zak*

August 8, 2018

Abstract

After the 2008 global financial crisis, regulatory oversight within the financial services industry increased dramatically, with many new policies requiring more data to be reported in less time. The fundamental properties of blockchain architectures have the potential to provide a holistic solution for regulatory reporting. This paper will examine the current methodologies for regulatory reporting and consider both a theoretical and technical blockchain solution. To create a more tangible understanding, this paper will focus on the blockchain platform Corda and the European regulation MiFID II. This paper then looks forward to how blockchain can be utilized across pre-existing and incoming regulation.

1 Introduction

The implementation of financial legislation can be notoriously slow, often moving at glacial speed; but when the date of enforcement arrives, seismic changes can disrupt the current industry landscape. Within the financial services industry, legislation can fundamentally alter the mechanisms of capital markets and therefore the conduct of business. One only needs to look at Dodd-Frank, Basel III, MiFID, and the most recent MiFID II for evidence.

After the 2008 global financial crisis, new legislation was acutely focused on regulatory oversight and enhanced compliance requirements. With each new piece of legislation, firms must learn the respective stipulations and produce a compliance solution before the date of enforcement, which is the date compliance is required and penalties for non compliance may begin being assessed. However, the current process of compliance, both in development and maintenance, is fraught with inefficiencies, ultimately causing increasing regulatory requirements and increasing expenses.

This paper examines whether a holistic blockchain solution may help mitigate the challenges and lower costs caused by increasing regulatory requirements within the financial services industry. By conducting a case study on how enterprise blockchain, particularly that of R3's Corda, could have significantly eased compliance with Europe's regulation MiFID II, this paper aims to analyze a blockchain solution while looking forward at a new regulatory landscape.

In order to establish a thorough and in-depth understanding of a potential blockchain solution, this paper has limited its scope to Corda. Blockchains come in many varieties and contain different system architectures; therefore, a tangible solution concretely grounded in technical specificity requires knowledge of a specific blockchain's capabilities. While this paper focuses on Corda, the ideas presented are not limited to it and may be adaptable to other blockchain platforms.

*The author would like to thank Ian Salmon, Angie Walker, David Ontiveros, Lamar Thomas, Kevin Rutter, George Calle, Alisa DiCaprio, Mark Raynes, Martin Sim and Austin Moothart for their invaluable help.

This paper will also focus on MiFID II's transaction reporting requirements. MiFID II is an example of sizable regulation, and it covers wide-ranging reform, from the restructuring of markets, to increased data reporting fields. While blockchain may present a solution for multiple regulatory areas, it appears very well suited for fulfilling transaction reporting requirements. Such requirements typically necessitate accurate, low-level data. Due to the similar nature in the types of data MiFID II reporting requires and that blockchain facilitates, this paper will limit its scope to transaction reporting.[1] The ideas presented within this paper are not limited to MiFID II or transaction reporting; they are intended to be adaptable to all forms of regulation.

This paper intends to be both theoretical and technical. Section 2 will explain the industry need for a new approach to regulatory compliance. Section 3 will introduce MiFID II's transaction reporting requirements in order to understand the capabilities that a compliance solution must contain. Section 4 will delineate the current methodology for regulatory reporting from one side of the data reporting process and highlight pain points within the system architecture. Section 5 will propose a blockchain solution for easing regulatory compliance. Section 6 will conclude the paper, looking at the larger implications of the paper's blockchain proposal.

2 Need for a Holistic Approach to Regulation

Navigating regulation proves a formidable task for financial institutions as new and revised policies perpetually sit on legislative agendas. In the United States alone, the 115th Congress has already been introduced to 449 new financial related legislations.[2] As many financial institutions have global reach with multiple product offerings, they may face compliance with over 400 regulatory and rule-making entities.[3] A decade after the global financial crisis of 2008, the quickened pace of regulatory change may appear to constitute the *status quo*; however, financial institutions still struggle to cope with the increasing demand from multiple regulators in multiple jurisdictions. Over 78% of large financial institutions cite this as a top challenge facing their firm.[4]

Beyond the sheer volume of incoming financial policy, legislation often contains requirements that significantly evolve as they progress from draft stage to final rule making, leading firms to delay critical decisions on how to implement compliance solutions. The proposed draft can be quite different than the final rule as revision stages and responses to consultation papers prompt changes to address industry concerns. Surrounding technical standards and guidelines to the proposed legislative corpus can be modified and published with little time before the compliance deadline.

As enactment day approaches, financial institutions scramble to satisfy the final requirements. For example, with less than six months until the enactment of MiFID II, nearly 90% of buy-side firms believed they were at "high or medium risk" of not being compliant by the enactment day deadline.[5]

Pressed for time, firms typically resort to interim solutions. Such solutions often take the form of expensive additional systems layered on top of pre-existing ones, ultimately creating a tangled web of integration. Though implemented with the intent of greater automation within the compliance process, solutions still require extensive manual reconciliation work. Furthermore, interim solutions may only satisfy the requirements of one incoming regulation; therefore, a new regulatory regime may require a multitude of interim solutions.

Looking ahead at an industry poised to experience only more financial regulation, firms must

[1] When blockchain functions as intended, it has the ability to immutably record low-level, atomic data with complete accuracy. This feature is core to the ideology behind blockchain and is fundamental to its architecture.

[2] The 115th Congress began on January 3, 2017 and ends on January 3, 2019. Statistics were taken from the Library of Congress on July 12, 2018. By the time of publication, this number can be assumed to have risen.

[3] Regan, Samantha, and Hamish Wynn. 2015. Accenture.com. `https://www.accenture.com/_acnmedia/PDF-5/Accenture-Regulatory-Change-Management.pdf.`

[4] Accenture. 2018. "Accenture Global Risk Study 2017 Banking Report." Accessed July 17.`https://www.accenture.com/t20170905T060353Z__w__/us-en/_acnmedia/PDF-60/Accenture-Global-Risk-Study-2017-Banking-Report.pdf.`

[5] Dilworth, Jordan. "90% of Buy-side Firms Are at Risk of Non-compliance by MiFID II Deadline, JWG Survey Finds." RegTechFS | Your Guide to Regulatory Change. June 29, 2017. Accessed August 02, 2018. `https://regtechfs.com/90-of-buy-side-firms-are-at-risk-of-non-compliance-by-mifid-ii-deadline-jwg-survey-finds/.`

implement holistic compliance solutions in order to drive efficiencies. While the industry spends over $270 billion[6] annually on compliance-related costs, it has paid more than $321 billion on settlements[7], enforcement actions, and fines since 2008. In the face of rapidly changing regulation, costs can be expected to increase unless a new approach is adopted by institutions. Financial firms must seek compliance models that are sustainable and adaptable for all forms of proposed regulation.

3 Understanding MiFID II's Transaction Reporting Requirements

To understand the challenges of current compliance systems and the possibility of an adaptable blockchain solution, this paper will use MiFID II as a guide. A basic proficiency of the regulation, specifically its transaction reporting stipulations, will be necessary and is provided within this section.

Taken into effect January 3, 2018, MiFID II represents the European Union's most recent, and perhaps most controversial, attempt at greater capital markets reform. Intended to amend the shortcomings of the pre-existing Markets in Financial Instruments Directive (MiFID) passed in 2004, MiFID II seeks to offer greater investor protection and improve the efficiency and transparency of European capital markets. With over 30,000 pages and 1.5 million paragraphs, the vast regulatory scope of MiFID II effectively touches upon every asset class and extends jurisdiction to nearly all firms engaged in financial instruments within the E.U.

MiFID II creates a daunting new regulatory landscape that institutions must navigate, particularly in the area of compliance. New measures to ensure market transparency and transaction reporting require increased reporting fields for more asset classes and venues. Additionally, greater focus on the quality of data, both in accuracy and timing, has been mandated. As mentioned in Section I, this paper will focus on these specific core measures.

For financial institutions, the expanded compliance required by MiFID II exacerbates the pre-existing problems embedded in their regulatory reporting processes. Within an already strained system, new reporting requirements create new opportunities for inefficiencies and inaccuracies. As of Q1 2018, according to Thomson Reuters, the vast majority (94%) of "global systemically important" financial firms are expecting their compliance team budgets to remain the same or grow in the coming year in order to cope with MiFID II and similar incoming legislation.[8]

In order to understand the impact of MiFID II's transaction reporting requirements on firms, Subsection 3.1 will provide the general specifications. While neither comprehensive nor inclusive of the nuances applicable to each rule, the scale of regulation should become apparent.

3.1 Transaction Reporting Requirements

MiFID II's transaction reporting requirements seek to prevent market abuse and promote market integrity. The regulation poses 65 new data fields to be reported across new and existing asset

[6] Patnaik, Dave. "The Rising Cost of Compliance & How the Best Banks Respond." Fair Lending, CRA & BSA/AML Compliance. November 08, 2017. Accessed July 19, 2018. https://www.trupointpartners.com/blog/cost-of-compliance-and-how-the-best-banks-respond

[7] It is important to note that fines may also be the result of intentionally vague regulatory requirements. Regulatory authorities tend to use equivocal language in order to deter market participants from circumventing the law. Additionally, only a few banks make up the majority of the fines. For example, Bank of America has paid $58 billion in fines and JP Morgan has paid $27 billion, making up almost 25% of the global total.
Sources: Deutsche Welle. "Financial Crisis Bank Fines Hit Record 10 Years after Market Collapse | DW | 10.08.2017." DW.COM. Accessed August 02, 2018. https://www.dw.com/en/financial-crisis-bank-fines-hit-record-10-years-after-market-collapse/a-40044540.

Partington, Richard. "Banks Trimming Compliance Staff as $321 Billion in Fines Abate." Bloomberg.com. March 23, 2017. Accessed July 19, 2018. https://www.bloomberg.com/news/articles/2017-03-23/banks-trimming-compliance-staff-as-321-billion-in-fines-abate.

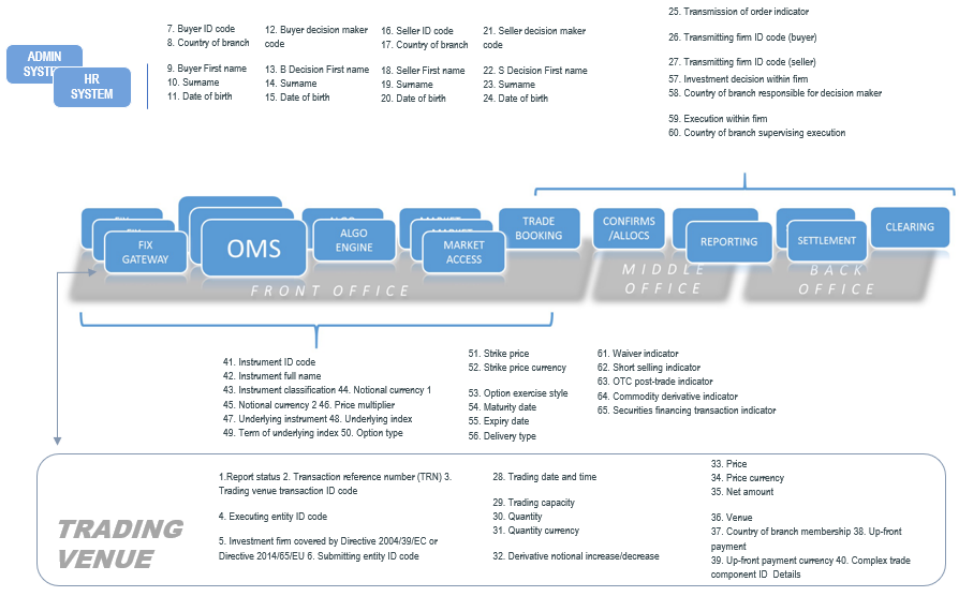
[8] Hammond, Susannah. "Cost of Compliance 2018." Accessed July 25, 2018. https://risk.thomsonreuters.com/content/dam/openweb/documents/pdf/risk/report/cost-of-compliance-special-report-2018.pdf.

classes. Data fields include detailed identification information on the trader or algorithm involved in the execution of a client order, as well as specific metrics on the trade itself. Investment firms and trading venues to which MiFID II applies need to provide their transaction report to the competent authority by the close of the following working day (T+1 8:00 pm CET). Notably, MiFID II allows for Approved Reporting Mechanisms (ARMs) or Approved Publication Arrangements (APAs) to report data on behalf of a firm as long as they are compliant with tailored requirements. For an abbreviated list of the 65 data fields, see Appendix A.

4 Current Methodology and Challenges for MiFID II Transaction Reporting

Accurately collecting and reporting transaction data is by no means an easy task, especially for MiFID II's 65 new reporting fields. Information required is scattered amongst the multiple parties and disparate autonomous software systems involved in the lifecycle of a transaction. For a single transaction report, data must be gathered and aggregated from these numerous data sources. Figure 1 categorizes MiFID II's 65 transaction reporting fields according to the data source and its respective software system.

Figure 1: MiFID II's 65 transaction reporting fields according to data source and software system/protocol.
Source: Ignite G2M



In an attempt to reduce the reporting burden, many financial institutions have turned to ARMs to conduct the MiFID II specific data consolidation and reporting process. ARMs are a specific Data Reporting Services Provider (DRSP) that are authorized to provide transaction reporting details on behalf of an investment firm in order for it to meet its reporting obligations. While the concept was first introduced in the U.K. in 2000 as part of the Financial Services and Markets Act, it has only now been extended to and widely used by the rest of the E.U., with ARMs acting as the MiFID II equivalent of trade repositories under the European Markets Infrastructure Regulation (EMIR).[9] Within the MiFID II ARMs market, firms tend to choose from three dominant providers:

[9]Team, Editorial. "Hurdling towards the Finish Line of MiFID II." Finextra Research. September 04, 2017. Accessed August 06, 2018. `https://www.finextra.com/blogposting/14462/hurdling-towards-the-finish-line-of-mifid-ii.`

TRAX, Abide Financial, and UnaVista.[10] Although this process is outsourced, responsibility for trade reporting remains with the financial firm.[11]

À la carte, ARMs may appear to reduce a firm's burden of transaction reporting; however, they still place a significant portion of the work onto the firm itself. A financial firm must still provide an ARM with a single output of all the aggregated data in which the firm has ownership of. If the firm already has this information internally, why might this be so troublesome?

As financial institutions grow both organically and through acquisition, multiple autonomous technological systems host business processes. Each individual platform holds the original source material required for the firm's relevant regulatory reporting. However, these various systems may record data in disparate ways, and their inability to interoperate leads data to become siloed within each autonomous framework. In an attempt to bridge the silos and provide a consolidated source of information for an ARM, additional layers of software are overlaid. Though, these layers leave gaps and manual interference is typically necessary.

As new regulation traditionally requires additional reporting data, compliance systems fail to easily adapt. In order for a compliance software solution to comprehensively record and aggregated reporting metrics, it must attempt a firm-wide integration of various, disconnected data streams. Effective data integration has proved notoriously difficult to implement for all types of enterprise systems, let alone a compliance one.[12] According to a recent E&Y report, the data consolidation challenge constitutes up to 60% of compliance work.[13]

How is this currently achieved? Dependent on the firm and their chosen solution, data integration architectures can vary widely; yet, the main methodology for ARM data sourcing is a combination of "big data" warehouses and integrated information designs. ARM data acquisition architectures are not limited to this methodology and may contain significant modifications. The hurdles of integration should become apparent as Subsection 4.1 walks through a more detailed guide on the lifecycle of regulatory reporting trade data within an investment firm.

It is important to note that Subsection 4.1 limits its scope to the transfer of order-level data within an order management system (OMS) within a firm. This excludes the additional challenge of then sourcing the relevant static and identification data that resides within the same firm's HR and administrative systems. Additionally, Subsection 4.1 takes the perspective of only one party involved in the trade. **This entire process is then extended to the broker's systems.**

4.1 The Lifecycle of Trade Data

You booked your trade– hopefully locked in a profit– and you move onto the next opportunity. But the collateral data's journey has just begun. This subsection will take a closer look at where your trade information goes after it leaves your hands and how it gets to its respective regulatory authority. Figure 2 illustrates an overview of the post-trade data lifecycle within an investment firm.

4.1.1 Booking a Trade

Within large financial institutions, the majority of trades are booked via front office systems, trading systems hosted on trading platforms, or alternative trading systems commonly conducted

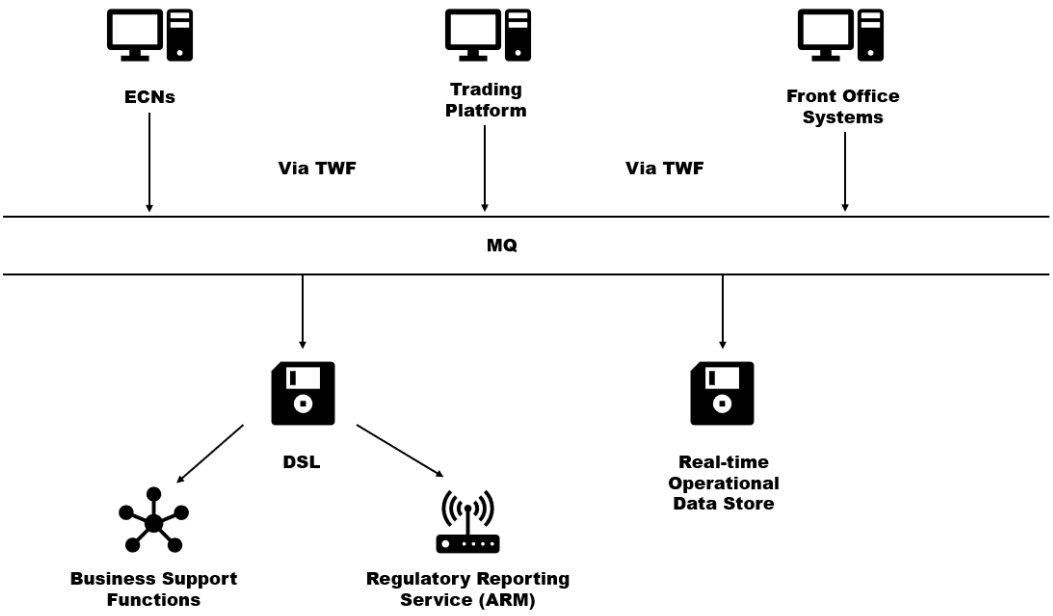
[10] "MiFID II Preparation - Reporting to ARMs (Approved Reporting Mechanism)." Cappitech Blog. May 08, 2017. Accessed August 06, 2018. `https://www.cappitech.com/blog/mifid-ii-preparation-reporting-to-arms-approved-reporting-mechanism/.`

[11] Nanaj, Bora. "ARMs: MiFID II's New Player within Transaction Reporting." RegTechFS | Your Guide to Regulatory Change. November 29, 2016. Accessed August 06, 2018. `https://regtechfs.com/arms-mifid-iis-new-player-within-transaction-reporting/.`

[12] Vicente, Pedro. "A Reference Architecture for Integrated Governance, Risk and Compliance." PhD diss., Technical University of Lisbon, 2011.

[13] Ernst & Young. Driving Efficiencies through a Holistic Approach to New Banking Regulations. Ernst & Young LLP., 2014.

Figure 2: Simplified illustration of the workflow for post trade data.
Source: R3



on electronic communication networks (ECNs).[14] Trades may also be booked via firm-specific platforms such as HSBC's Evolve, an e-FX platform for corporates.[15] The information transferred during this booking process contains only a portion of the total data fields required by MiFID II. For example, a client has data field 41: Instrument ID code but lacks data field 4: Execution Entity ID code, which is held by the broker.

Adding complexity, one ECN, trade platform, or front office system is not used uniformly across an institution. For example, the FX desk may use Evolve, while the equities desk may use the ECN Instinet. This variance is then extended across the numerous desks and divisions within an institution.

4.1.2 Converting to a Common Format

Depending on what front office system a transaction was booked on, the information may be recorded in different formats. Recorded data falls into one of two file formats: binary or text. While this seems like a relatively small problem, binary and text files fundamentally encode data differently. In a text file, each bit represents standard characters. Each field relevant to the order is then transmitted as a key value pair (i.e. Tag 41 = Symbol). This format enables easier readability and editing. In the financial services, most venues use the text file protocol Financial Information eXchange (FIX). In a binary file, each bit is a custom data field, and therefore it becomes more difficult to read. A decoder is necessary to read and interpret the data. NASDAQ's OUCH is a widely used example of financial binary text file protocol. Venues that utilize a binary format do so to increase performance at the cost of flexibility and ease of use.[16]

Beyond binary or text, the information contained within a file is ultimately text-based, meaning it can be modified. Any external player with sufficient access can effectively tamper with or alter the data stored. For example, in data field 41, the instrument ID code could be changed to represent

[14] ECNs are automated systems that match buy and sell orders for securities. Though there are numerous ECNs, the most widely employed include Instinet (mostly used by market makers for NASDAQ trades), SelectNet, and NYSE Arca.

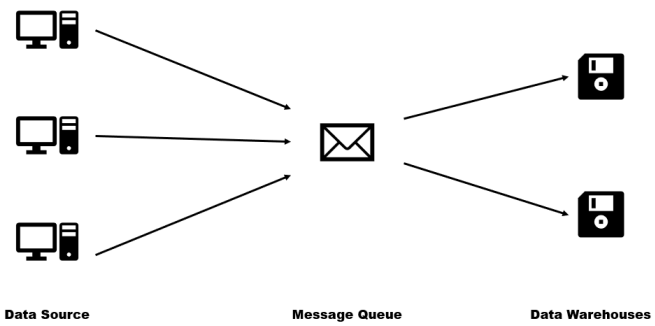
[15] "HSBC Evolve Voted Best E-FX Platform for Corporates." Basel III | Capital and Liquidity. Accessed July 19, 2018. `https://www.gbm.hsbc.com/insights/economics/hsbc-evolve-voted-best-efx-platform-for-corporates.`

[16] NASDAQ. O*U*C*H Version 4.2. 2018.

another ID.

The trade data files within each autonomous front office system must then be pushed to a message queue (MQ) through a trade workflow gateway (TWF). The TWF is an additional collection of services that routes data between systems and publishes trades in a common format. Once in the MQ, the format of the trade data files must be homogenized, and an appropriate next destination must be determined. Typically this constitutes a data lake or warehouse. The MQ shuttles data from system to system, never actually storing the information. Figure 3 illustrates the mechanism of a MQ.

Figure 3: Simplified illustration of the flow of information through a message queue. Important to note, the MQ does not store data.
Source: R3



4.1.3 Sending to an ARM

The MQ then passes relevant trade information, like data field 41, to a data services layer (DSL) which functions both as a data warehouse and a data feed. Relevant trade data sits within the storage platform and can provide data consumers, like an ARM, the necessary information. Due to the many complexities within the data's life cycle, manual reconciliation occurs at the DSL level to ensure accuracy. Compliance workers must check that the information stored within the DSL correctly reflects the same information initially entered into the front office system.

However, the problem of ARM data sourcing does not end here. Due to the widely adhered to Principle of Least Privilege (PoLP),[17] data warehouses such as DSLs are only permissioned to have access to just enough information needed for its intended purpose. As large institutions have many various and overlapping sublines of business, separate DSLs exist to mitigate the potential for insider trading and legal violations. Once again, firms must attempt to accurately consolidate the numerous DSY warehouses for each division within a firm.

This paper does not seek to address the monolithic challenge of data integration, however, it does intend to explore an alternative method for regulatory compliance. Under current compliance systems, MiFID II reporting requirements require arduous data management processes to ensure all information is accounted for and accurate. For each transaction, data from numerous trading systems and data warehouses, across multiple asset classes, need to be: consolidated, validated, re-formatted, stored internally, and reported in one report by an ARM by T+1.

And while ARMs may help firms meet their reporting obligations, albeit with inefficiencies and undue complexities, they ultimately constitute an immediate solution specific to MiFID II's increased requirements. Their purpose is specifically designed to help firms meet transaction reporting obli-

[17] The Principle of Least Privilege (PoLP) is a design within information security and computer science where each level of computing environment may only access the information and resources that are necessary to perform its duties. PoLP may be applied to every level of the system to ensure better security, minimized external attack surfaces, limit malware propagation, and improve audit readiness.

gations as defined under Article 26 of MiFIR.[18] New regulation may call for yet another system layered on top.

A better solution must exist.

5 Architecture of a Blockchain Solution

MiFID II, like much other regulatory legislation, presents a data problem that lends itself to a blockchain solution. From the initial booking of a trade, to its final place within a regulatory authority's database, the nature of the data involved with reporting requirements coincide with the fundamental principles of blockchain. Data must move through multiple internal and external systems and pass checkpoints for reconciliation and accuracy. This type of data, known as immutable states, and its respective transfer among parties is a core competency of blockchain. This paper will examine a blockchain solution in varying levels of technicality. Subection 5.1 provides a high-level overview of how blockchain can ease regulatory compliance specifically for MiFID II transaction reporting; Subsection 5.2 takes a deep-dive into the technical details of a Corda specific solution.

5.1 High-Level Overview of a Blockchain Solution

Blockchain technology is a novel solution for compliance challenges because counterparties can effectively and accurately record immutable states. For example, according to MiFID II, when an equity trade executes on a multilateral trading facility (MTF) within the E.U., data on its transaction identity, price, quantity, and identification code must be recorded and reported. Traditionally, this information would have flowed through the cumbersome system described in Section 4. However, an equity instrument recorded on a blockchain already would contain this information within its own set of states.

The architecture of blockchains also enable each party to have a full view of the data pertaining to all of their transactions. This results from consensus mechanisms, which require states on the ledger to be digitally signed by all parties involved before each state is validated and notarized. For example, R3's Corda, employ nodes with vaults, which provide a consolidated view of information that has been permissioned for them to see.[19] All transactions must pass through the counterparties' respective node, and the final state of each gets placed within a node's vault database. Vaults record every transaction that a firm is involved in or has permission to see.[20]

In addition, data on a blockchain can be easily reported to regulators. Unlike large data stores, the relevant information contained within a state does not need to be converted into different formats and transferred multiple times to be consolidated. Once a transaction has been verified and stored in the vault, all participants can be confident that the information is accurate and will remain the same forever. No reconciliation processes are required. A comprehensive source to pull information from the vault for regulatory reporting purposes exists. MiFID II requirements, like the 65 data fields for financial instruments on E.U. venues, can be specified, pulled, formatted, and reported.[21]

A blockchain compliance solution extends beyond just a single regulation like MiFID II. Since the solution is architectural, it can easily accommodate new regulation. Due to the consolidation of reporting data within a vault, new regulatory reporting requirements only need to be added to the list of information pulled from the vault.

[18] MiFIR is a set of rules created alongside MiFID II, and it is nearly always referred to in connection with MiFID II. When MiFID II reporting is mentioned, both within this paper and at large, it typically refers to the MiFIR regulation.

[19] For those interested in more detail regarding the technical specificities of a Corda solution see Section 5.2. Additional details may also be found within the white paper *Corda: A Distributed Ledger* by Mike Hearn.

[20] This is all done in an immutable and accurate way. Details on the immutability and accuracy of blockchain fall beyond the scope of this paper, though this claim has been well substantiated.

[21] Additional stipulations within regulation typically address time constraints for when data should be reported and what reference time should be used. For example, reporting compliant with MiFID II requires data to recorded in UTC time. Timestamping protocols and designs fall beyond the scope of this paper.

5.2 Technical Architectural Outline

Beyond a high-level overview, this paper intends to examine a blockchain solution grounded in technical specificity. The enterprise blockchain platform Corda will be used, however, the architectural proposal may be extended to other platforms.

In an effort to address the rules regarding PoLP discussed within Subsection 4.1.3, a single firm may deploy several nodes, each segregated and aligned to a specific line of business. Subsequently, when a transaction flows to the node that is permissioned to view it, it also gets stored within that vault's database. As a result, several stores of immutable states exist within a firm's blockchain network.

In order to consolidate each vault, an observer node can be deployed within a firm. An observer node is imbued with the ability to observe all transactions taken place within a blockchain network (i.e. for this purpose, all the various nodes irrespective of line of business) and their relevant data without the power to interfere. The node is purely observational. As with any Corda node, it contains its own vault and corresponding database. The observer node's vault database effectively consolidates each of the firm's individual nodes' vault databases, creating a "master vault". The concept of a "master vault" enables firms to have a view of the consolidated data which can then be used for other purposes beyond regulatory reporting.

Furthermore, vault data is stored in relational databases. The data contained within the database is held in a form that can be SQL queried. For the purposes of regulatory reporting, the vault becomes the consolidated and accurate data source in which information can be drawn from.

Importantly, nodes and vaults are independent of asset class. Unlike the current methods of data transfer within financial institutions, FX trades, for example, can be handled in the same way as equity trades. On a blockchain, asset classes may be recorded differently within each state, but ultimately the platform knows how to manage and classify each one within the vault based off specific identifiers.

In order to create a consolidated report for regulatory authorities similar to that which an ARM provides, an application programming interface (API) can be used. An API may even consist of the current compliance offerings, only modified with the ability to interoperate with Corda. Within the API interface, users should be able to set specifications on the information needed to be pulled from the vault. These specifications will be tailored to regulations. The API can pull such data using query tools and organize it to fit the required reporting fields and formats outlined by the legislation.

The ease of dictating the data sourced from the observer vault enables adaptability to evolving regulation. With each new requirement, only lines of code need to be implemented or changed within the existing system. There's no need to then employ additional layers of software, infrastructure, and third-party data service providers.

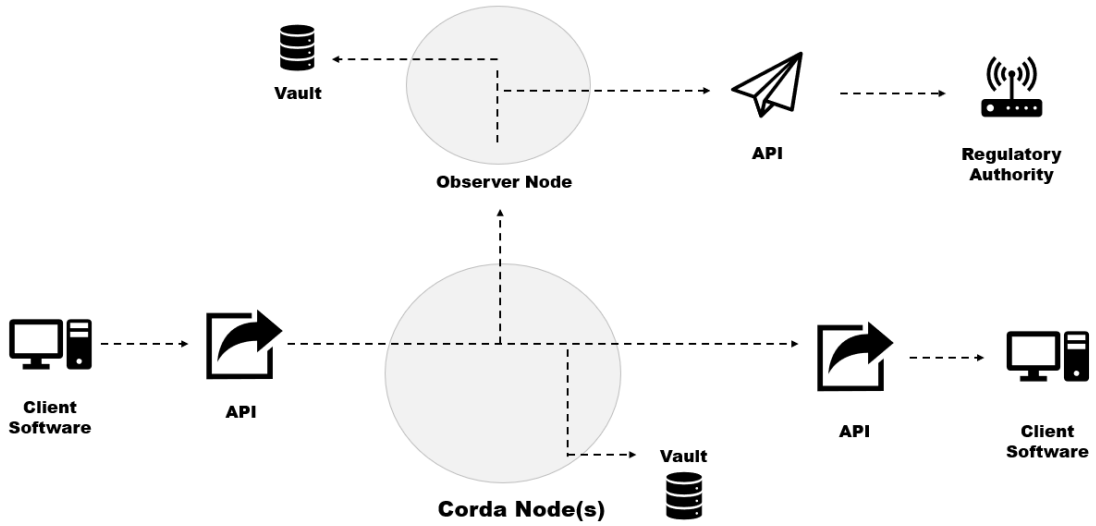
Admittedly, this architecture scheme sees limitations if reporting requirements call for data not already being recorded on the ledger. However, this could be amended by expanding the data fields of a transaction itself. Figure 4 outlines the architectural scheme of how a Corda vault can be leveraged within a blockchain solution.

6 Conclusion

In the fragmented compliance systems currently employed by firms, new regulation can only be solved by adding additional layers of services and software to an already cumbersome, monolithic system. To comply with MiFID II, firms simply adopted ARMs rather than implementing a blockchain solution, which would have streamlined the process of producing a consolidated data output. Inefficient and incomplete, the existing internal systems leave only larger data silos with more questions on the accuracy of information. Though implemented with the intent of greater compliance automation, extensive manual work still remains.

A blockchain solution may solve many of the challenges currently faced by regulatory compliance. Data integration from numerous, disparate sources is largely already embedded within the

Figure 4: Visualization of the architecture of a blockchain solution.
Source: R3



blockchain transaction process itself, and the immutability and accuracy of such data eliminates the need for manual reconciliation processes. The inherent data integration capabilities of blockchain provide an adaptable mechanisms for coping with future regulation and reporting requirements. Ultimately, third-party service providers like ARMs may no longer be needed. The specific architecture details of this mechanism were outlined here with respect to Corda and MiFID II.

Implementing a blockchain solely for the purpose of regulatory reporting seems unlikely due to the inertia of overhauling existing systems. However, a blockchain solution for regulatory reporting adds momentum to the argument for enacting the technology. Other synergies from capital market assets placed on a blockchain are likely necessary for large financial institutions to fully adopt blockchain.

While this paper's proposed blockchain solution strictly addressed regulatory requirements, it may also shed light on the challenge of general data integration. This is a future topic of inquiry and one that may solve the notorious challenge of integrating firm data into one consolidated warehouse.

Appendix A Selection of MiFID II Transaction Reporting Requirements

COMMISSION DELEGATED REGULATION (EU) 2017/590 of 28 July 2016 supplementing Regulation (EU) No 600/2014 of the European Parliament and of the Council with regard to regulatory technical standards for the reporting of transactions to competent authorities

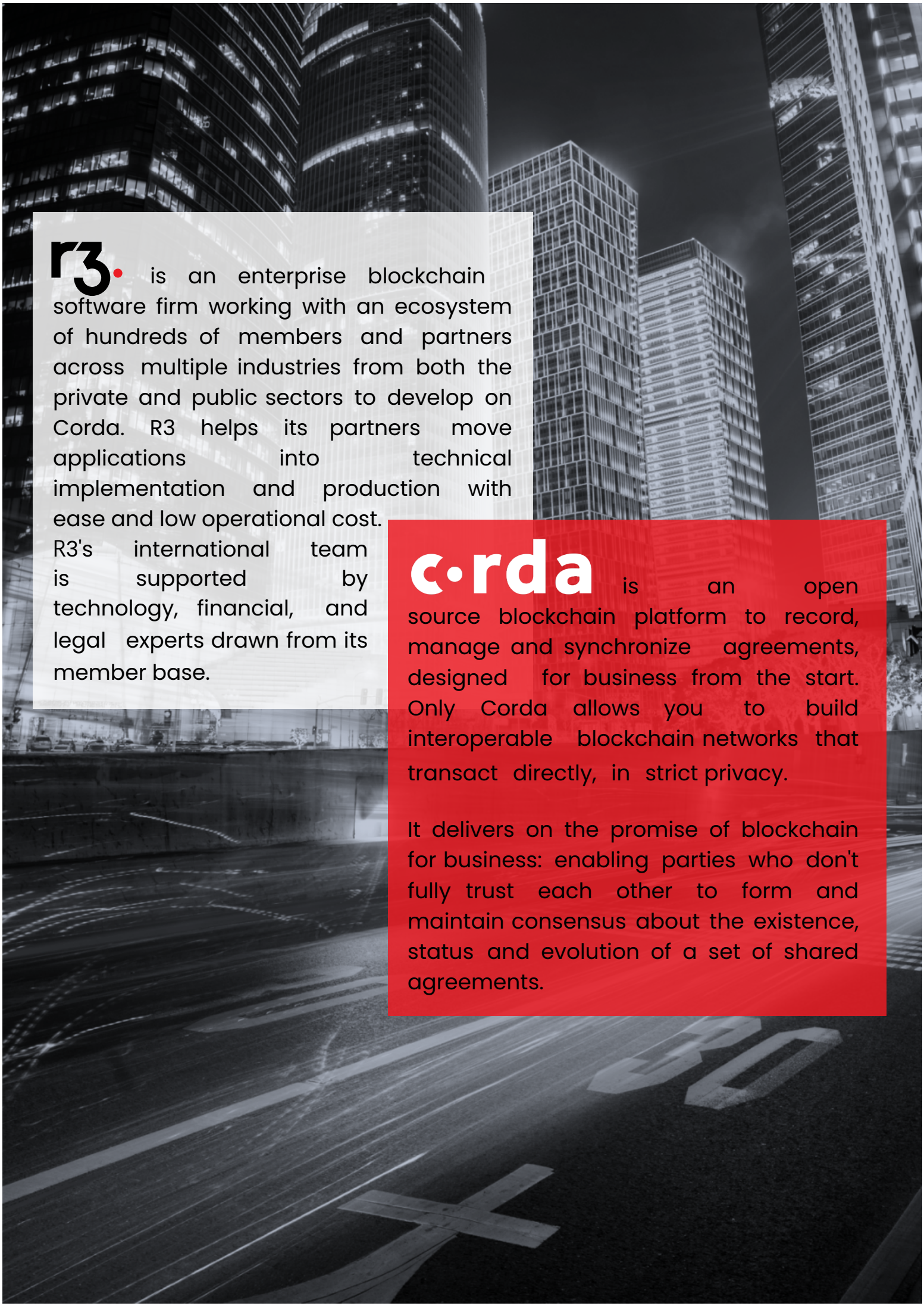
Table 2

Details to be reported in transaction reports

All fields are mandatory, unless stated otherwise.

N	FIELD	CONTENT TO BE REPORTED	FORMAT AND STANDARDS TO BE USED FOR REPORTING
1	Report status	Indication as to whether the transaction report is new or a cancellation.	'NEWT' – New 'CANC' – Cancellation
2	Transaction Reference Number	Identification number that is unique to the executing firm for each transaction report. Where, pursuant to Article 26(5) of Regulation (EU) No 600/2014, a trading venue submits a transaction report on behalf of a firm that is not subject to Regulation (EU) No 600/2014, the trading venue shall populate this field with a number that has been internally generated by the trading venue and that is unique for each transaction report submitted by the trading venue.	{ALPHANUM-52}
3	Trading venue transaction identification code	This is a number generated by trading venues and disseminated to both the buying and the selling parties in accordance with Article 12 of Commission Delegated Regulation (EU) 2017/580 (1). This field is only required for the market side of a transaction executed on a trading venue.	{ALPHANUM-52}
4	Executing entity identification code	Code used to identify the entity executing the transaction.	{LEI}
5	Investment Firm covered by Directive 2014/65/EU	Indicates whether the entity identified in field 4 is an investment firm covered by Article 4(1) of Directive 2014/65/EU.	'true'- yes 'false'- no
6	Submitting entity identification code	Code used to identify the entity submitting the transaction report to the competent authority in accordance with Article 26(7) of Regulation (EU) No 600/2014. Where the report is submitted by the executing firm directly to the competent authority, it shall be populated with the LEI of the executing firm (where the executing firm is a legal entity). Where the report is submitted by a trading venue, it shall be populated with the LEI of the operator of the trading venue. Where the report is submitted by an ARM, it shall be populated with the LEI of the ARM.	{LEI}
Buyer details — For joint accounts fields 7-11 shall be repeated for each buyer. — Where the transaction is for a transmitted order that has met the conditions for transmission set out in Article 4, the information in fields 7-15 shall be populated by the receiving firm in the receiving firm's report with the information received from the transmitting firm.			

Instrument details			
41	Instrument identification code	Code used to identify the financial instrument This field applies to financial instruments for which a request for admission to trading has been made, that are admitted to trading or traded on a trading venue or on a systematic internaliser. It also applies to financial instruments which have an ISIN and are traded on organised trading platform outside of the Union where the underlying is a financial instrument traded on a trading venue.	{ISIN}
Fields 42-56 are not applicable where: **transactions are executed on a trading venue or with an investment firm acting as a SI; or** **field 41 is populated with an ISIN that exists on the reference data list from ESMA**			
42	Instrument full name	Full name of the financial instrument	{ALPHANUM-350}
43	Instrument classification	Taxonomy used to classify the financial instrument A complete and accurate CFI code shall be provided.	{CFI_CODE}
44	Notional currency 1	Currency in which the notional is denominated. In the case of an interest rate or currency derivative contract, this will be the notional currency of leg 1 or the currency 1 of the pair. In the case of swaptions where the underlying swap is single-currency, this will be the notional currency of the underlying swap. For swaptions where the underlying is multi-currency, this will be the notional currency of leg 1 of the swap.	{CURRENCYCODE_3}
45	Notional currency 2	In the case of multi-currency or cross-currency swaps the currency in which leg 2 of the contract is denominated. For swaptions where the underlying swap is multi-currency, the currency in which leg 2 of the swap is denominated	{CURRENCYCODE_3}
46	Price multiplier	Number of units of the underlying instrument represented by a single derivative contract. Monetary value covered by a single swap contract where the quantity field indicates the number of swap contracts in the transaction. For a future or option on an index, the amount per index point. For spreadbets the movement in the price of the underlying instrument on which the spreadbet is based. The information reported in this field shall be consistent with the values provided in fields 30 and 33.	{DECIMAL-18/17}



R3 is an enterprise blockchain software firm working with an ecosystem of hundreds of members and partners across multiple industries from both the private and public sectors to develop on Corda. R3 helps its partners move applications into technical implementation and production with ease and low operational cost. R3's international team is supported by technology, financial, and legal experts drawn from its member base.

Corda is an open source blockchain platform to record, manage and synchronize agreements, designed for business from the start. Only Corda allows you to build interoperable blockchain networks that transact directly, in strict privacy.

It delivers on the promise of blockchain for business: enabling parties who don't fully trust each other to form and maintain consensus about the existence, status and evolution of a set of shared agreements.