



Ripple Solutions Guide

Version 2.0

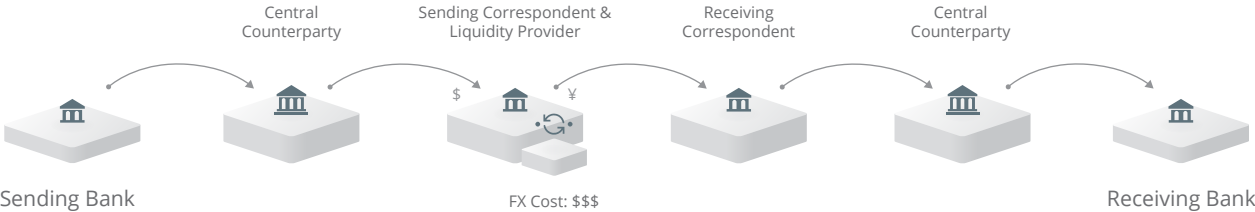
March 11, 2016

Ripple Overview

Ripple’s distributed financial technology allows banks to directly transact with other banks to settle transactions in real time. An alternative to today’s global payment infrastructure, Ripple eliminates time delays and ensures certainty of settlement, resulting in lower transaction costs for banks and their customers.

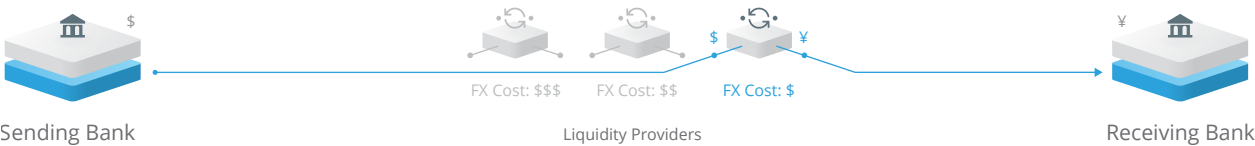
Today: Correspondent Banking

Cross-border payment networks today are fragmented and siloed, resulting in high processing costs, lengthy settlement times, and a poor customer experience. Cross-border payments have to be routed through a series of counterparties across a diverse set of messaging and settlement protocols. These inefficiencies in the system result in a total cost of \$1.6T¹ per year for all participants in the ecosystem – including payment originators, banks and liquidity providers.



Ripple: Direct Bank-to-Bank Settlement

Ripple bridges these siloed networks with a common global infrastructure that brings new efficiency to financial settlement by enabling real-time settlement, ensuring transaction certainty and reducing risk. It enables institutions to differentiate their cross-border payment services while lowering the total cost of settlement. It is designed specifically to meet the needs of financial institutions by fitting within their existing risk, compliance, and information security frameworks.



1 Ripple analysis across: World Trade Organization, *International Trade Statistics 2014*; Institute of International Finance, *Aggregate Capital Flows 2014*; Federal Reserve Financial Services, *Cross Border Payments, 2015*

Benefits

Access: Ripple provides direct access to a growing, global network of financial institutions and liquidity providers instead of relying on correspondent banking relationships for cross-currency settlement.

Certainty: Ripple's technology tightly integrates payments messaging with funds settlement, allowing for unprecedented visibility into a transaction's lifecycle.

Speed: Ripple's distributed technology enables banks to settle cross-border payments in real time allowing them to serve their customers in new ways with differentiated services.

Cost: Through Ripple, banks can lower their cost of cross-currency settlement by minimizing settlement risk and operational costs.

Use Cases

Direct bank-to-bank settlement allows banks to introduce highly differentiated products and services to their customers, meeting the demand for faster, low-cost, global payments. Banks with internal FX market making capabilities can integrate Ripple into their FX operations for a full-stack solution.

International Transaction Banking Service:

With the ability to settle funds internationally in real-time, banks can repackage and provide this service to other regional banks to serve their customers. Banks can serve as a correspondent bank for Ripple transactions.

International Corporate Payments: Banks can offer real-time, on-demand international payment services for their corporate customers, enhancing their corporate treasury solutions portfolio and allowing their corporate customers to achieve superior working capital management.

Cross-Border Intra-Bank Currency Transfers:

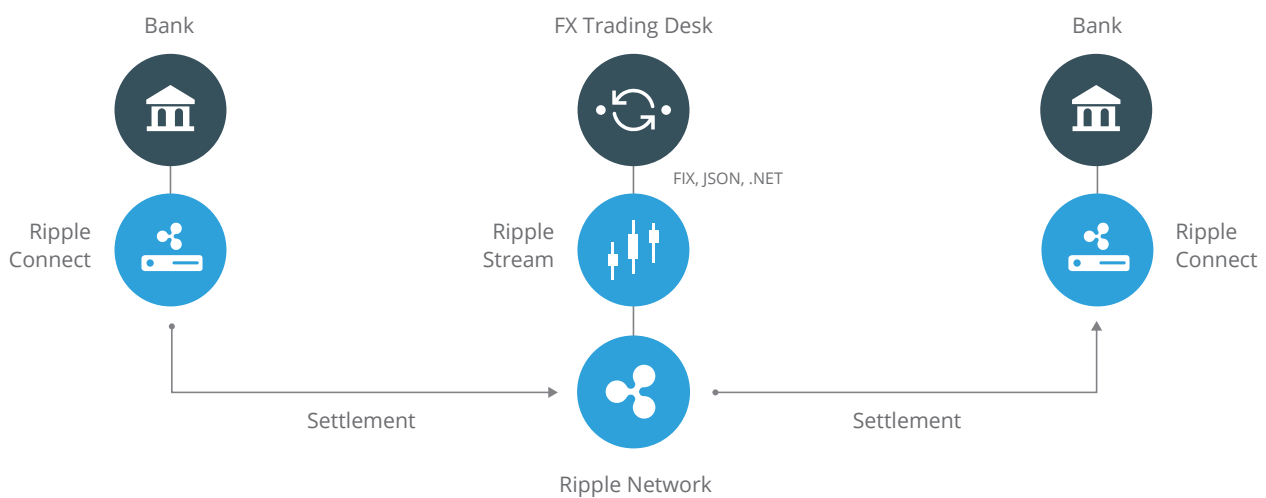
Banks with branches in different countries can use Ripple to transfer funds between their entities in different countries at a fraction of the time and cost, allowing the bank's treasury to allocate capital more efficiently across international operations.

Remittance Service for Retail Customers:

Ripple's real-time settlement and complete transaction traceability lowers the total cost of settlement, enabling banks to profitably offer low-value international payments to their retail customers.

Solution Overview

Ripple's solution is built around a network that requires no central operator, resulting in instant transaction verification and settlement certainty. It offers a cryptographically secure end-to-end payment flow with transaction immutability and information redundancy. Ripple is designed to comply with your bank's risk, privacy and compliance requirements. It is architected to fit within your bank's existing infrastructure, resulting in minimal integration overhead and business disruption.



There are three key components to a full-stack solution for banks:

Ripple Connect

Ripple Connect is a plug-and-play module that processes international payments for banks. It connects to the receiving bank's Ripple Connect to exchange KYC and risk information, fees, payment details and expected time of funds delivery. It communicates with the Ripple network to get the lowest currency quotes. It packages this information and presents the entire cost structure to the sending bank, providing unprecedented visibility into the total costs of the transaction. Once the sender approves the transaction, it interfaces with the Ripple Network to settle the trade and notifies all parties of the transaction confirmation.

Ripple Stream

Ripple Stream is an interface for liquidity providers (the bank's FX desk) to submit bid/ask offers to the Ripple network. It uses FIX and .NET APIs to plug into the liquidity provider's existing systems, allowing for an easy interface with their trading clients.

The Ripple Network

The Ripple network contains the Ripple Consensus Ledger (RCL), a secure distributed ledger that uses the consensus process to settle transactions. Because of its distributed nature, it does not require a central operator, and offers transaction immutability and information redundancy. RCL holds the order book with bid/ask offers from payment initiators and liquidity providers. Its path-finding algorithm enables it to find the lowest foreign exchange rate across all order books and currency pairs.

Product Overview: Ripple Connect

Ripple Connect, a component of Ripple's cross-currency settlement solution, integrates the internal systems of financial institutions to the decentralized Ripple Consensus Ledger (RCL), which operates on the Ripple network. This connection enables real-time settlement, which banks can use to process international payments. Additionally, Ripple Connect provides a way for banks to exchange KYC and other compliance information, fees, and the estimated delivery time of the payment before the payment is initiated. The payment data that is exchanged through Ripple Connect can be used to meet jurisdiction-specific regulatory needs and other enhanced services.

How it Works

To send an international payment with Ripple Connect, the sending bank requests a quote from the receiving bank. The receiving bank responds with their fees and any PII or other data that the sending bank requested. Then Ripple Connect queries the RCL to get the best available FX rate for the payment and constructs a quote that is presented to the initial sender to accept or reject. After the sender accepts the quote, the sending bank executes an internal book transfer to debit the funds from the sender, then settles the payment through RCL to the receiving bank. Both banks monitor the RCL for the transaction. When the receiving bank sees that the transaction is in a validated ledger on the RCL, the receiving bank executes an internal book transfer to deliver the funds to recipient. Throughout the entire process, either bank can query the state of the payment at any time because each payment is assigned a unique identifier.

Key Features

The key features of Ripple Connect include:

Pre-transaction Communication: Financial institutions can provide transaction fees, delivery time, FX rate, and PII data about the sender and receiver before executing the payment.

Fee Transparency: Ripple Connect allows financial institutions to disclose the total cost of payment (including the processing fee charged by the sending and receiving institutions) to the sender before executing the payment.

Funds Settlement with Unique Identifier: Each end-to-end payment has a payment ID that can be used to query the status of the payment at any point, including funds settlement.

Configurable Fees: Financial institutions can set fees for payments made with Ripple Connect.

Payment Delivery Confirmation: Financial institutions receive confirmation when the funds are delivered to the final receiver.

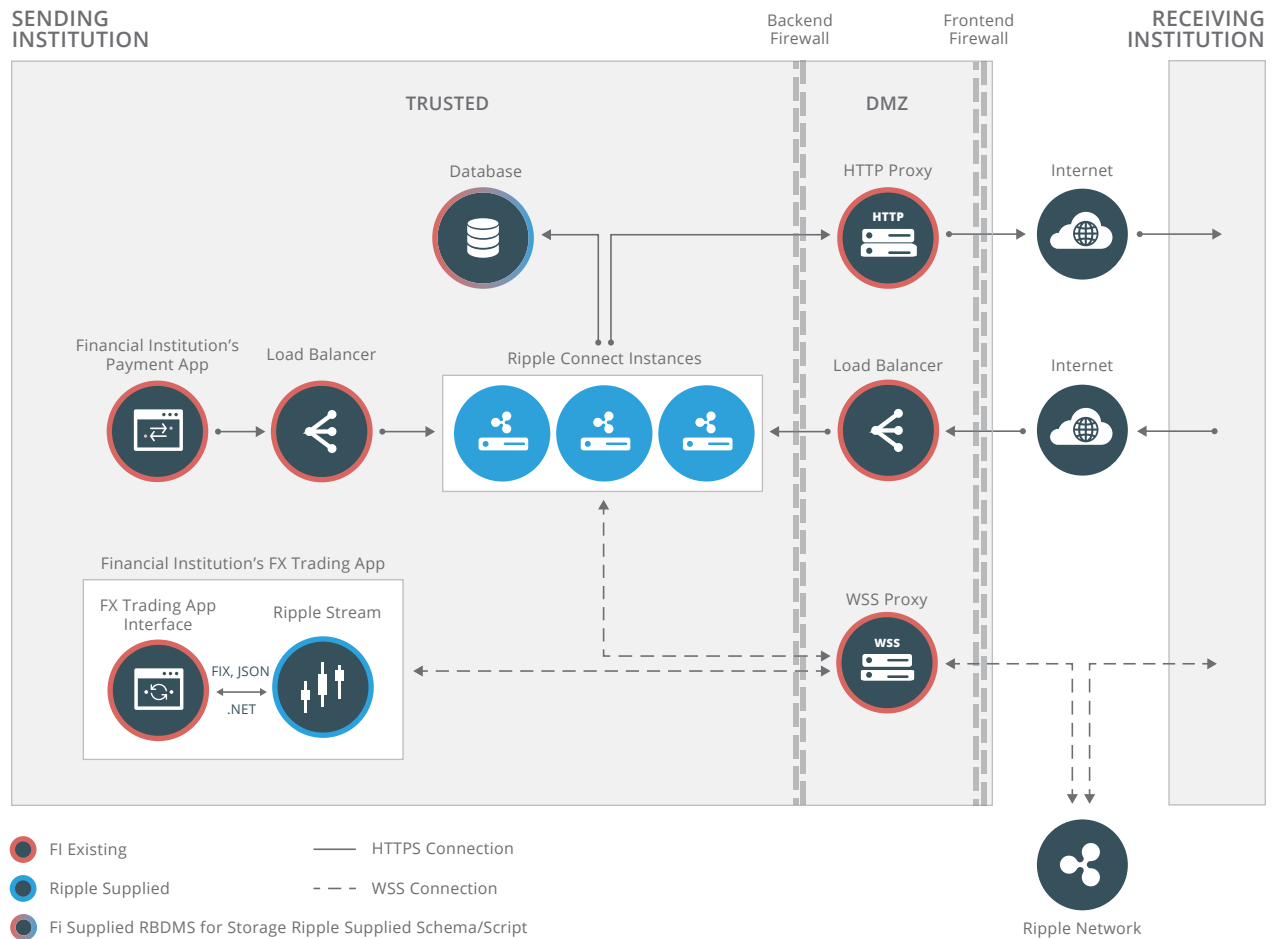
Secure Communication: Ripple Connect uses Transport Layer Security (TLS) v1.2 to communicate with existing financial institution systems and corresponding Ripple Connect instances.

End-to-end Transaction Visibility: Both the sending and receiving financial institution have full visibility into the state of the payment, reducing lost or stuck payments.

Liquidity Access: Financial institutions can access liquidity provided by trusted providers from around the world.

Architecture

Ripple Connect is typically installed on-premises behind the corporate firewall of a financial institution, with a load balancer handling inbound connections and a proxy server handling outbound connections. You can deploy multiple instances of Ripple Connect behind the load balancer to scale to your volume of payments, as long as the load-balanced Ripple Connect instances share the same database. The typical deployment architecture of Ripple Connect at a financial institution includes the following:



- Financial institutions' internal systems communicate with Ripple Connect's RESTful APIs over secure HTTPS connections using OAuth 2.0 for authentication.
- The Ripple Connect instances at corresponding partner institutions conduct pre-transaction communication over HTTPS. Pre-transaction communication allows partners to identify beneficiaries, exchange PII, transaction fees, delivery times, jurisdictional information, and more.

- To get the best available FX rates for each payment, Ripple Connect queries the Ripple Consensus Ledger (RCL) using a secure WebSocket protocol (WSS) connection.
- Ripple Connect connects to the the Ripple Consensus Ledger over WSS to settle payments in near real-time on the RCL. Financial institutions can connect to the Ripple network through a publicly accessible instance of rippled (the software on which the Ripple Consensus Ledger operates) or through a rippled instance dedicated to the financial institution.
- Financial institutions can optionally host a rippled server in a private infrastructure that communicates with the Ripple network over TLS.

Technical Requirements

Operating System	Red Hat Enterprise Linux (RHEL) 7.1 or 6.7
SELinux	Ripple recommends that SELinux be set to: <ul style="list-style-type: none"> • SELINUX=enforcing • SELINUXTYPE=targeted See Enabling and Disabling SELinux in the official Red Hat documentation for more information about enabling SELinux.
OS Dependencies	pkgconfig, ntp, ntpdate, openssl-devel, openssl, psmisc, sysstat, python, expect
Architecture	x86 (64-bit)
RAM	4 GB
CPU	2 Cores
Storage	50 GB
Supported Database Connections	<ul style="list-style-type: none"> • PostgreSQL • Microsoft® SQL Server® 2012
Deployment Options	RPM
RPM Dependencies	Node.js v0.12

Product Overview: Ripple Stream

Ripple Stream is an order book management system that enables FX trading desks to use industry-standard tools, such as FIX, to facilitate FX markets on the Ripple Consensus Ledger (RCL). Ripple Stream provides an interface for trading desks to place the bid/ask orders on the RCL that provide the foreign exchange to enable cross-currency payments. Ripple Stream is designed to integrate with the bank's existing trading interface using FIX or JSON APIs. It can also be integrated as a .Net library into the bank's trading client.

How it Works

Ripple Stream opens a WebSocket connection to the Ripple Consensus Ledger (RCL) to provide a stream of information on the RCL. With Ripple Stream you can subscribe to events on the RCL, and create, modify, and cancel orders on the RCL.

Ripple Stream uses the same WebSocket connection to submit transactions such as new orders, order modifications, and order cancellations to Ripple. Ripple Stream remembers the orders that have been submitted and provides instant updates as soon as those orders are partially or fully executed on the RCL.

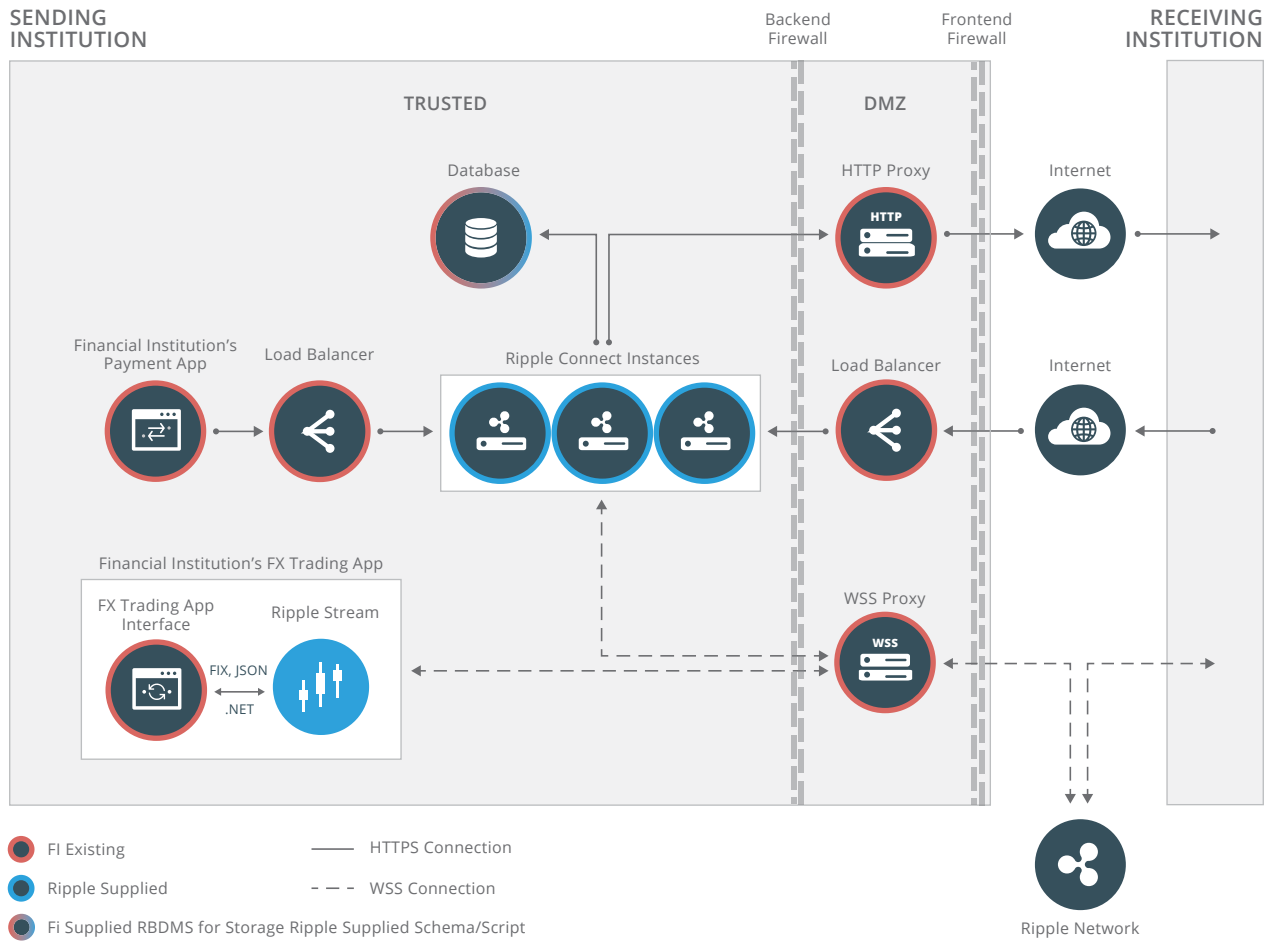
Key Features

The key features of Ripple Stream include:

- | | |
|--|---|
| Access: Volume for global cross-currency payments on the Ripple network initiated by the bank. | Compatibility: Ripple Stream works with existing trading clients via FIX, JSON APIs, and a .NET library interface. |
| Minimized Risk: Minimal FX exposure through real-time settlement; lowered counterparty risk through real-time trade confirmation. | Settlement: Funds settlement in near real-time. |

Architecture

Ripple Stream is typically installed on-premises behind the corporate firewall of a financial institution and integrated into the financial institution's existing trading application through a FIX, a .NET library, or JSON API. Ripple Stream uses a secure WebSocket protocol (WSS) connection to communicate with the Ripple Consensus Ledger (RCL). This connection provides real-time market data to the financial institution's existing FX trading applications. Ripple Stream uses the same WSS connection to monitor the RCL for changes to orders placed by the trading desk, changes to order books, and changes to specific accounts.



Technical Requirements

Operating System	Windows
OS Dependencies	n/a
Architecture	x86 (64-bit)
RAM	8 GB
CPU	1 Core
Storage	60 GB
Supported Database Connections	n/a
Deployment Options	FIX (hosted/local), JSON (Web Server), .NET (.dll)

The Ripple Network

The Ripple network is a shared public ledger administered collectively by a network of servers. This ledger tracks the accounts and balances of Ripple users. Within the Ripple Network, all transactions are authorized and settled through a process called consensus. This process entails a supermajority of Ripple servers mutually agreeing that a transaction within the network is valid before updating the ledger.

Ripple servers use public/private key cryptography to verify whether transactions are valid. Each transaction that gets submitted is signed with a unique digital signature, analogous to how people sign paper checks with a unique signature in traditional banking. Ripple servers mathematically verify that the correct signature appears – the signature of the owner of the funds – before including transactions in a new ledger.

Consensus must be reached among a supermajority of connected computers in order to make changes to the ledger. This is what is known as an atomic process – either a transaction is completely verified, or not.

This process is what enables the Ripple Network to offer users real-time settlement (typically between 3 to 6 seconds) and bypass the need of a central operator, which as explained above, circumvents layers of fees that financial institutions, business and/or consumer bear for traditional payments. In other words, the process of consensus is what enables fast, secure and decentralized settlement on the Ripple network.

This distinguishes Ripple from other digital currency protocols, such as Bitcoin, which rely on a process called proof of work (i.e. mining) to validate transactions on the block chain. Unlike Bitcoin, Ripple does not rely on mining to reach consensus, so it does not consume the large amounts of energy that Bitcoin does, nor is the network's security related to the amount of processing power devoted to it. For a more detailed explanation of the consensus mechanics, please refer to the Consensus White Paper on ripple.com/whitepapers-reports.

How it Works

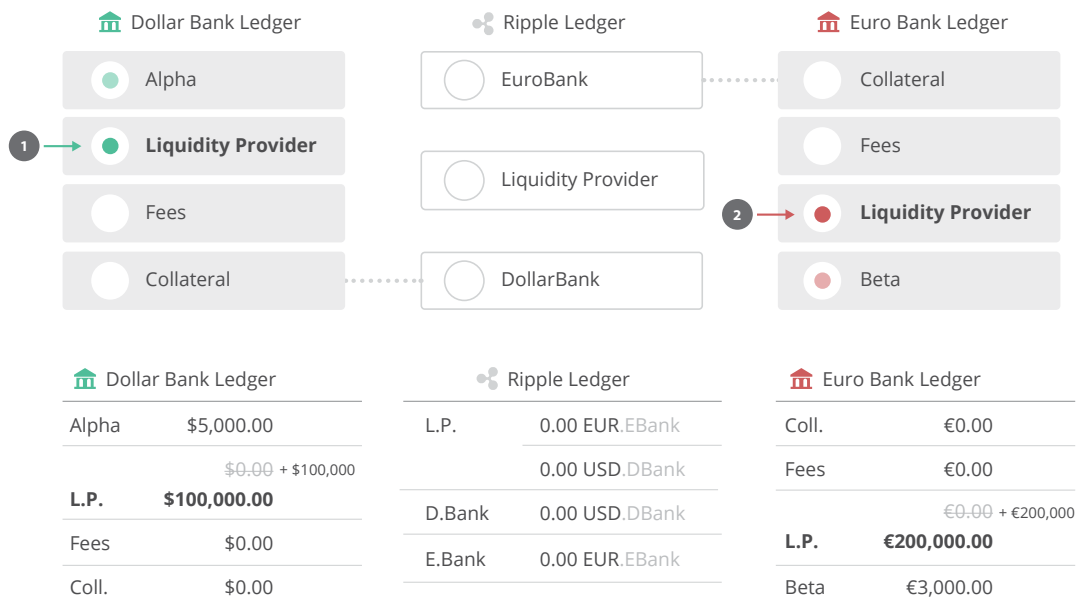
Flow of Funds

This section will use an example payment to demonstrate the flow of funds through Ripple. In this example, Alpha Corp (in the U.S.) needs to pay Beta Corp (in the Euro Zone) a total of €100. Alpha Corp has an account with Dollar Bank in the U.S. and Beta Corp has an account with Euro Bank in the E.U. Both banks are integrated with Ripple.

SETUP

To enable cross-currency flows on Ripple, banks can leverage their existing nostro/vostro relationships with other banks and provide liquidity through their FX trading desks, or can use external market makers to provide FX liquidity for exotic currency corridors. This example will refer to that function as the liquidity provider (whether it is the bank's FX organization or an external market maker).

As part of the setup process, the liquidity provider ensures both bank accounts are pre-funded with the local currencies.

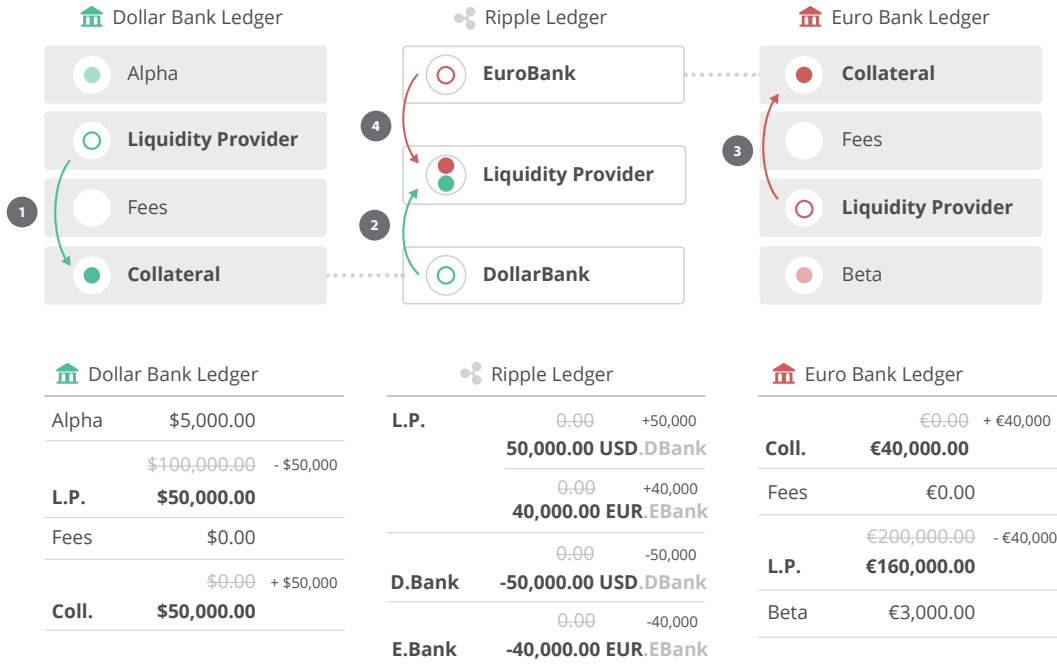


Each bank sets up a collateral account, the balance of which is reflected on the Ripple ledger. Any contribution that a liquidity provider makes to the collateral account is reflected in the liquidity provider's account on the Ripple ledger. The Ripple ledger tracks the obligation of the bank to the

liquidity provider for FX liquidity. In this case, the Dollar Bank has an obligation of \$50,000 to the liquidity provider on the Ripple ledger.

Similarly, the liquidity provider funds the collateral account at Euro Bank for the EUR funds to be reflected on the Ripple ledger. The Ripple ledger reflects this €40,000 obligation to the liquidity provider.

Once the collateral accounts are funded, the liquidity provider posts an FX order on the Ripple ledger. In this case, let's assume the offer is EUR/USD at 1.1429.

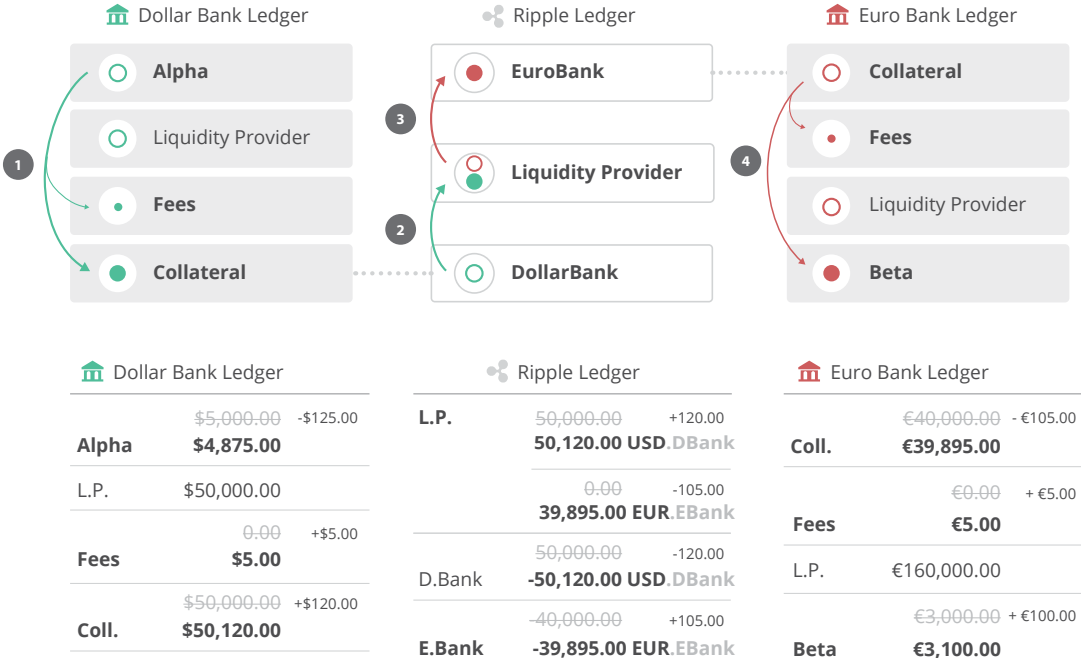


PAYMENT (INTEGRATED MESSAGING AND SETTLEMENT) FLOW

When a payment is initiated by Alpha Corp, the Ripple Connect instances at both banks exchange information about Alpha Corp. and Beta Corp. for KYC/AML checks and sanctions screening. These CIP/PII fields are entirely configurable by both banks. The sending Ripple Connect also queries the receiving bank for the processing fees that the receiving bank would charge to post the payment for Beta Corp. It also gets the exchange rate from the order book. In this case, it is EUR/USD at 1.1429.

The sending bank's Ripple Connect compiles this information, adds the sending bank's processing fees and presents the bank with the "all-in cost" of the transaction. Assuming that the sending bank's fees are \$5, the receiving bank's fees are €5, and the EUR/USD rate at 1.1429, the total cost of sending €100 to Beta Corp would be \$125.

Once Alpha Corp accepts the charge, the payment is initiated. Dollar Bank debits Alpha Corp's account to the amount of \$125, collects the \$5 fee and credits the collateral account \$120.



The EUR/USD trade is executed on the Ripple ledger.

The liquidity provider's and the bank's balances are updated on the Ripple ledger to show an increased obligation in the amount of \$120 by the Dollar Bank to the liquidity provider and a decreased obligation in the amount of €105 by the Euro Bank. This is an atomic process, meaning that both intra-bank settlement legs of the transaction happen simultaneously, to eliminate the 'one-leg' risk.

Once the transaction is settled on the Ripple ledger, Euro Bank collects the €5 fee and posts €100 to Beta Corp's account.

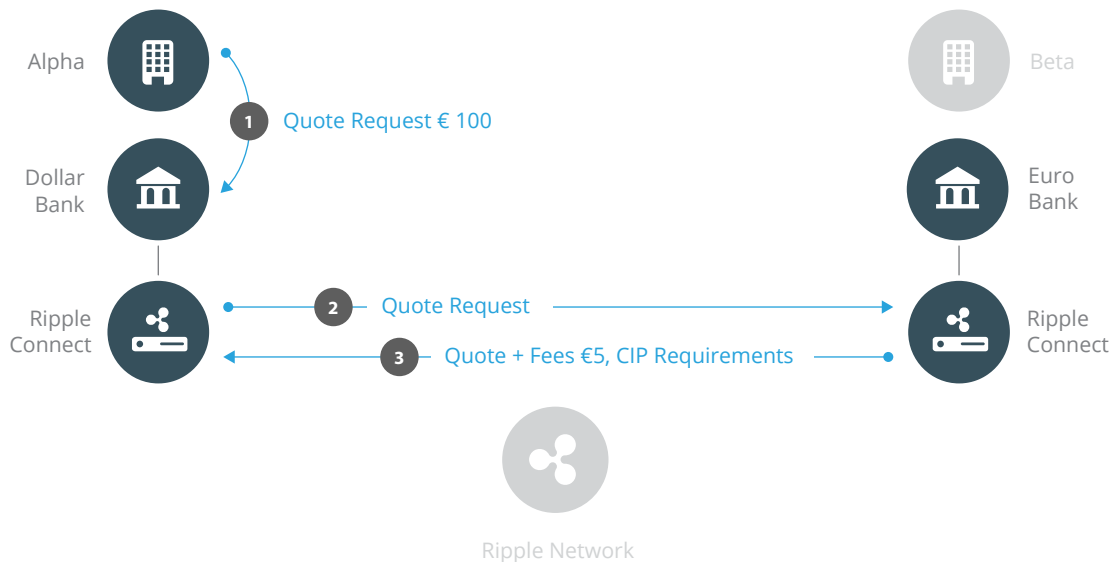
Once the funds are posted on the recipient's account, Dollar Bank is notified so that it can deliver a confirmation of beneficiary fund receipt to Alpha Corp.

API Process Flow

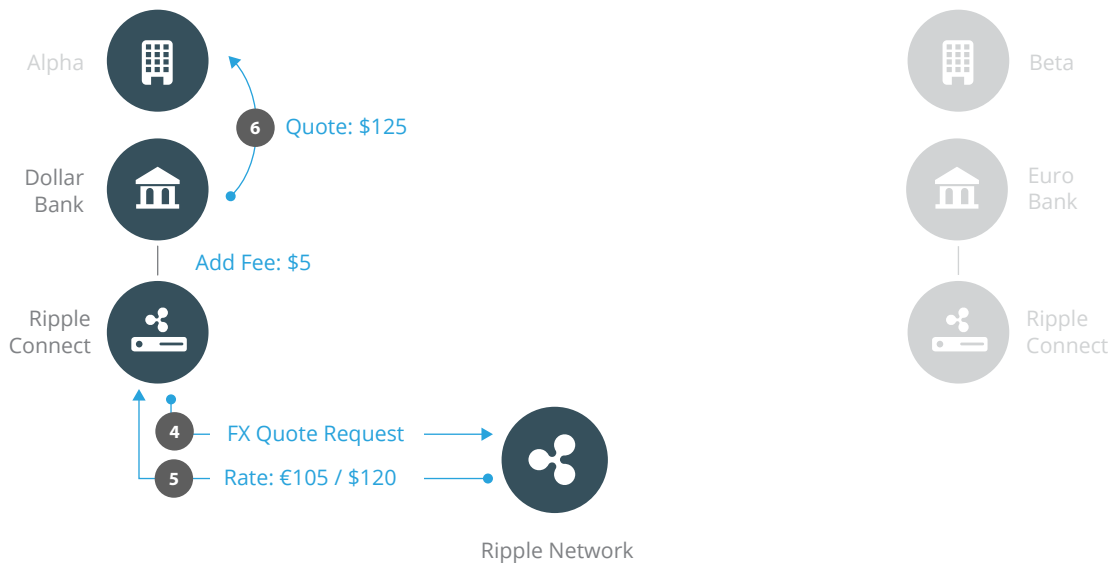
The payment described above involves the following steps for the API process for Ripple Connect:

QUOTING PROCESS

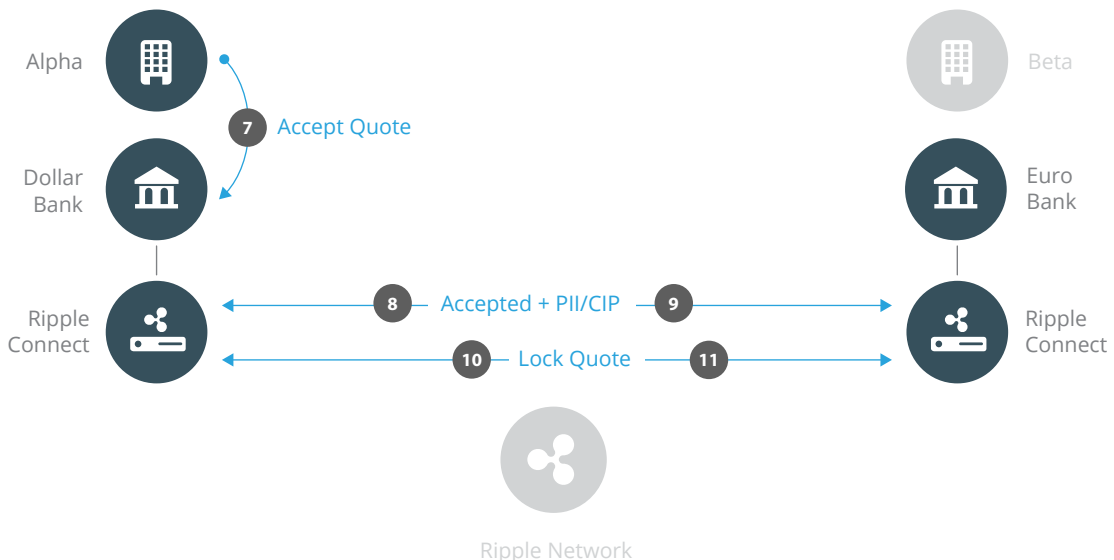
1. The initial sender requests a quote from the sending institution. The sender supplies the following information:
 - a. Sender. For example, acct:alpha@sender_bank.com
 - b. Final receiver. For example, acct:beta@receiver_bank.com
 - c. Amount to be received. For example, 100.
 - d. Currency to be received. For example, EUR.
2. The Ripple Connect instance at the sending institution requests a quote from the receiving institution
3. The Ripple Connect instance at the receiving institution replies with its portion of the payment contract, which includes its fees (€5), and requests for any information required from the sending connector (for example, CIP or other customer metadata required to comply with local jurisdictional requirements).



4. The Ripple Connect instance at the sending institution (the sending connector) queries the Ripple Network to get the FX rate for the payment.
5. Gets quote from Ripple Network
6. The sending institution constructs its portion of the payment, including its fees (\$5).



7. The initial sender is given the opportunity to review and approve the quote.
8. The sending institution then submits an Accept Quote request, providing any of the additional information (such as PII) requested by the receiving institution in the body of the request. The body of the request also contains requests for any additional information (such as PII) that the sending institution requires to process the payment.
9. The receiving institution verifies the additional information provided by the sending institution and assigns a unique payment ID to the payment object. The receiving institution responds to the Accept Quote request with the payment object in an "accepted" state.
10. The receiving institution polls its Ripple Connect instance for payments in an "accepted" state, retrieves any additional information (such as PII) requested by the sending institution, and submits a Lock Quote request.
11. The sending institution verifies the additional information it requested from the receiving institution, and responds with the payment object in a "locked" state.

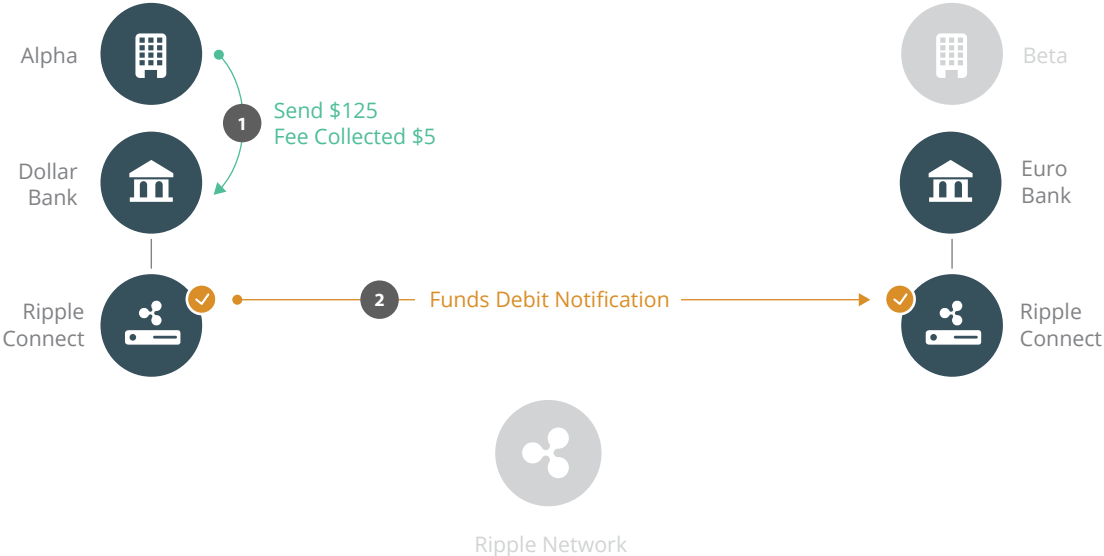


Both institutions now have an identical payment object in a locked state, with all the information that both institutions need to execute the payment.

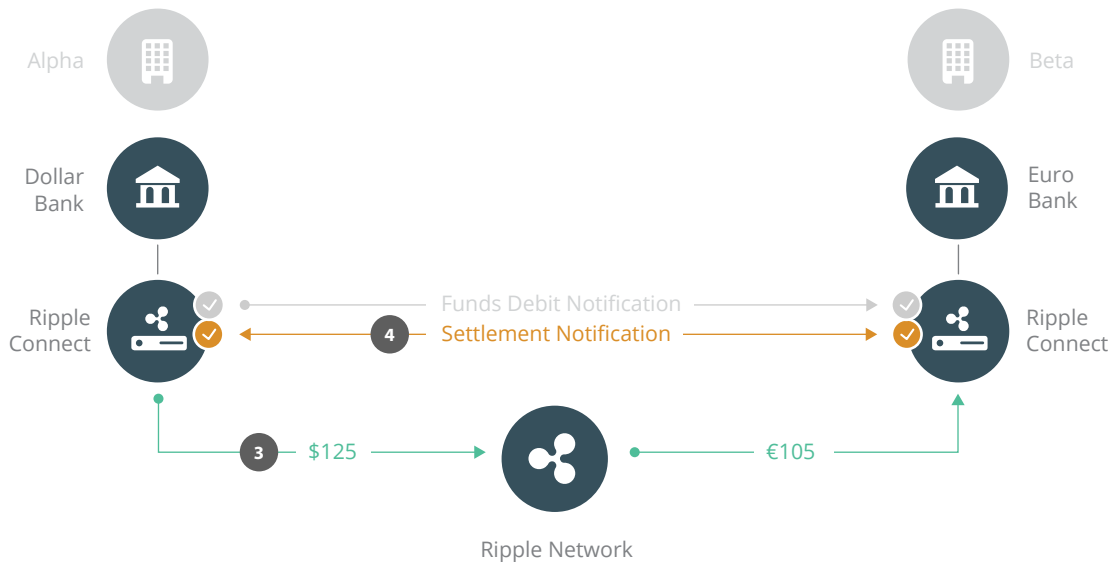
PAYMENT PROCESS

After both banks accept the quote, the sending institution can send the end-to-end payment, which is comprised of three sub-payments: sending, settlement, and receiving.

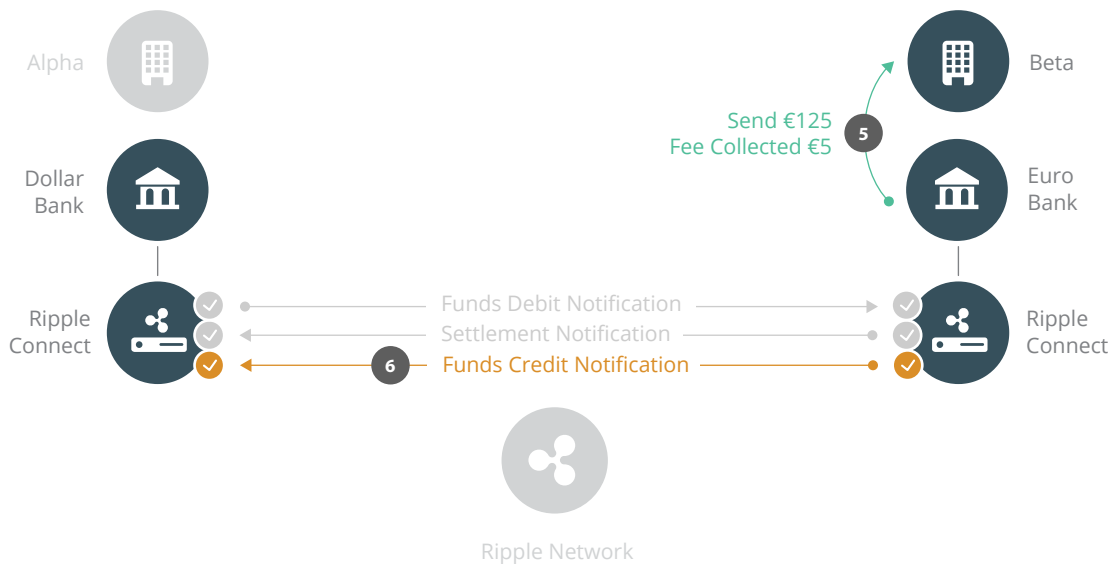
- 1. The sending institution debits the sender's account and credits its own (that is, the sending institution's) collateral account. This is the sending payment (\$120 for the payment and \$5 for the fee).
- 2. The sending institution sends a notification to the receiving institution that the funds have been debited from the sender's account and credited to the sending institution's collateral account.



- 3. The sending institution then sends a Ripple payment to the Ripple Network for settlement. Once settled, the receiving institution's Ripple Connect is notified.
- 4. The sending institution notifies the receiving institution that the settlement payment has been sent.



5. The receiving institution debits its collateral account and credits the final receiver's account. This is the receiving payment.
6. The receiving institution notifies the sending institution that the receiving payment has been delivered to the final receiver.



The payment is now complete. Alpha Corp. sent 125 USD and 100 EUR was delivered to Beta Corp's account.

Impact on Compliance

Ripple as a Technology Service Provider

Ripple delivers licensed software and integration services that enable clients to facilitate real-time payments. In the scope of this activity, Ripple may be considered a vendor or third-party technology service provider; however, this categorization and any resulting regulatory requirements vary depending on the specific laws of each country.

Financial institutions often rely on third-parties for technical services and may have internal programs to ensure the prudent management of these vendors. These programs and their due diligence standards are often unique to each institution, reflecting its operations, size, complexity and risk controls. Depending on the country, such programs are recommended or required by some regulators. Generally, as a third-party technology service provider, Ripple may be subject to these vendor management program requirements of its financial institution clients.

Aside from meeting the financial institution's vendor management requirements, Ripple may be subject to a regulator's oversight, approval and examination, depending on the rules of each country.

The regulatory treatment of Ripple is dependent on several factors, such as:

- the type client being serviced (including its type of license, charter, and designation)
- country of integration and geographic scope of operations
- volume and scope of activity enabled through the software provided
- level of dependency on the software provided, and
- other factors determined by the financial institution or regulator.

Over the past two years, Ripple has engaged with central banks and regulators globally to educate them on distributed networks. As business engagements are formalized, Ripple works with each financial institution to identify and meet all relevant regulatory requirements ahead of integration.

KYC and AML Compliance Processes

Use of Ripple for payments does not impact a financial institution's compliance responsibilities. Recognizing this, Ripple's products are designed to complement a financial institution's existing customer onboarding, due diligence and transaction monitoring programs.

When using Ripple, a financial institution's customer onboarding and Know Your Customer (KYC) processes remain unchanged. The financial institution maintains full responsibility for ongoing compliance with Anti-Money Laundering (AML) and Office of Foreign Assets Control (OFAC or, more broadly, "sanctions") legislation and regulations. Financial institutions are also responsible for ongoing monitoring of transactions conducted through Ripple in accordance with their existing transaction monitoring program requirements. U.S. Financial institutions also maintain responsibility for compliance with foreign correspondent account recordkeeping and due diligence requirements specified under Section 312 of the USA PATRIOT Act. Use of Ripple does not alter these obligations of the financial institution.

The messaging capability within Ripple Connect enables financial institutions to comply with U.S. Travel Rule requirements. It also enables upfront fee negotiation to assist with Regulation E pre-payment disclosure obligations (Section 1073 of the Dodd Frank Act). The direct, two-way communication between sending and receiving financial institutions allows for the secure transfer of additional data about the payment, its sender and its recipient.

While the financial institution's compliance with AML and sanctions obligations remains unchanged, the timing of its sanctions screening activities may need to be altered given the real-time nature of Ripple transactions. To capitalize on the speed at which transactions are conducted over Ripple, financial institutions may wish to augment their sanctions screening processes to pass this benefit on to their customers. This consideration is institution-specific, dependent on the capabilities, speed, and compliance policy of the financial institution.

Fee Pre-disclosure

Ripple enables financial institutions to have complete clarity into the fees and FX cost of the payment before initiating the transaction. This transparency allows the financial institution to accurately quote the total cost of sending the payment to the consumer before sending the funds.

Fee transparency on Ripple is a significant advantage over payment systems today, which do not provide visibility into the total cost before sending the payment. Ripple's ability to pre-disclose all fees prior to sending the payment not only improves the customer experience, but also enables compliance with laws in some countries, specifically the United States.

Security on Ripple

Using Ripple, your customers' data remains private and secure, behind your bank's firewalls. Financial transaction history is recorded on the Ripple ledger; however, transactions are not linked to any identifiable information and cannot be directly associated with any individual account or your financial institution. Transaction values and fees represent the only information recorded on the public ledger. In addition, Ripple is releasing a private ledger version for financial institutions in which no information is tracked on a public record.

Cryptographic Security

Financial transactions on Ripple are signed using industry-standard cryptographic algorithms ECDSA and ED25519. Only your financial institution can cryptographically sign for your transactions — no other institution or individual can do it on your behalf. Ripple servers use public/private key cryptography to verify whether transactions are valid. Each transaction that gets submitted is signed with a unique digital signature, analogous to how people sign paper checks with a unique signature in traditional banking. Ripple servers mathematically verify that the correct signature appears – the signature of the owner of the funds – before including transactions in a new ledger.

Payment Data Separation

Implementing a payment system on Ripple provides a layer of separation and security between payment data and settlement data. While financial transactions are on the Ripple Consensus Ledger, the actual payment data is encrypted and shared only between the two institutions making payments to each other. Payment data such as the following is stored and maintained in an internal application database private to the sending and receiving institutions while mapping back to financial transactions that occur on Ripple:

- Identifiers for originators and beneficiaries
- Required PII/CIP information for originator and beneficiary
- Additional payment information such as invoice numbers
- Misc. data and memo data
- Additional fees

Secure Communication

Financial institutions' internal systems will communicate to Ripple Connect over secure HTTPS connections using OAuth 2.0 for authentication. All traffic between Ripple Connect instances at corresponding partner institutions conduct pre-transaction communication over HTTPS as well. Ripple Connect connects to the the Ripple Consensus Ledger over WSS (Secure websockets) to settle financial transactions in near real-time on the Ripple Consensus Ledger. Again using secure websockets, financial institutions can connect to the Ripple network through a publicly accessible instance of rippled (the software on which the Ripple Consensus Ledger operates) or through a rippled instance dedicated to the financial institution. Lastly, the Ripple network leverages TLS to ensure communication is secure between all the nodes on the network.

About Ripple

Ripple provides global financial settlement solutions to ultimately enable the world to exchange value like it already exchanges information – giving rise to an Internet of Value (IoV). Ripple solutions lower the total cost of settlement by enabling banks to transact directly, without correspondent banks, and with real-time certainty of settlement. Banks around the world are partnering with Ripple to improve their cross-border payment offerings, and to join the growing, global network of financial institutions and market makers laying the foundation for the Internet of Value.

Ripple is a venture-backed startup with offices in San Francisco, New York and Sydney. As an industry advocate for the Internet of Value, Ripple sits on the [Federal Reserve's Faster Payments Task Force Steering Committee](#) and co-chairs the [W3C's Web Payments Working Group](#).

Contact Us

To learn more about how your financial institution can be Ripple-enabled, please contact us at ripple.com/contact

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