FXRP

Flare Networks
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Abstract

FXRP is a trustless representation of the XRP token on the Flare Network, which enables XRP holders to use smart-contracts with the XRP token. The ensuing ecosystem provides incentives for agents to participate via the earning of fees, as well as the capacity to arbitrage.

1 Introduction

The XRP Ledger (XRPL) is a decentralised global payments and Foreign Exchange (FX) network. Its native token, XRP, is the fourth largest cryptocurrency by market capitalization of tokens in circulation[1], and the third largest if the total number of tokens in existence is taken into account[2]. Furthermore, XRPL and the Ripple ecosystem has one of the largest and most active developer communities: RippleNet and the XRP Ledger have meaningful enterprise and institutional uptake, and Ripple Labs and the XRP community have been highly successful in creating a decentralised payments and FX network. However, XRPL has been optimized for its payments and FX usecase and as such, because it does not support Turing complete smart contracts, presents limited utility for other use cases.

To date, there have been various approaches to representing the value of a non Turing complete token, such as Bitcoin, XRP or even the USD, on a smart contract platform, each introducing a certain degree of centralization into the system. In contrast, FXRP achieves trustlessness by leveraging a wide group of participants, none of whom need to be trusted as they have locked collateral that is managed smart contracts run on the Flare network which is decentralized.

The Flare Network [FN20] is a new Turing Complete Smart Contract platform, based on the Avalanche protocol [Roc18] in a Federated Byzantine Agreement (FBA) setting [CC19], and integrating the Ethereum Virtual Machine. Its native token, the Spark, is generated through a utility fork of XRP [FN20]. Furthermore, Flare uses the XRP encryption scheme, which can facilitate the usage of XRPL and Flare for XRP users.

The Flare Network and the Spark token enable the utility of XRP to be substantially extended by allowing for its use in any decentralised usecase whilst remaining trustless throughout the entire process. By using the Spark as collateral, a trustless representation of XRP, called FXRP, is issued which allows XRP holders to use smart-contracts with the FXRP token on the Flare Network. Furthermore, the resulting ecosystem, called the FXRP system, provides incentives to participants via the earning of fees on transactions as well as opportunities for XRP-FXRP arbitrage.

This document sets out the FXRP system as follows. First, in section 2, the FXRP ecosystem is introduced, alongside an overview of the collateral system and the fee structure. Next, in section 3, the issuance and redemption processes are presented, and illustrated with some examples. Management of collateral is further discussed in section 4, and the conditions for arbitrage reviewed in section 5. Finally, in section 6 the governance aspects of the system are discussed.

2 FXRP system

The FXRP system is a set of financial mechanisms encoded in smart contracts that enables XRP holders to create and redeem a 1:1 representation of the XRP token on the Flare Network, called FXRP. In order to achieve this, the system relies on agents participating in the system, putting up Spark as collateral and earning fees in return.

[1] As displayed on Coinmarketcap on 07/24/2020.

[2] Taking into account the approx. 100Bn tokens in existence and the price quoted on Coinmarketcap.

2.1 FXRP - a trustless representation

In order to create a representation of XRP on Flare in a trustless and decentralized manner, we first make the assumption that *the loss of a unit of XRP to a designated beneficiary can be fully rectified by awarding said beneficiary an alternative asset that allows them to replace the lost unit of XRP with no additional financial burden*.

This assumption allows us to specify the creation of an asset on Flare called *FXRP* which is convertible for XRP and collateralized by Flare's native token, the *Spark* [FN20].

Definition 2.1. An *FXRP* is the XRP representation issued on Flare Network.

Sparks can be purchased at the XRP/Spark exchange rate.

Definition 2.2. The *XRP/Spark exchange rate* η is the amount of Spark that can be purchased with 1 XRP.

2.2 System overview

FXRP is created by an XRP holder, called an *originator*, sending XRP to a series of accounts maintained on the XRPL by parties called *agents*.

Definition 2.3. An *originator* is a party that wishes to create FXRP on Flare Network by sending XRP to an agent's accounts on XRPL.

Agents have locked up Flare's native token, the Spark, as collateral against which FXRP can be issued and redeemed, and for which the agents earn a return (see section 2.4). In this transaction, the originator specifies the account on Flare to receive newly created FXRP. This is known as the issuance process, and is further discussed in section 3.1.

Alternatively, an FXRP holder who wishes to redeem FXRP back into XRP is termed a *redeemer*.

Definition 2.4. A *redeemer* is a party that wishes to redeem FXRP on Flare Network for XRP on XRPL.

The redeemer sends to the *FXRP System* the amount of FXRP that they wish to redeem, plus a redemption fee and the XRPL address to which they wish to redeem. The agents are then obligated to fulfil this redemption request by sending the requisite amount of XRP to the redeemer on XRPL. If after a specified amount of time (as measured by the closed ledger index on XRPL), the redeemer is missing any portion of their redeemed XRP, the agents collateral is used to reimburse the redeemer with the corresponding value of Spark tokens plus a margin to compensate for the transaction fees to replace the XRP. Furthermore, the agents at fault are also penalised. This is known as the redemption process, and is further discussed in section 3.2.

Definition 2.5. The *FXRP system* is the set of Smart Contracts (decentralised programs) that operate FXRP on the Flare Network.

The collateral system (see section 2.3), administered by the FXRP smart contracts on Flare, is the underpinning of the *trustless* issuance of the XRP representation. Collateral must be sufficient such that accounting for volatility of the XRP/Spark exchange rate the total value of the collateral pledged is never less than that total value of FXRP that is in circulation plus a reasonable negative economic penalty to agents such that redemption requests are almost always honored directly in XRP.

2.3 Collateral system

The collateral system is designed principally to reimburse a redeemer of FXRP for XRP on XRPL in the event that the agent(s) fail to complete the redemption transaction. The collateral used is Flare's native token - Spark. Each agent places a certain amount of Spark as collateral, the Spark Committed.

Definition 2.6. The *Spark Committed* (SC) is the total amount of Spark each agent holds in the FXRP System. This consists of the initial commitment amount with adjustments for any further additions and withdrawals, i.e.

$$\text{SC} = \text{Initial commitment amount} + \text{additions} - \text{withdrawals}. \tag{1}$$

This will allow for a given amount of FXRP to be issued, as determined by the Collateral Ratio.

Definition 2.7. The *Collateral Ratio* (CR) is the system wide *value* ratio that determines how much value in Spark is held as collateral by the FXRP System to secure 1 FXRP. At the outset this is set to 2.5.

These variables then determine the FXRP Issuance Cap, i.e. the total amount of FXRP that can be issued,

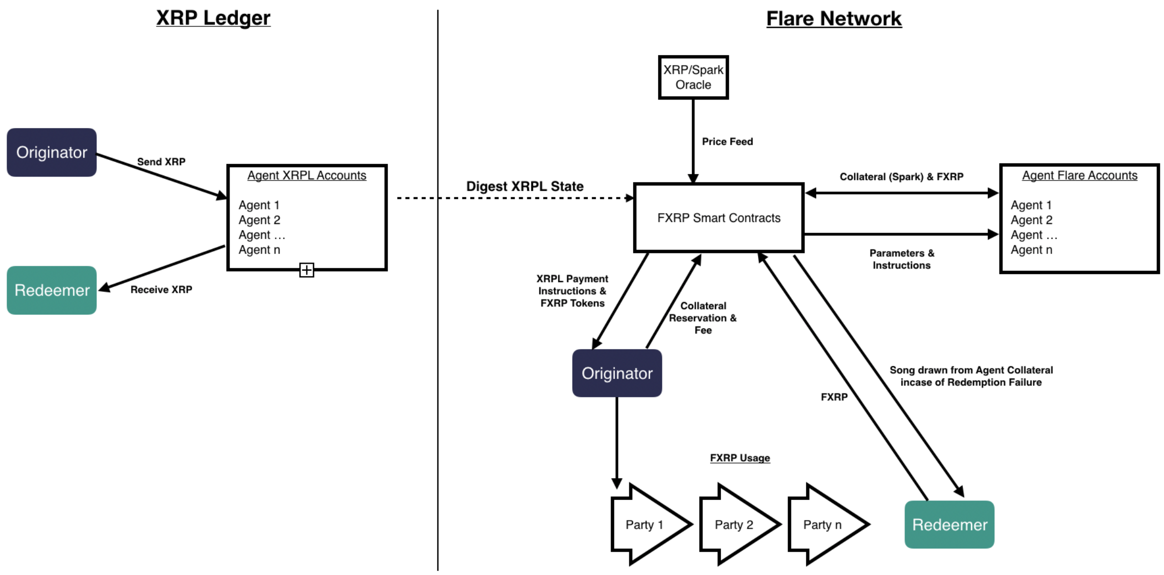

Figure 1: *Overview of the FXRP System* Originators and redeemers send/receive XRP to/from agents accounts on XRPL. These agents hold accounts on Flare Network, whereby they have locked up a certain amount of collateral held in a smart-contract. This will allow holders of XRP to create and redeem FXRP.

Definition 2.8. The *FXRP Issuance Cap* is the total amount of FXRP that could exist given the current system parameters. i.e.

$$\text{FXRP Issuance\_Cap=SC} \div (\text{CR}*\eta). \tag{2}$$

Example 2.1. At an XRP/Spark rate of $\eta = 0.5$ and CR=2.5, 2.5 Spark must held by the system for every 2 FXRP issued. If an originator wants to issue 10 FXRP, then this corresponds to 5 Spark and therefore 12.5 Spark will initially be held as collateral by the FXRP System. Over time, this amount will fluctuate with the XRP/Spark exchange rate.

The amount of FXRP an agent issued is their FXRP open.

Definition 2.9. The *FXRP Open* is the total amount of FXRP in existence apportioned to each agent. The sum of each agents FXRP Open is the total amount of FXRP Open for the entire system and the total amount of FXRP in existence.

Each agent will thus have some of their collateral used to issue FXRP, called the Utilized Collateral.

Definition 2.10. *Utilized Collateral* (UC) is the amount of collateral held by the FXRP system against an agent's FXRP Open, drawn from the agent's Spark Committed,

$$\text{UC = FXRP\_Open} * \eta * \text{CR}. \tag{3}$$

They may then have some collateral remaining which has not been used to issue FXRP, called the Remaining Collateral. This can be used to issue additional FXRP, and is called the Remaining Issuance Capacity.

Definition 2.11. The *Remaining Collateral* (RC) is the amount of collateral that is not being utilized, i.e. RC= SC - UC.

Definition 2.12. The *Remaining Issuance Capacity* (RIC) is the amount of FXRP that can be issued from the Remaining Collateral,

$$\text{RIC} = (\text{RC} \div \eta) \div \text{CR} \tag{4}$$

Each agent has then an Agent Collateral Ratio quantifying their amount of exposure.

Definition 2.13. The *Agent Collateral Ratio* (ACR) is the agent's individual collateral ratio, defined by

$$\text{ACR} = \text{SC} \div (\text{FXRP\_Open} * \eta). \tag{5}$$

The collateral system is thus defined by the following set of variables: the Spark Committed, the Collateral Ratio, the FXRP issued, the Utilized Collateral Ratio, the Remaining Collateral, the Remaining Issuance Capacity and the Agent Collateral Ratio.

In example 2.2, these quantities are computed in the case of four agents holding collateral on the network.

Example 2.2. We assume CR=2.5, $\eta = 0.5$ and that four agents hold collateral on the system. Agent 1 has committed 450 Sparks, and the remaining agents have each committed 150, bringing it to a total of 900 Sparks committed as collateral i.e. SC=900 Sparks. This thus results in an FXRP Issuance Cap of 900÷(2.5*0.5)=720 FXRP. We assume that 600 FXRP have been issued on the system, proportionally distributed by the agents. In the case of agent 1, this corresponds to (450/900)*600=300 FXRP, which is their FXRP Open. Their utilized collateral is computed as UC=300*0.5*2.5=375 Sparks. This means their remaining collateral is RC=450-375=75 Sparks. Agent 1 thus has a remaining issuance capacity RIC=(75÷ (0.5*2.5))=60, and their collateral ratio is ACR=450/(300*0.5)=3. These quantities are computed for each agent, and displayed in the following table.

Agent account	SC	FXRP Open	UC (Spark)	RC (Spark)	RIC (FXRP)	ACR
1	450	300	375	75	60	3
2	150	100	125	25	20	3
3	150	100	125	25	20	3
4	150	100	125	25	20	3
FXRP System Total	900	600	750	150	120	3

2.4 Agent fees

By putting up Spark as collateral, agents can earn fees in three ways: the creation of FXRP, the redemption of FXRP and via the collateral reservation process. All fees are expressed as a percentage of the transaction size. The *Creation Fee* is an amount of additional XRP that the originator pays to the agents in order to create FXRP. Similarly, the *Redemption Fee* is an amount of additional FXRP that the redeemer pays to the agents in order to redeem FXRP. Finally, the *Collateral Reservation Fee* is the amount a potential originator pays to the system as a result of initiating the creation of FXRP. This fee is required such that there is an opportunity cost to making an agent's collateral inaccessible.

Definition 2.14. The *Creation Fee* (CF) is the cost in XRP of Creating FXRP, which depends on the amount the originator wishes to create (Creation_amount) and the cost of doing so (Creation_Fee_Rate), i.e.

$$\text{CF} = \text{Creation\_amount} * \text{Creation\_Fee\_Rate}. \tag{6}$$

Definition 2.15. The *Redemption Fee* (RF) is the cost in FXRP of Redeeming FXRP, which depends on the amount the redeemer wishes to obtain (Redemption_amount) and the cost of doing so (Redemption_Fee_Rate), i.e.

$$\text{RF} = \text{Redemption\_amount} * \text{Redemption\_Fee\_Rate}. \tag{7}$$

Definition 2.16. The *Collateral Reservation Fee* (CRF) is the cost in Spark of reserving collateral in the creation process, which depends on the amount the originator wishes to create and the XRP/Spark rate.

$$\text{CRF} = \text{Creation\_amount} * \eta * 0.001. \tag{8}$$

All of the fees are set by governance from the holders of the Spark token as defined by in [FN20]. Only the Creation Fee should be varied to respond to supply and demand. The Collateral Reservation and Redemption Fees should be low and stable. Hence the voting threshold to alter the Creation fee is far lower than that of the other two.

3 Issuance and redemption

3.1 FXRP issuance

The issuance of FXRP proceeds in a sequence of steps. First, a holder of XRP on XRPL that wishes to create FXRP on Flare i.e. an originator, is first required to reserve collateral capacity on Flare. This is done by submitting a *Collateral Reservation Transaction* (see def. 3.1) alongside a Collateral Reservation Fee. If the system Remaining Issuance Capacity is greater or equal to the amount of FXRP to be created *and* the Collateral Reservation Fee is correct, the system will then return a *Transaction Formula* (TF). If, on the other hand, there is insufficient collateral available or there is some other fault with the Collateral Reservation Transaction, the system outputs *Reservation Failed*, and returns the Collateral Reservation Fee to the originator. Simultaneous to issuing the TF, the FXRP system will move collateral as per the TF apportionment from each participating agent's Remaining Collateral (RC) to the agent's Utilized Collateral (UC). This will thus reduce the participating agent's as well as the system's Remaining Issuance Capacity (RIC).

Definition 3.1. The *Collateral Reservation Transaction* (CRT) is sent from an originator to the FXRP system, and consists of the following four fields:
1. the amount of FXRP to be created,
2. the Flare address to be credited with newly created FXRP,
3. the XRPL account from which the XRP originates,
4. the total amount of XRP that will be sent, which is the amount of FXRP to be created *and* the creation fee.

In response, the system returns a Transaction Formula, which contains information defining what transactions the originator will need to complete on XRPL and how.

Definition 3.2. The *Transaction Formula* (TF) specifies the following four fields:
1. a *Transaction Identifier*, which is a unique code relating to the specific transaction to be included in the XRP transaction memo field,
2. a *Transaction Formula Apportionment* (TFA), which specifies the amount of XRP to be sent by the originator to each agent on XRPL, determined pro-rata by the Remaining Issuance Capacity (RIC) of each agent i.e. TFA_Agent = RIC_Agent ÷ RIC_System ,
3. the *agents XRP addresses*, in order for item 2 to be completed,
4. the *XRPL Last Ledger Sequence Number*, which is the highest ledger index on XRPL in which the transaction can be validated.

Once the Transaction Formula has been issued, the originator must send XRP to the agent's accounts on XRPL, in the manner and amounts as set out by the TF. That is, the originator must include the Transaction Identifier in the memo field of each transaction, each transaction must originate from the XRP account specified in the collateral reservation process and each transaction must happen by the close of the XRPL ledger close specified by the Last Ledger Sequence Number, see def 3.2.

The last ledger sequence number criteria precludes a transaction from settling on XRPL if it cannot be validated by that ledger number[3]. This allows the FXRP system to release collateral against a specific Transaction Identifier that is not fulfilled by the ledger cut off. Furthermore, it protects the originator against completing XRP transactions to agents against which the FXRP system does not hold collateral.

The Flare network will continually digest the state of the agent's accounts on the XRP ledger. After the validation of the XRPL ledger specified by the last ledger sequence number for each agent account; for an amount of XRP that has been transferred from the originator to the agent, referencing the Transaction Identifier and from the account specified in the TF, the FXRP system will issue an equal amount of FXRP to the originators address on Flare, up to and including the amount specified in the TF.

Note that any other outcomes, such as the originator sending too much XRP to any specific agent or some other error, cannot be rectified by the system.

3.2 FXRP redemption

A holder of FXRP might wish to redeem their FXRP for XRP. In this case, they need to send a Redemption Transaction to the FXRP system, containing the amount to be redeemed as well as specifying relevant XRPL and Flare account information.

Definition 3.3. A *Redemption Transaction* is sent from a redeemer to the FXRP system, which contains:
1. the amount of FXRP that they wish to redeem plus the redemption fee,
2. a specification of the XRPL account to credit with the redeemed XRP,
3. a specification of the Flare account for crediting in case of total or partial redemption failure.

An Agent Redemption Formula is then sent to each participating agent, which amongst other fields, specifies the Agent Redemption Apportionment, i.e. the FXRP system will apportion the redemption across the agents relative to each agent's utilized collateral.

Definition 3.4. An *Agent Redemption Formula* (ARF) is sent from the FXRP system to the agents, and specifies the following three fields:

[3] For more on XRPL, see https://xrpl.org/consensus.html

1. a *Redemption Identifier* that is unique to the specific redemption transaction and agent,
2. a specification of the redeemer's XRPL account to credit,
3. the *Agent Redemption Apportionment* (ARA), ARA= Redemption_Amount * (UC_Agent ÷ UC_System),
4. a last ledger sequence number by which the XRP must have been received into the redeemers account.

At this point, it is up to each agent to send the correct amount, as specified in the ARF, to the specified account by the specified last ledger sequence number. Failure to do so results in penalties. More specifically, this defines redemption *cycles*, summarised in table 1.

Stage	Amount sent by agent	Fees received by agent	Redeemer receives
Cycle 1	full	receives fees	full XRP
	partial	no fees received yet	partial XRP
Cycle 2	full	fees on amount sent in cycle 1	full XRP
Failure			equivalent amount of Spark
			redemption fee on unfulfilled amount
			redemption failure fee on amount unfulfilled

Table 1: *Redemption cycles* An agent has 2 cycles to complete redemption before incurring losses. If the agent sends the full amount of XRP to the redeemer by the end of cycle 2, they can then earn fees on the amount sent in cycle 1. Failure to do so results in the redeemer being awarded an equivalent amount of Spark as well as some compensatory fees. Furthermore, the agent loses then 50% of their remaining collateral relating to this redemption amount, with the remaining balance returned.

3.2.1 Redemption cycle 1

Each agent is obligated to ensure that the amount of XRP specified by the Agent Redemption Apportionment is transferred to the redeemer's address on XRPL. The Redemption Identifier allows for different addresses to fulfil the redemption obligation such that XRP does not necessarily have to originate from the agent's listed address on XRP. Note that this capability does not transfer the penalty for non performance from the agent to a third party.

The FXRP system will digest the state of XRPL. After the validation of the specified ledger index on XRPL, for each agent, for an amount of XRP, up to and including that specified by the RF, that has reached the redeemers account, referencing the Redemption Identifier, the FXRP system will move an equivalent amount of value in collateral from the Agents Utilized Collateral to the Agents Remaining Collateral (any redemption amount not fulfilled remains collateralized).

For any agent that has fully completed their assigned redemption transaction, the pro-rata share of the redemption fee will be sent to their account.

3.2.2 Redemption cycle 2

For each agent, for any amount of XRP that has not reached the redeemer by the specified ledger index, the FXRP system will issue a second last ledger sequence number by which the remaining amount must have reached the redeemer's account.

If, after the FXRP system has digested the validation of ledgers up to the second specified ledger, any agent has fully completed their assigned redemption transaction, they will receive the pro-rata share of the redemption fee on the amount that reached the redeemer under the Redemption Cycle 1 only. The remaining redemption fee will be burned.

3.2.3 Redemption failure

Subsequent to the validation of the second specified XRPL ledger, for each agent that remains deficient on their assigned redemption transaction by any amount, the redeemer will be sent the value of the missing XRP in Spark tokens (at the instantaneous prevailing rate) drawn from the agent's collateral to their specified Flare address. Furthermore, the redeemer will be refunded the pro-rata redemption fee on the amount unfulfilled as well as being awarded a redemption failure fee on the amount unfulfilled. The redemption failure fee is equal to the redemption fee on the amount of XRP missing at this prevailing XRP/Spark rate, which may have changed since the redemption transaction was initiated. This is to ensure that transaction costs to acquire the missing XRP using Spark are covered.

The defaulting agent(s) will lose 50% of their remaining collateral relating to this missing redemption amount, which will be destroyed. The balance of collateral will be returned to the agent.

3.2.4 A worked example of the redemption process

The following example illustrates the redemption process throughout cycle 1, cycle 2 as well as in the case of redemption failure, with a fluctuating exchange rate. This is in order to emphasise that the redeemer is not exposed to price fluctuations in the rate from the moment the redemption is requested.

Example 3.1. In the following, consider that $\eta = 0.5$, SC=900, CR=2.5, IC=720 FXRP and 600 FXRP have been issued so far, as in example 2.2. Alice has 150 FXRP which she wishes to redeem. If the redemption fee is 1.5% of the total to redeem, she will then have to send 2.25 FXRP i.e. 1.13 Spark to the system. The redemption apportionment is based on FXRP_Open, and is spread across the four agents as follows:

Agent account	FXRP Open	Redemption apportionment (%)	Alice's redemption (FXRP)
1	300	50	75
2	100	16.67	25
3	100	16.67	25
4	100	16.67	25
FXRP System Total	750	100	150

Next, redemption happens. Let agent 1 and agent 4 complete their redemption apportionment in the first cycle. Agent 2 partially completes it in the first cycle (i.e. sends in 15 XRP instead of the 25 XRP due, that is, 60% of the total due), and fully completes it in the second cycle. Agent 3 does not complete at all. Thus, agent 1, 2 and 4 receive fees based on the amount they have redeemed in the first cycle, whereas the balance of the fee due to agent 2 is burnt. Note that the redemption fee associated with agent 3 has not been burned. This is summarised by the following table:

Agent account	XRP received by end of cycle 1	XRP received by end of cycle 2	Original pro-rata Fee share (Spark)	fees paid (Spark)	Fee burned (Spark)
1	75	75	0.56	0.56	0
2	15	25	0.19	0.11	0.08
3	0	0	0.19	0	0
4	25	25	0.19	0.19	0
FXRP System Total	115	125	1.13	0.86	0.08

Collateral is moved from UC to SC for the portions redeemed. By the end of the first redemption cycle, the XRP_Spark Price has increased to $\eta = 0.52$. The fees have been sent to the account. UC and RC are updated, as the exchange rate has changed. This results in SC=900.86, and an FXRP Issuance Cap=692.97 FXRP.

Agent account	SC	FXRP Open	UC (Spark)	RC (Spark)	RIC (FXRP)	ACR
1	450.56	225	292.5	158.06	121.59	3.85
2	150.11	85	110.5	39.61	30.47	3.40
3	150	100	130	20	15.38	2.89
4	150.19	75	97.5	412.69	317.45	3.85
FXRP System Total	900.86	485	630.5	630.36	484.89	3.57

Following Redemption Cycle 2, agent 2 has completed the redemption transaction but agent 3 remains deficient. The XRP/Spark price has now risen to 0.53. The system must now compensate Alice based on the default at the new rate (because the Alice should be able to exactly replace her missing XRP and should not be exposed to price risk). Alice was suppose to be refunded agent 3's fee i.e. 0.19 Spark, and receive 25 XRP. At the new exchange rate, this corresponds to 13.25 Spark, with a redemption default fee (1.5%) of 0.19875.

The account of agent 3 is given by the following table

Agent 3	FXRP	Spark
FXRP_Open	100	
UC		132.5
Collateral relating to Alice redemption		33.125
Payout to Alice from collateral		13.449
RC		19.676
burn 50%		9.838
Returned Collateral		9.838

After everything is complete, the system has reached the end of redemption cycle 2. Now, $\eta = 0.53$, CR=2.5, SC=877.573 Spark, Issuance Cap=663.32 FXRP, 450 of which have been issued so far.

Agent account	SC	FXRP Open	UC (Spark)	RC (Spark)	RIC (FXRP)	ACR
1	450.56	225	298.125	152.435	115.045	3.78
2	150.11	75	99.375	50.735	38.29	3.78
3	126.713	75	99.375	27.338	20.633	3.19
4	150.19	75	99.375	50.815	38.351	3.78
FXRP System Total	877.573	450	596.25	281.323	212.319	3.68

This example illustrates the various stages of the redemption process, on both the agent as well as redeemer side, as well as the crucial role played by the collateral put up by agents and held by the system.

4 Collateral management

The collateral held by the system provides users of the FXRP system the guarantee that they will under no circumstances lose the XRP assets sent to the system. As such, the FXRP system places a strong requirement on each agent's ACR in order to maintain the viability of the system. This is captured by the control criteria set out in section 4.1. Furthermore, over time, each agent's ACR will fluctuate, subject to the changes in XRP/Spark price as well as the agent's decisions, such as adding or removing collateral, and unwinding their position.

4.1 Control criteria

The FXRP system has a single governing collateral criteria: *each agent's Agent Collateral Ratio **must** be maintained strictly above the Collateral Ratio*. This is to create faith in the FXRP system, due to the system remaining over collateralized at all times and creating a persistent strong economic incentive against Agent Redemption Default. In order to maintain this, a Collateral Call Band is introduced.

4.2 Collateral call band

Definition 4.1. A *Collateral call band* (CCB) is a narrow band below the defined Collateral Ratio in which an individual agent's Agent Collateral Ratio may persist for a limited time, say n_1 blocks, during which the agent must take action.

For the purposes of this document and for the CR=2.5, the Collateral Call Band is set between 2.45 and 2.5 i.e. $2.45 \leq$ CCB < 2.5.

From the initial system observation that an agent's ACR has fallen into the CCB (but not below) the agent has n_1 blocks to either post additional Spark, or reduce their FXRP Open (and hence their Utilized Collateral) by sending FXRP to the FXRP System, or a combination of both such that the agents Collateral Ratio returns to being equal to or greater than 2.5.

If after n_1 blocks, where n_1 is a system parameter, the agent's ACR is still below 2.5, or at any time if the agent's ACR falls below 1.45, then the FXRP system will buy out the agents issued FXRP using the agents Spark collateral. To do so, the system will place place a bid for FXRP equal to the amount issued by the agent, at the XRP/Spark exchange rate. If unsuccessful, the bid will increment every m blocks, where m is a system parameter until the system acquires the requisite amount of FXRP. Once acquired the FXRP will be deleted and the system will return any remaining balance to the agent.

4.3 System determined collateral adjustments - XRP/Spark Price

The XRP/Spark price induces changes in the amount of collateral available each agent has. Holding all else constant and within the limits of each agent's Agent Collateral Ratio, fluctuations in the XRP/Spark rate shifts collateral back and forth between Utilized Collateral and Remaining Collateral.

If the XRP/Spark rate increases i.e. XRP goes up relative to Spark, then collateral is drawn from the agent's Remaining Collateral balance - until the point at which the Agent Collateral Ratio approaches the Collateral Ratio. Conversely, if the XRP/Spark rate decreases, then Utilized Collateral is reduced whilst Remaining Collateral increases. In both cases, holding all else constant, the Remaining Issuance Capacity changes as per definition definition 2.12.

Example 4.1. Consider the system from example 2.2. Next, say the system collateral and the CR remain constant, but the exchange rate has changed to $\eta = 0.55$. This translates into an updated FXRP Issuance Cap of 514.286 FXRP, and will impact on each agents collateral and exposure. For agent 1, the utilized collateral is now UC=412.5, and thus RC=37.5, with updated values of RIC=27.27 and the ACR=2.73. The following table summarises each agents and the systems updated state.

Agent account	SC	FXRP_Open	UC (Spark)	RC (Spark)	RIC (FXRP)	ACR
1	450	300	412.5	37.5	27.27	2.73
2	150	100	137.5	12.5	9.09	2.73
3	150	100	137.5	12.5	9.09	2.73
4	150	100	137.5	12.5	9.09	2.73
FXRP System Total	900	600	825	75	54.54	2.73

4.4 Agent determined collateral adjustments

An agent can choose to either add or remove collateral at any time, as well as to exit the system i.e. unwind their position.

4.4.1 Adding Collateral

An Agent can add Spark as Collateral at anytime.

4.4.2 Removing collateral

An agent can remove any amount of Remaining Collateral. By definition, if the agent has any outstanding FXRP_Open, removing all the Remaining Collateral will bring the Agent Collateral Ratio to 2.5. Hence it is likely useful to the agent to leave some margin for price volatility.

Example 4.2. Now, consider the system from example 4.1. The exchange rate has changed to $\eta = 0.4$, and agent 2 decides to remove 30Spark from collateral, reducing their SC from 150 to 120. The total SC has thus also decreased from 900 to 870. Agent 2's remaining collateral will thus also decrease down to 20, with RIC=20 and ACR=3.

Agent account	SC	FXRP_Open	UC (Spark)	RC (Spark)	RIC (FXRP)	ACR
1	450	300	300	150	150	3.75
2	120	100	100	20	20	3
3	150	100	100	50	50	3.75
4	150	100	100	50	50	3.75
FXRP System Total	870	600	600	270	270	3.625

4.4.3 Position unwinding

An agent may reduce their outstanding FXRP_Open by obtaining FXRP and sending it to the FXRP system. Hence an agent wishing to exit the system may send an equal amount of FXRP, as they have issued, to the FXRP system. This will bring their Utilized Collateral to zero and their Remaining Collateral to 100% of their Spark Committed. They can then remove all of their Collateral from the FXRP system.

5 XRP-FXRP arbitrage

The convertibility of 1 FXRP for 1 XRP is the basis of the FXRP system and is further enforced by arbitrage criteria. Indeed, if the price steps out of line whilst there is sufficient collateral in the system, then it may be profitable to exploit the arbitrage criteria, which in aggregate will bring the price back into line.

Let XRP_price be the price of buying or selling XRP in some base currency, such as USD, and let FXRP_price be the price of FXRP in the same base currency. Profitable arbitrage occurs in two ways. First, when it is possible to create an amount of x FXRP, and sell it for more than the creation cost. Second, when it is possible to directly buy FXRP and redeem it for a greater XRP value than the purchase price and the fees.

This creates arbitrage bounds for the FXRP price relative to the XRP price beyond which it will be profitable to create or redeem FXRP, thus modifying supply and bringing the FXRP price back within any arbitrage bounds. This ensures that FXRP value will remain tightly coupled to the XRP price. This can be considered the theoretical fair value of the FXRP price relative to the XRP price (assuming the FXRP system is adequately collateralized).

5.1 Selling FXRP

In order to sell an amount of x FXRP, a quantity of x XRP must first be purchased, at a cost of $x \cdot \text{XRP\_price}$. Next, FXRP can be created at a cost of $x \cdot (\text{Creation\_Fee\_Rate} + 0.001)\text{XRP\_price}$ in USD, comprising of the creation fee and the collateral reservation fee. Finally, the created FXRP can be directly sold to an exchange at a cost of $x \cdot \text{FXRP\_selling\_cost} \cdot \text{XRP\_price}$ in USD, where FXRP_selling_cost is a percentage rate charged by exchanges for selling FXRP into the chosen base currency.

Thus, the total cost of creating an amount of x FXRP and selling it is

$$x \cdot \text{XRP\_price} + x \cdot (\text{Creation\_Fee\_Rate} + 0.001)\text{XRP\_price} + x \cdot \text{FXRP\_selling\_cost} \cdot \text{XRP\_price}, \quad (9)$$

The amount obtained in selling it is $x \cdot \text{FXRP\_price}$. Thus, it is profitable to create FXRP and sell it when

$$\text{FXRP\_price} > (1 + \text{Creation\_Fee\_Rate} + 0.001 + \text{FXRP\_selling\_cost})\text{XRP\_price}. \quad (10)$$

As a consequence, the supply of FXRP will increase, and should thus lead to a lower price of FXRP.

5.2 Buying FXRP

Alternatively, at times,it may be profitable instead to directly buy FXRP from an exchange and then redeem it. An amount of say y FXRP is directly purchased from an exchange, at a USD cost of $y \cdot \text{FXRP\_price} \cdot \text{FXRP\_buying\_cost}$, where FXRP_buying_cost is a percentage rate charged by exchanges for buying FXRP into the chosen base currency. The cost of redeeming it and obtaining XRP (or, in the event of agent redemption default, an equivalent value in Spark) is $y \cdot \text{Redemption\_Fee\_Rate} \cdot \text{FXRP\_price}$. Thus, the total cost is

$$y \cdot \text{FXRP\_price} \cdot \text{FXRP\_buying\_cost} + y \cdot \text{Redemption\_Fee\_Rate} \cdot \text{FXRP\_price} \quad (11)$$

The amount obtained in selling it is $y \cdot$ XRP_price. Thus, it is profitable to directly purchase FXRP and redeem it when

$$\text{XRP\_price} > (1 + \text{Redemption\_Fee\_Rate} + \text{FXRP\_buying\_cost})\text{FXRP\_price}. \quad (12)$$

As a consequence, the supply of FXRP will decrease, and should lead to an increase in the price of FXRP.

6 Governance

FXRP is governed by Spark token holders according to the governance system set out in [FN20]. Each Spark token equals one vote. Because different decisions have different impacts on FXRP, three decision rules are specified: *simple majority* (definition 6.1), *super majority* (definition 6.2) and *super super majority* (definition 6.3). Each of these places specific requirements on the number of Spark tokens participating in the voting process, as well as the number of votes for a proposition to pass.

Definition 6.1. For a *simple majority decision*, a proposition is confirmed if strictly more than 50% of Spark tokens vote in favor of it and there is a minimum turnout of 30% of total Spark tokens.

Definition 6.2. For a *super majority decision*, a proposition is confirmed if strictly more than 2/3rd of Spark tokens vote in favor of it and there is a minimum turnout of 50% of total Spark tokens.

Definition 6.3. For a *super super majority decision*, a proposition is confirmed if strictly more than 80% of Spark tokens vote in favor of it and there is a minimum turnout of 70% of total Spark tokens.

The variables are preset such that they fall into categories listed in table the table below. Changing the category of a variable requires a code update.

The table 2 shows decision categories for the automated variables.

Simple Majority	Super Majority	Super Super Majority
Creation Fee	Collateral Ratio	Change to General Operating Procedures
	Redemption Fee	Other code changes
	Collateral Reservation Fee	
	Collateral Call Band	
	Emergency Action	

Table 2: Decision Categories

953fbdd4ac2d5a2f1e413cbd378be0f3135010d81b4b643c6020e96ca49fc0c9

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