



Welcome to the 2nd
Interledger Workshop

July 6, 2016 @ Level39



Interledger

Intro to the Project

Adrian Hope-Bailie

Live Stream: <https://bluejeans.com/795795755>

IRC: **irc.w3.org #interledger**

(to get on the queue to ask a question type q+)

Wifi: **L39-Visitor**

Tweet **@interledger** or use the hashtag **#interledger**

Agenda For Today

09:15 - 09:30 Intro to the Interledger project

09:30 - 10:00 An Interledger Overview

10:00 - 10:45 ILP Packet, Addressing and Routing

10:45 - 11:00 Coffee/Tea break

11:00 - 11:45 Building with ILP: The Stack, Ledger Plug-Ins and “Trustlines”

11:45 - 12:00 Application/Setup Protocols and the W3C Web Payments activity

12:00 - 13:00 Lunch

13:00 - 13:30 Weaving the ILP fabric into BigchainDB

13:30 - 14:00 Demonstrating Real-Money Payments using ILP

14:00 - 17:30 Interledger Hackathon (Coffee/Tea/Snacks available throughout)

What Is the Interledger project?

Interledger Project (interledger.org)

- Community-developed protocol(s) for connecting payment networks
- A vision for the Internet of Value

W3C Community Group (w3.org/community/interledger)

- Co-chaired by:
 - Adrian Hope-Bailie (Ripple) and
 - Dimitri De Jonghe (Ascribe/BigChainDB)
- Mailing list, IRC, Blog, Member Management



A Little History

October 2015	Published the Interledger White Paper
November 2015	Launched Interledger Community Group at W3C (190+ participants)
February 2016	First workshop in San Francisco (50+ attendees)
February 2016	First draft of Crypto-conditions RFC
March 2016	First draft of Architecture Overview (ILP - RFC 1)
June 2016	Re-launch of interledger.org website
July 2016	Second workshop in London (150+ attendees)
July 2016	IETF Berlin - BoF session - Thursday 21 July at 16:20



Interledger

An Overview

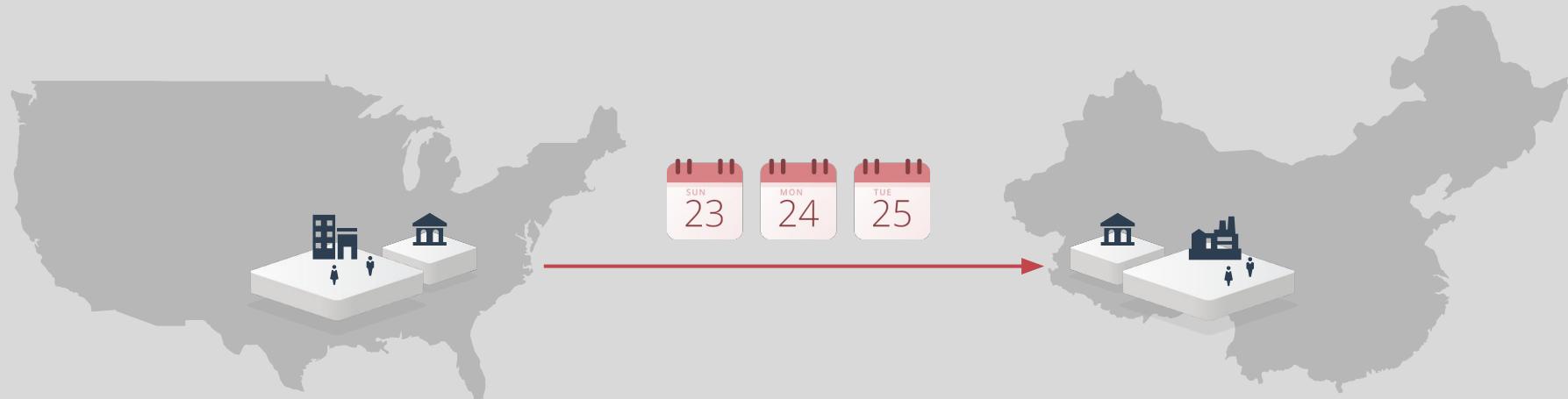
Stefan Thomas



The State of Payments Is Sad.

Today's Infrastructure

Designed for High Value or Batch Payments



Low-Volume High-Value Slow Batch Payments

A System From a Different Time

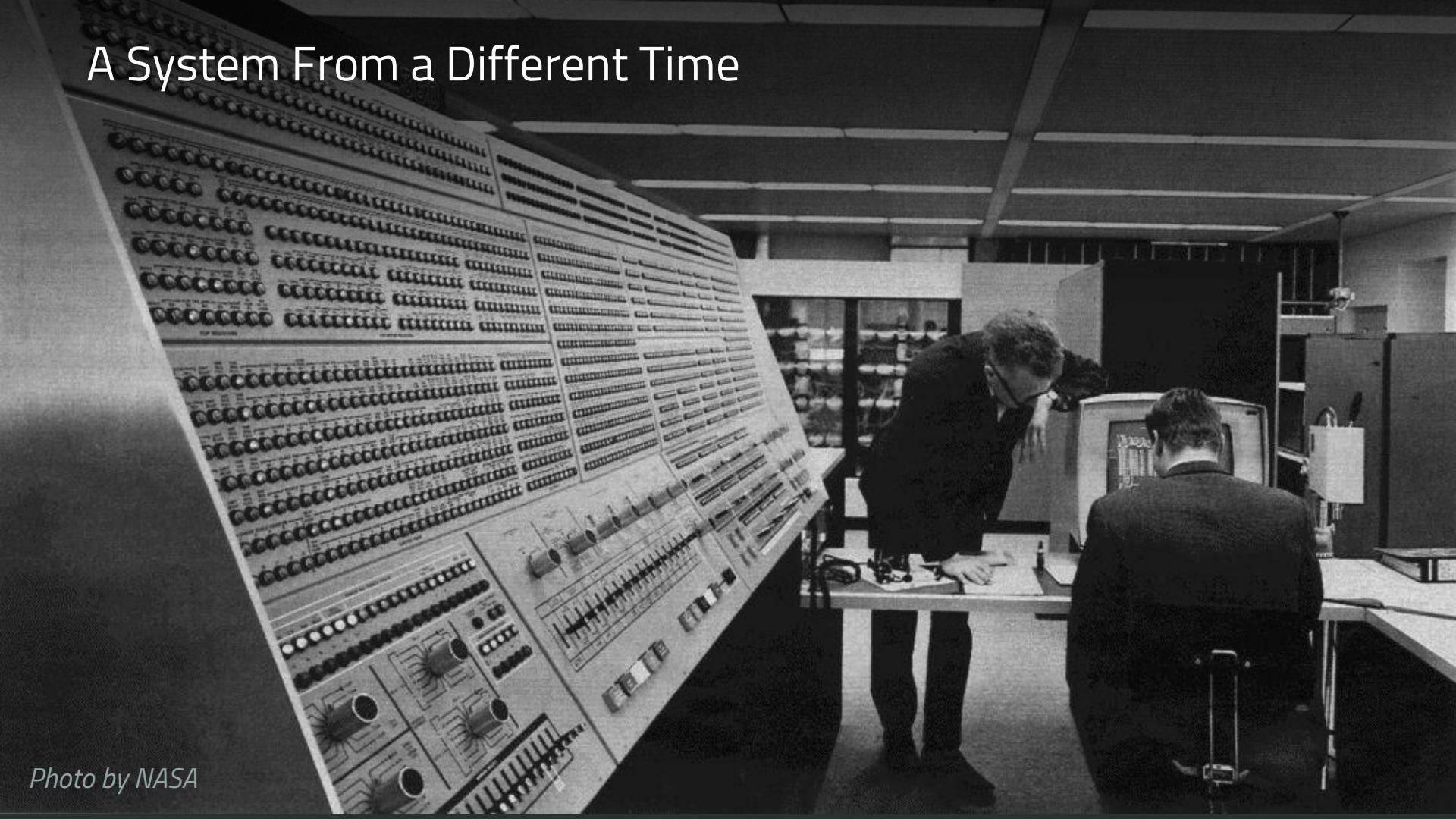


Photo by NASA

Where Is The Competition?



Photo: CountryStyle Photography



Plenty of Innovation



Accepted Payment Methods

Prineta.com

But: Global Reach Is Prohibitively Expensive

Nostro account costs: liquidity, regulations, operations, risk and compliance

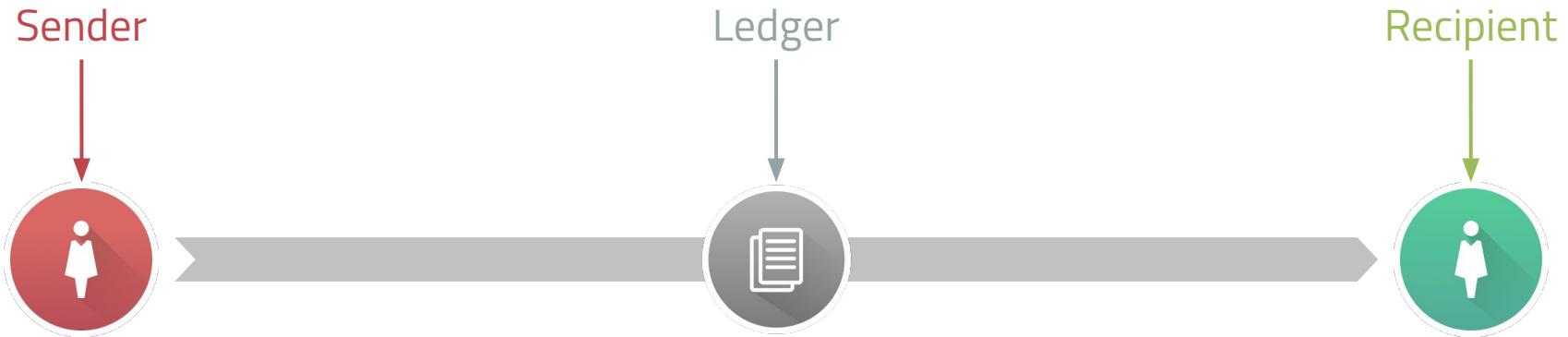


BACK TO
BASICS

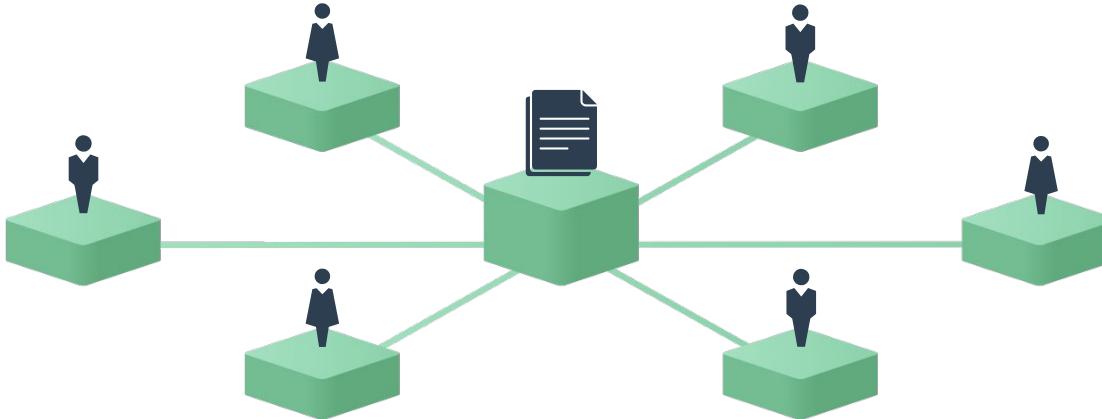


John *Hudson*
the Hudson *25*
Lake *2.* *8.*
✓ 27. 8.

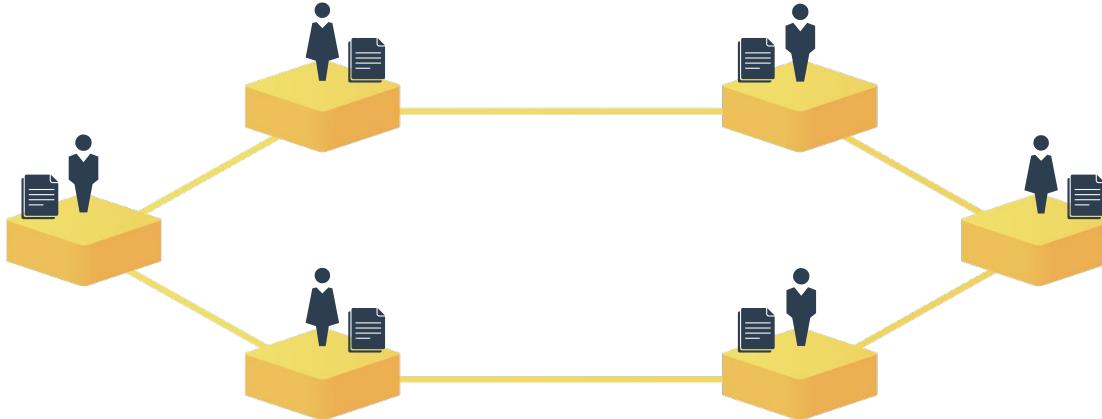
Ledgers Track Accounts and Balances



Central Ledger Model



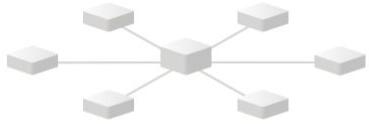
Distributed Ledger Model



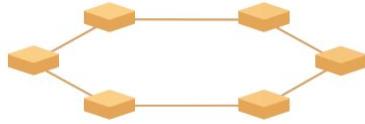
A dramatic black and white photograph of three men dressed in early 20th-century gangster-style clothing. They are standing in front of a dark, textured brick wall. Each man is holding a revolver and has another one crossed over his shoulder. The man on the left wears a dark coat and hat, the center man wears a light-colored coat and hat, and the man on the right wears a light-colored coat and a tall, dark hat. The lighting is low-key, creating strong shadows and highlights.

The World Will **Never Agree**
On One Ledger

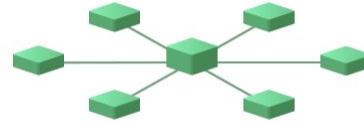
Diversity Is A Good Thing



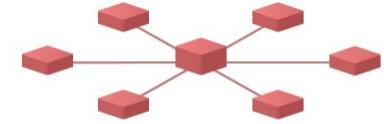
ACH



Blockchain

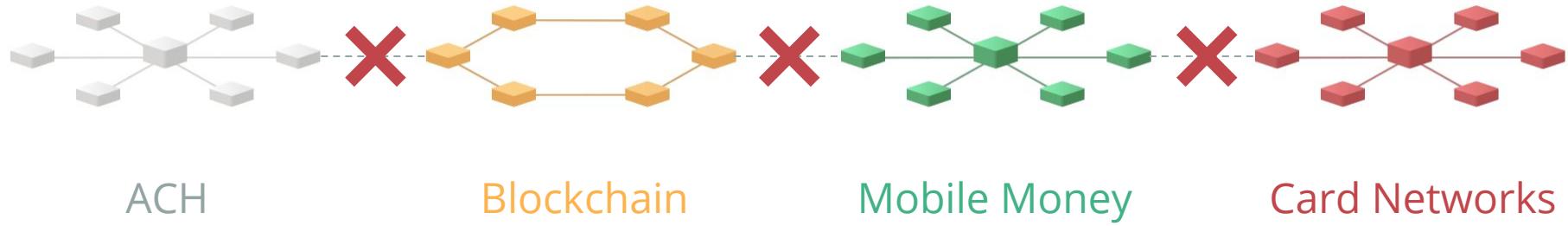


Mobile Money



Card Networks

But Why Is Everything Disconnected?



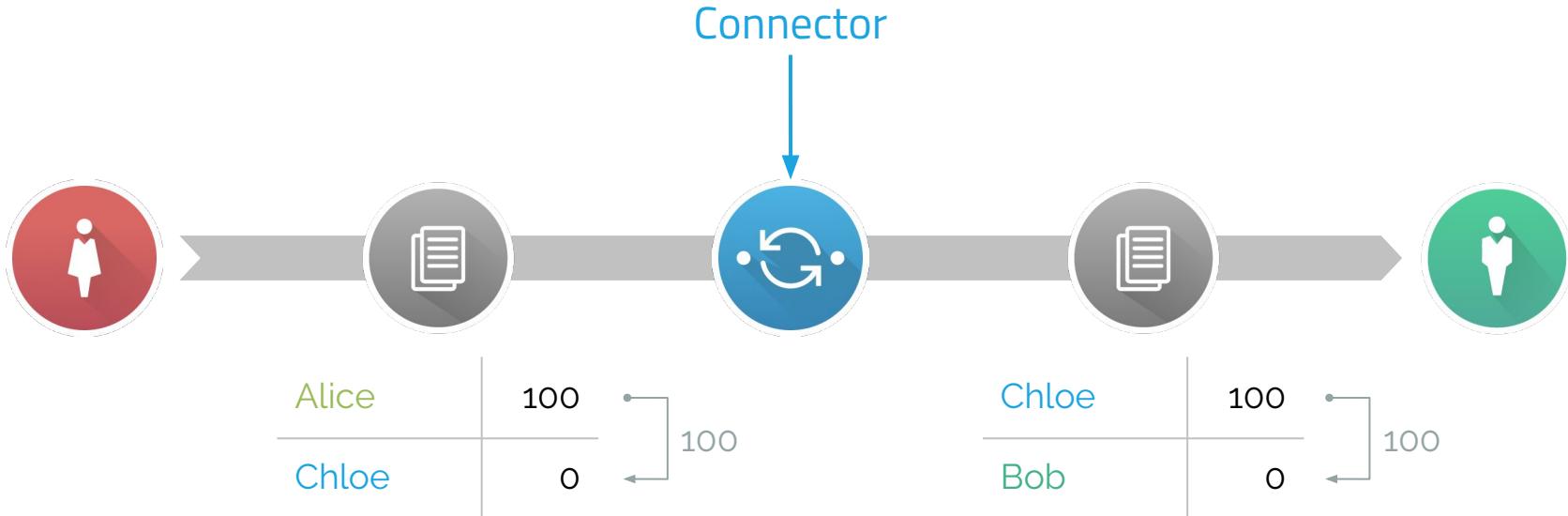
How Is Money Transferred Across Ledgers?



We Know That There Must Be Local Transfers



Connectors Link Two Ledgers

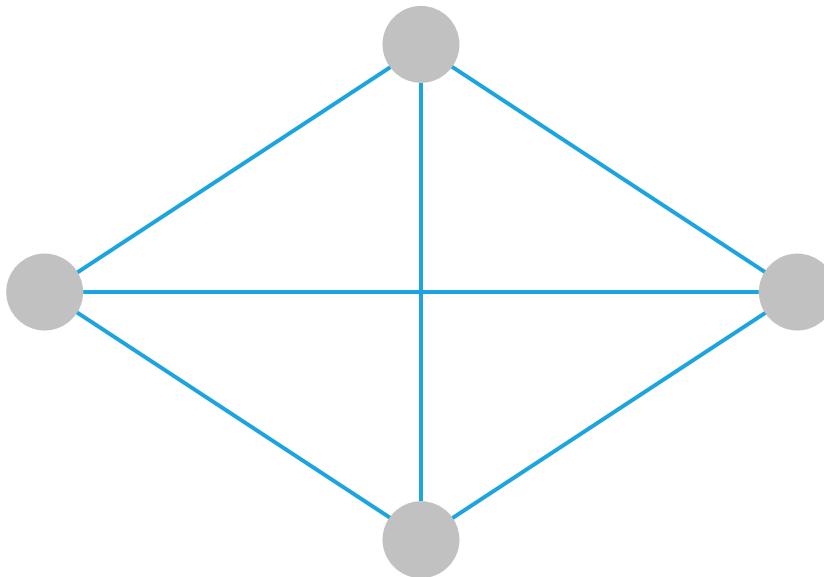


Bilateral Connections Don't Scale



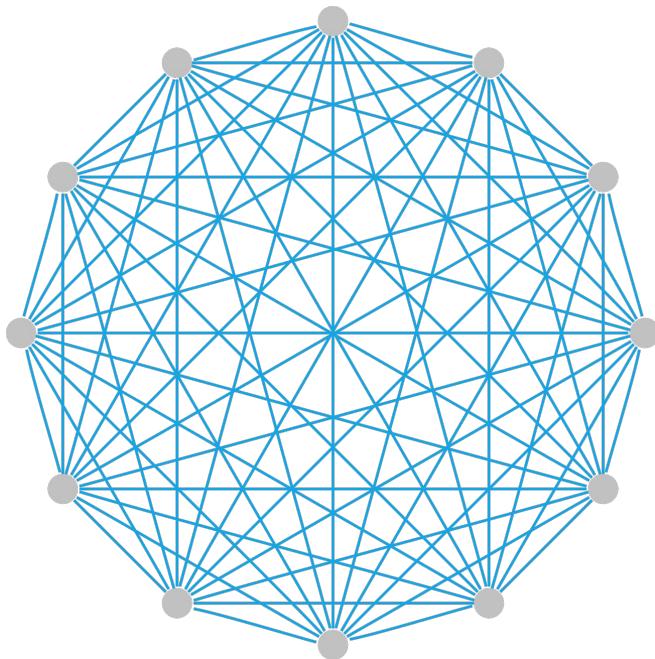
Bilateral Connections Don't Scale

$O(n^2)$



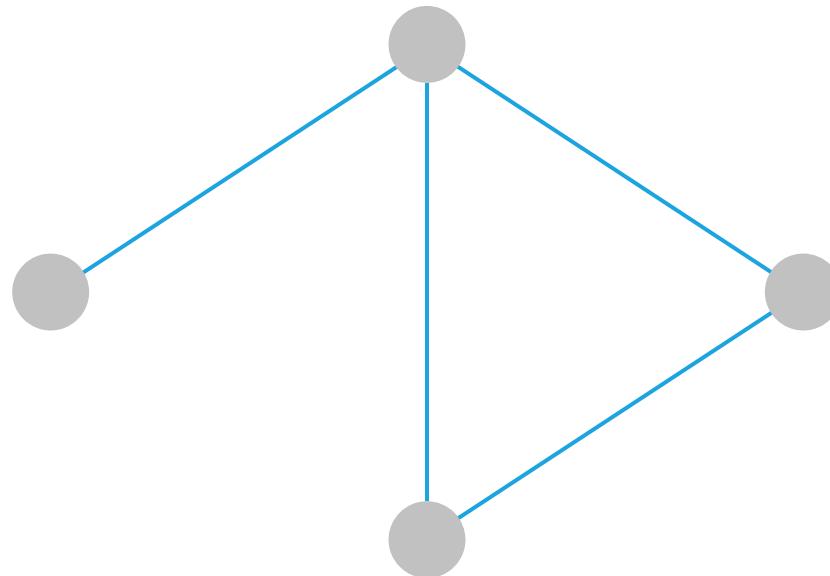
Bilateral Connections Don't Scale

$O(n^2)$



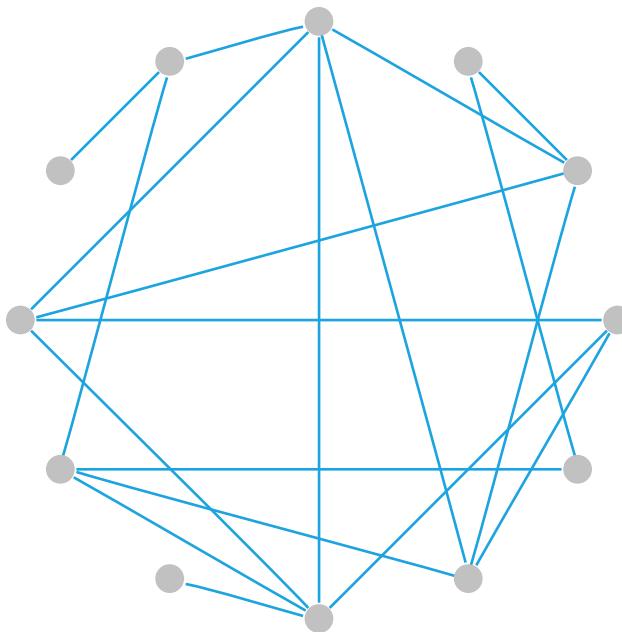
Networks Do Scale

$O(n)$



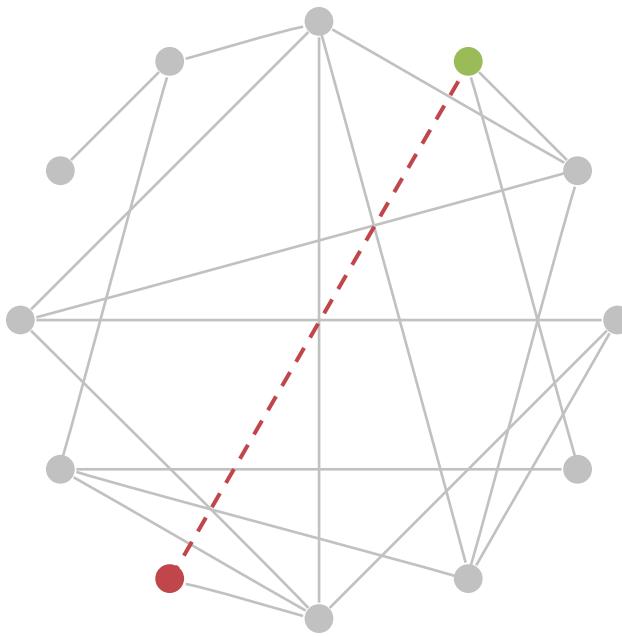
Networks Do Scale

$O(n)$



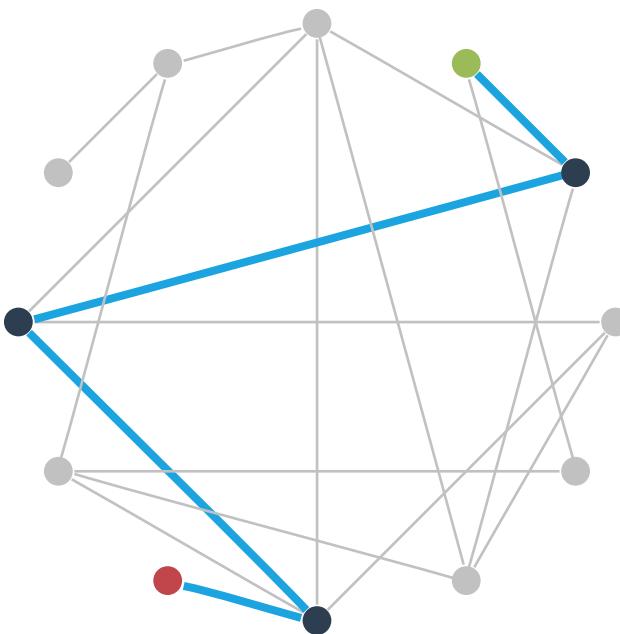
Sending With No Direct Connection

$O(n)$



We Need Multiple Hops

$O(n)$



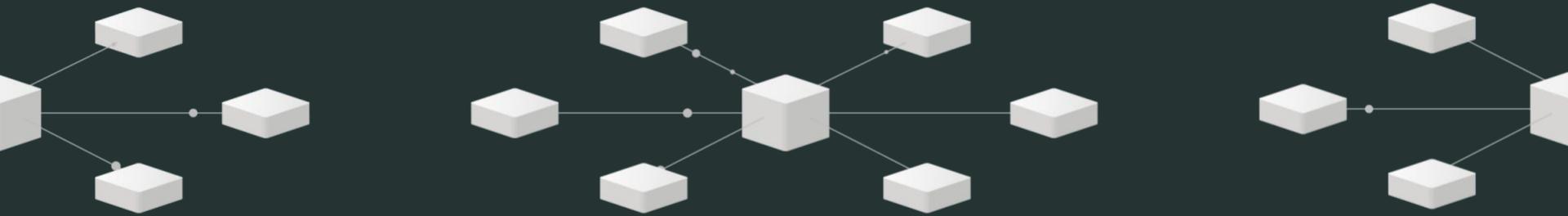
BUT HOW?



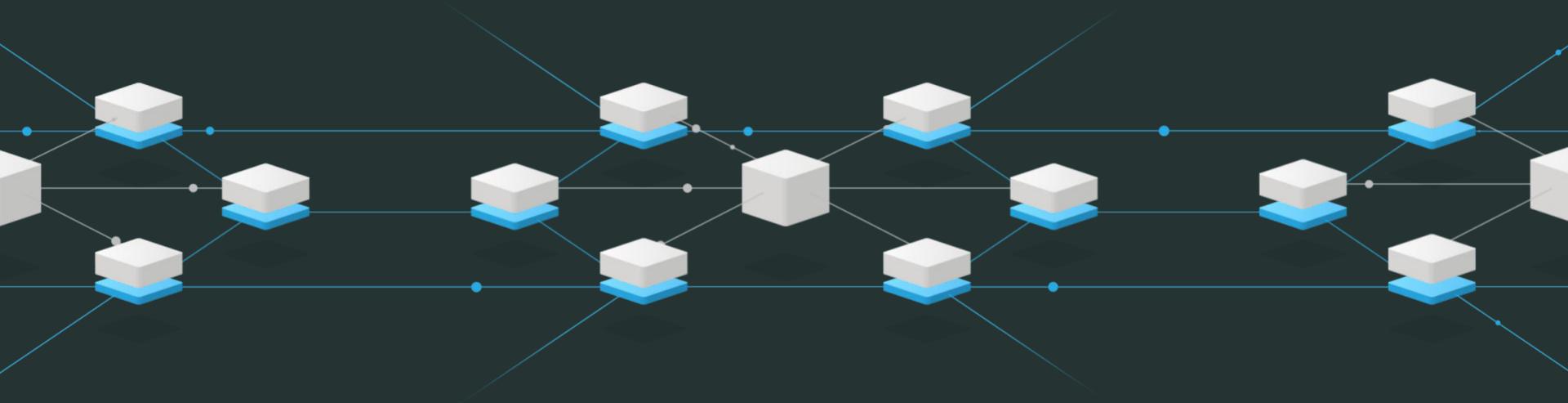
A photograph of a well-used workshop. The walls are covered in wooden shelves and pegboards holding various tools like hand saws, power tools, and measuring instruments. The floor is covered in sawdust and debris. Large stacks of green and blue plastic storage bins are on the left. In the center, there's a workbench with a fan and some wood pieces. The right side shows more shelving and hanging equipment.

TO THE WORKSHOP!

Learning From History



Internet: Network of Networks





The internet protocol implements
two basic functions:
addressing and fragmentation.

— *RFC 791*

Internet: Network of Networks

204.28.124.148

IP Address



Internet Architecture

Application

HTTP SMTP NNTP NTP RTP

Transport

TCP UDP

Internetwork

IP

Network

WIFI BLUETOOTH ETHERNET



Interledger

The protocol for connecting ledgers.

Interledger Architecture

Application

SPSP PPSP ...

Interledger

ILP

Network

ISO 20022
BITCOIN ETHEREUM



Interledger In One Slide (Really)

Where?

How much?



Interledger In One Slide (Really)

address: "us.wf.bob"

How much?



Interledger In One Slide (Really)

address: "us.wf.bob"

amount: "1023.20"

Interledger In One Slide (Really)

address: "us.wf.bob"

amount: "1023.20"

When?

Why?

Interledger In One Slide (Really)

address: "us.wf.bob"
amount: "1023.20"
expiry: "2016-07-06T09:00:10Z"
Why?

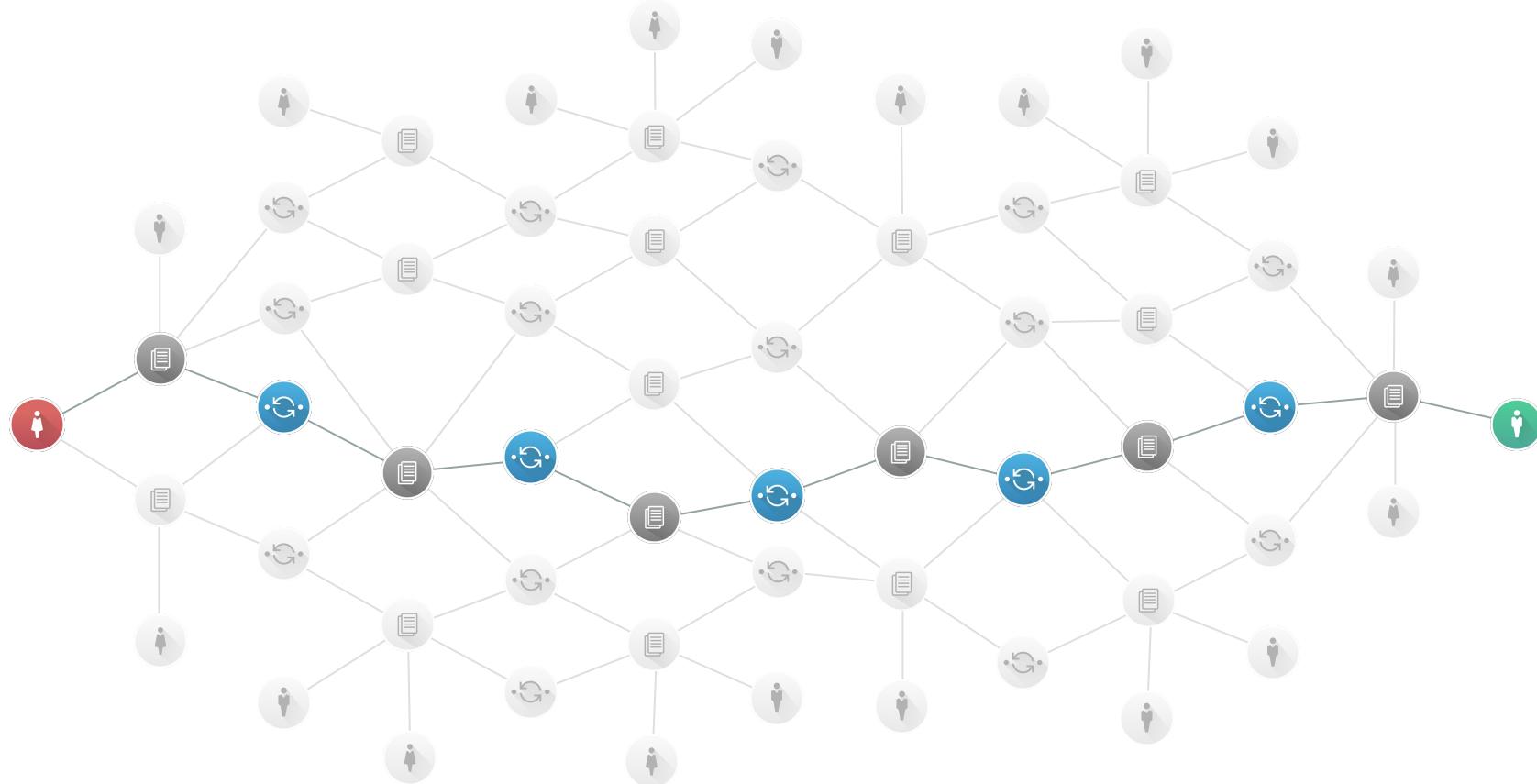
Interledger In One Slide (Really)

address: "us.wf.bob"
amount: "1023.20"
expiry: "2016-07-06T09:00:10Z"
condition: "cc:0:3:4a7DEpj8f9..."

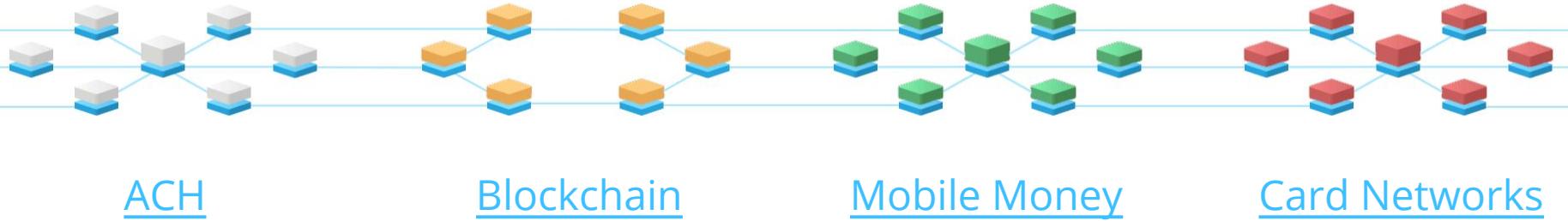
Now We Can Support Longer Chains



The Interledger



A Standard for Real-Time Payments Across Networks



Show us!



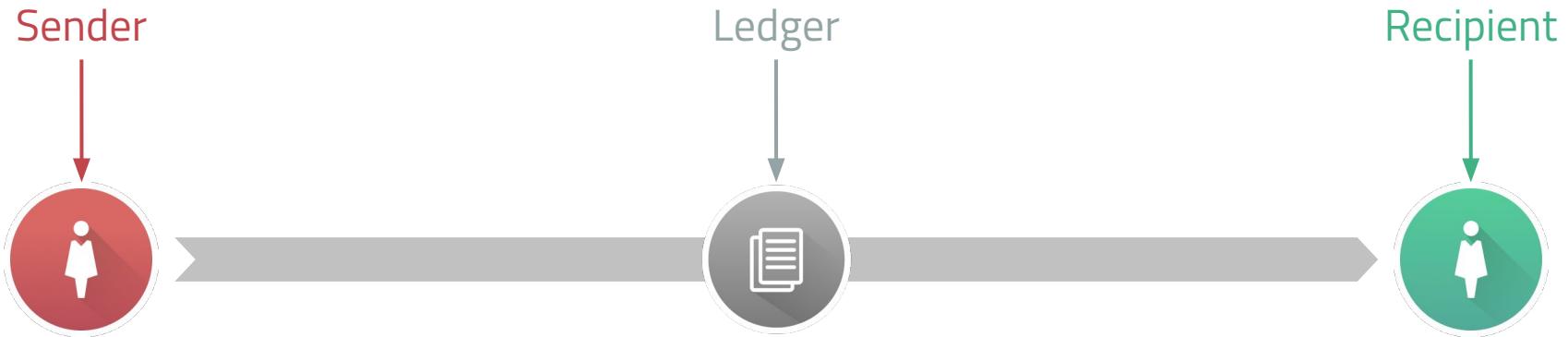


How It Works

IP Packet, Addressing, Routing

Evan Schwartz & Stefan Thomas

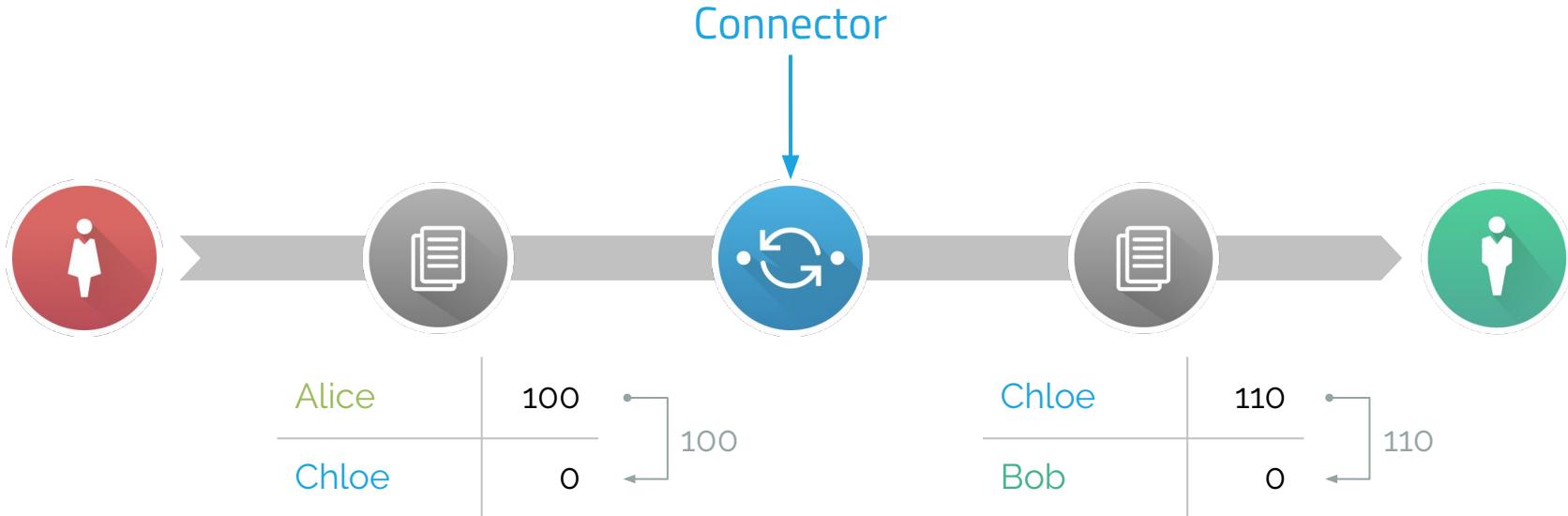
Ledgers Track Accounts and Balances



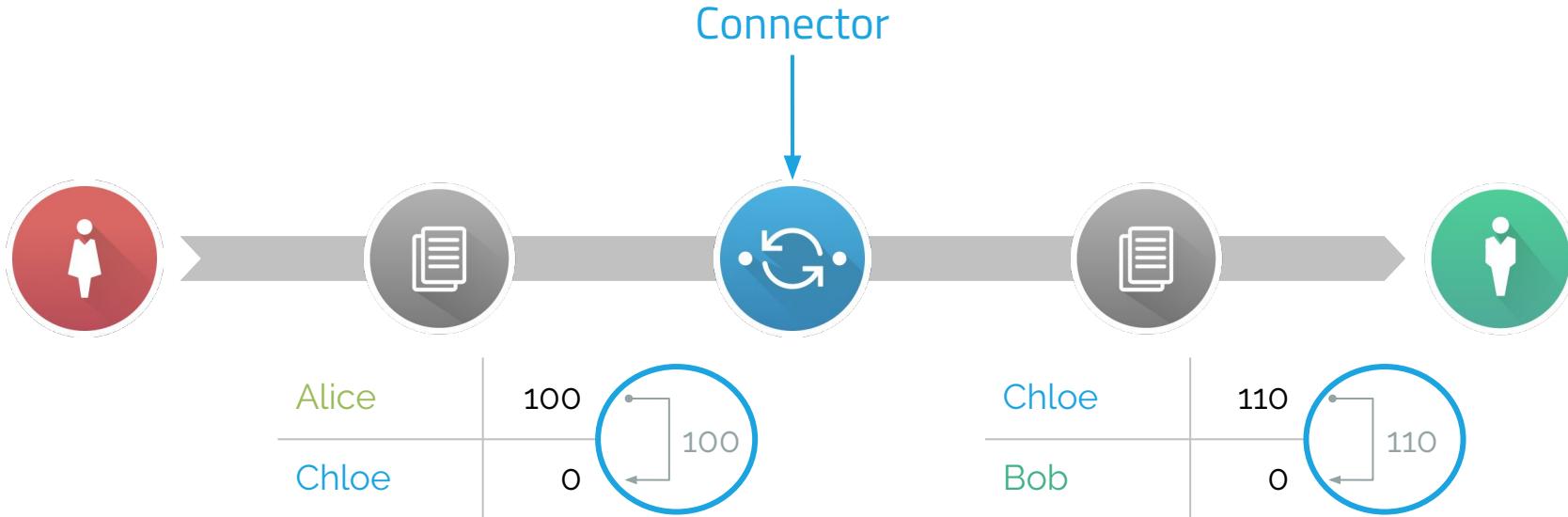
But Not Everyone Is on the Same Ledger



Connectors Relay Money

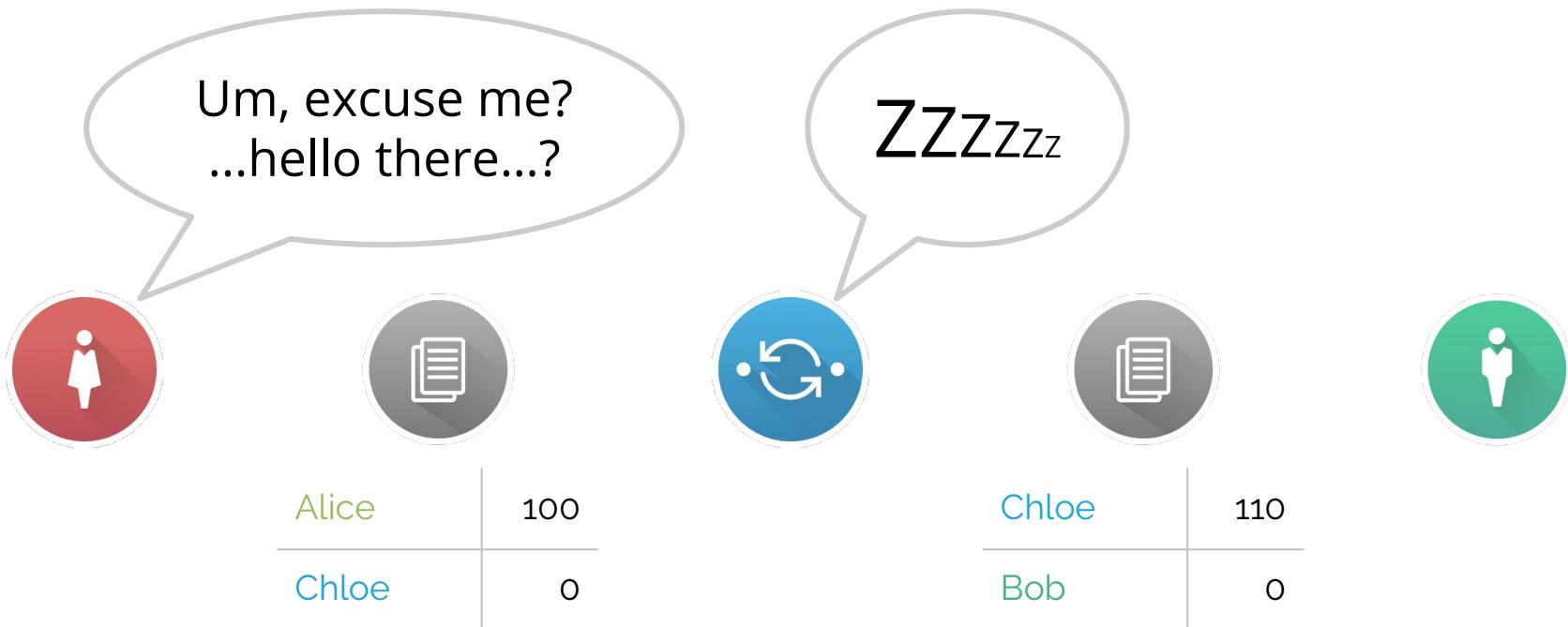


Connectors Convert Currencies



How do we ask a connector
to pass on a payment?

We Need a Way to Send Instructions to Connectors



Interledger In One Slide

address: "us.wf.bob" ← Hierarchical identifier

amount: "1023.20" ← Decimal amount

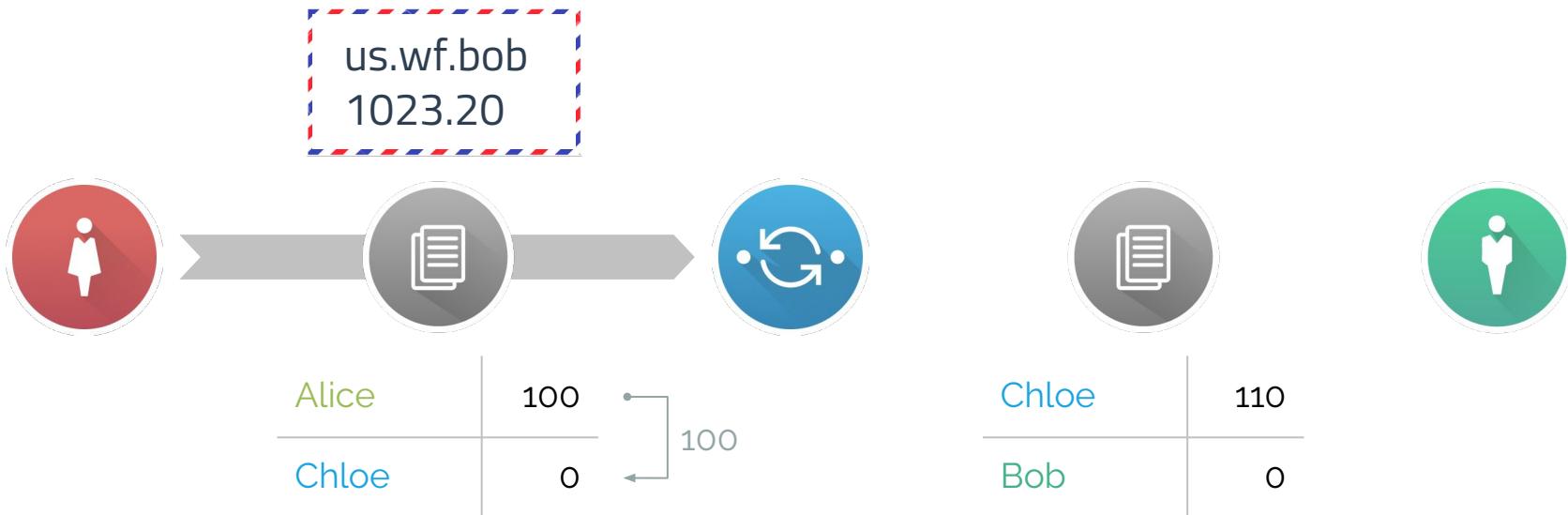


us.wf.bob

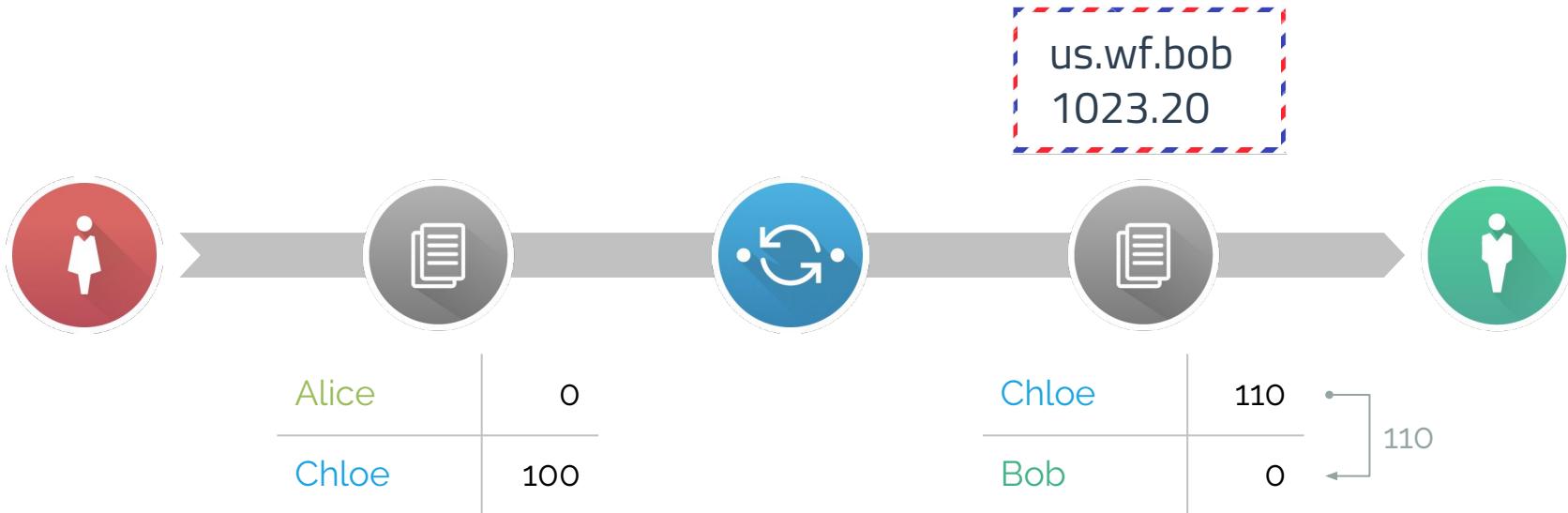
1023.20

PAR AVION
AIR MAIL
CORREO AEREO

Sender Attaches Packet to Local Transfer



Connector Forwards the Packet via Another Transfer



Paths Can Be Short



Or Long



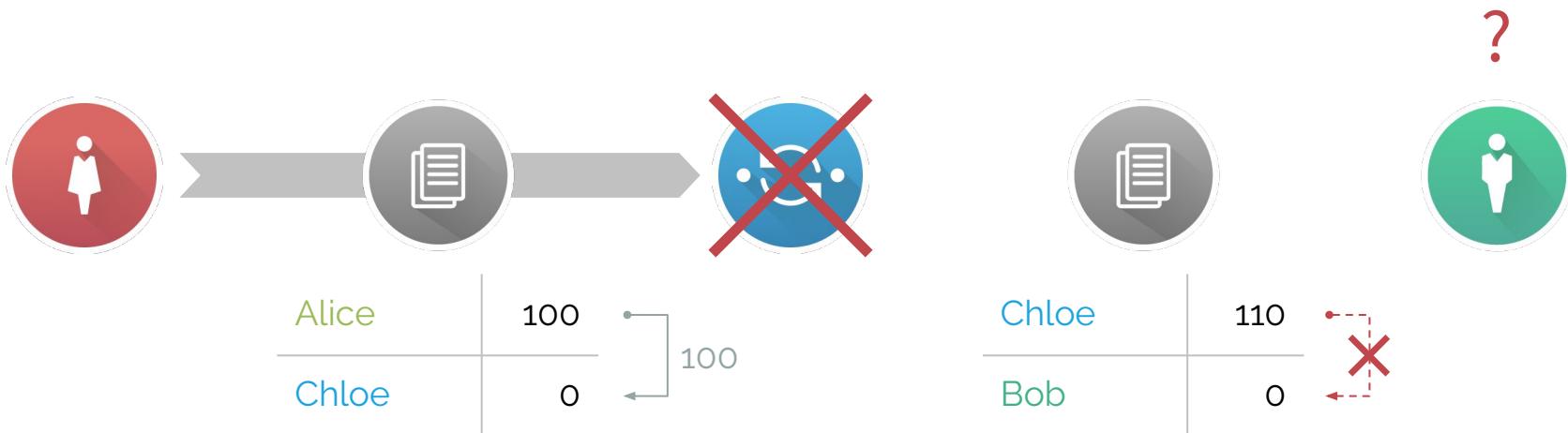
Uh oh...



Can we trust connectors?



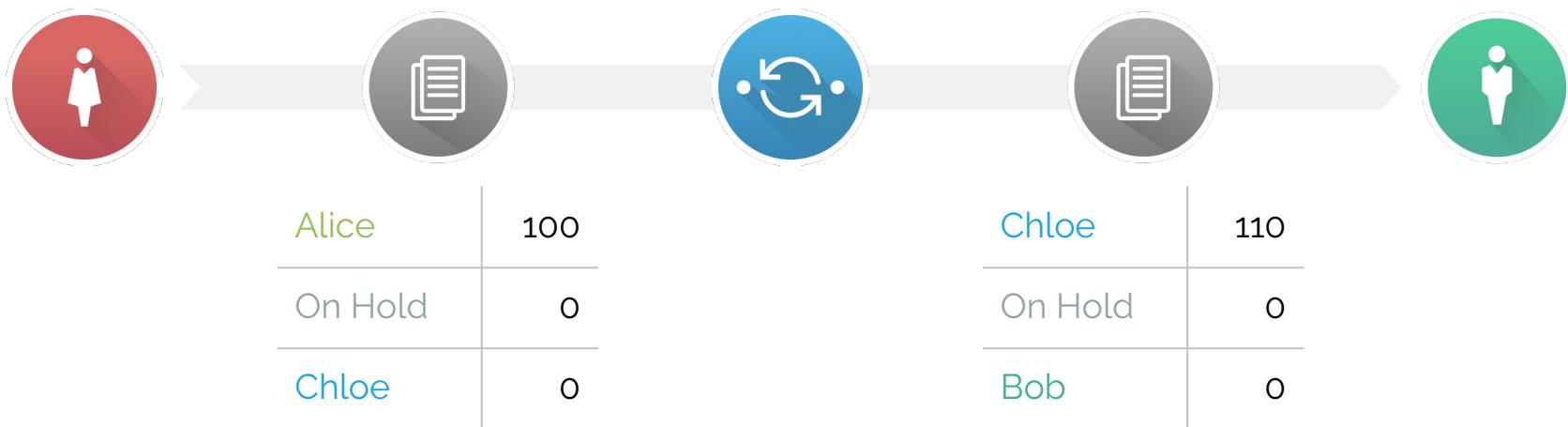
If Connectors Fail, Would We Lose Money?



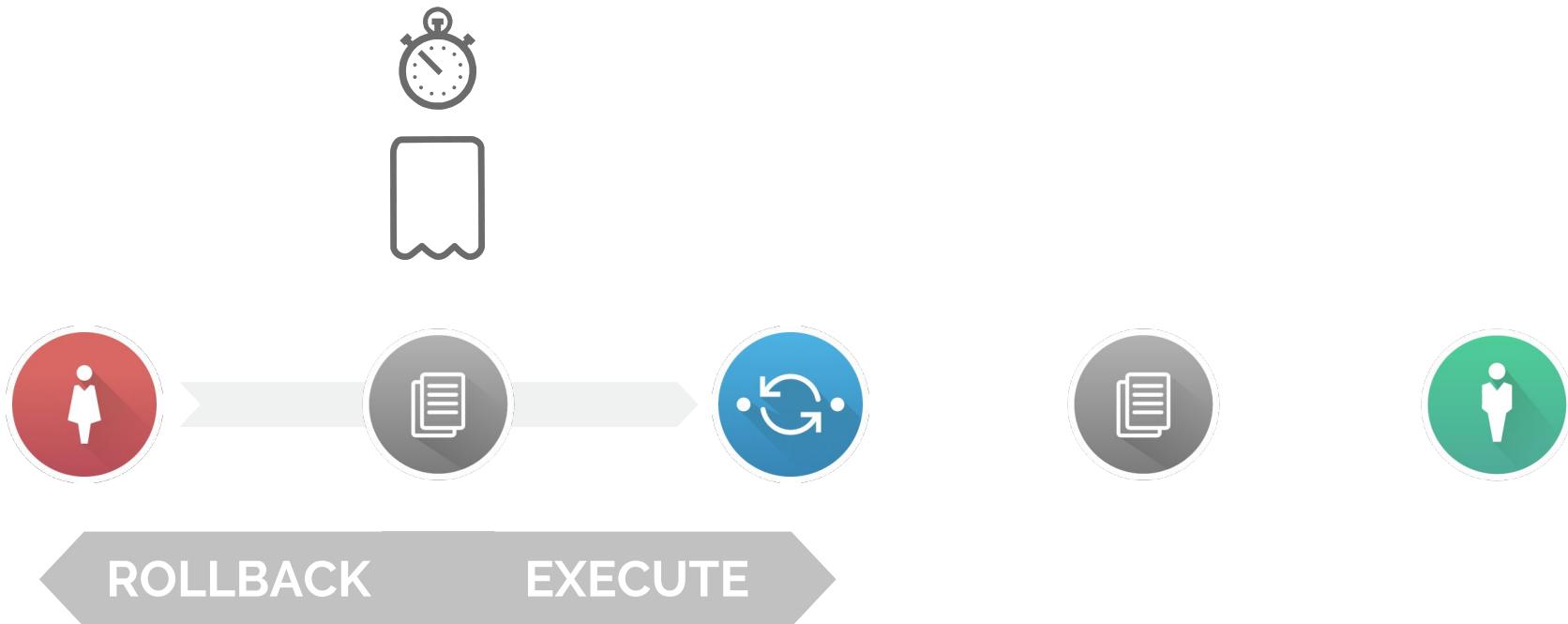
Holds Provide Security



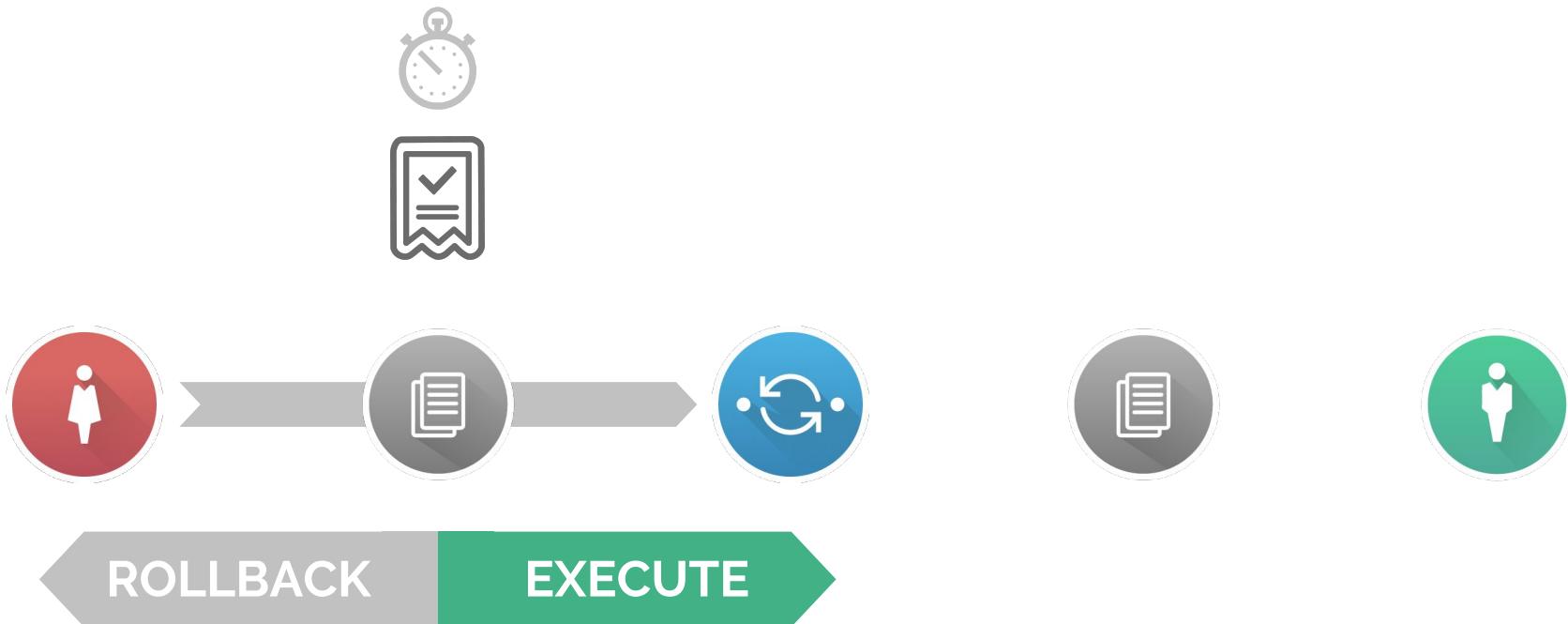
Ledgers Provide Hold Functionality



Holds Are Dependent on Conditions + Expiries



Condition Fulfillment Executes Transfer



Timeouts Cause Funds to Be Returned



ROLLBACK

EXECUTE

Interledger In One Slide (Really)

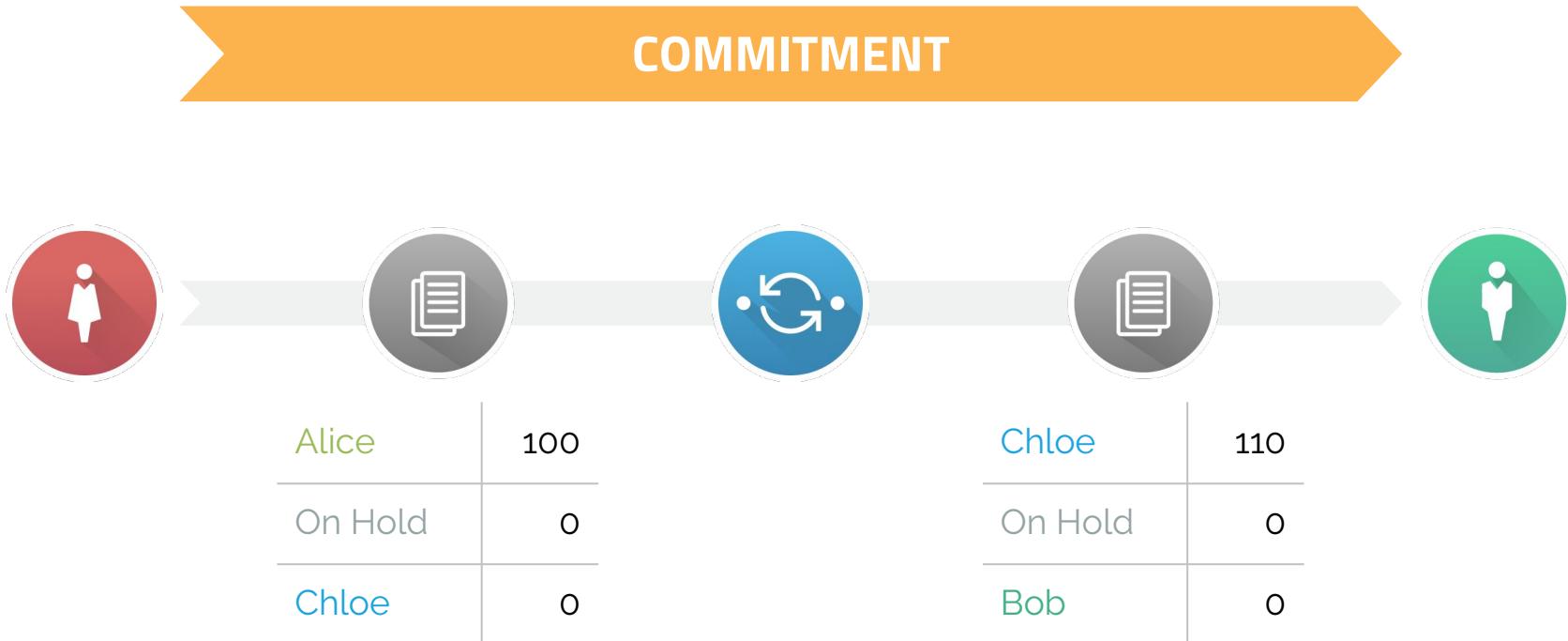
address: "us.wf.bob"

amount: "1023.20" Timestamp (ISO 8601)

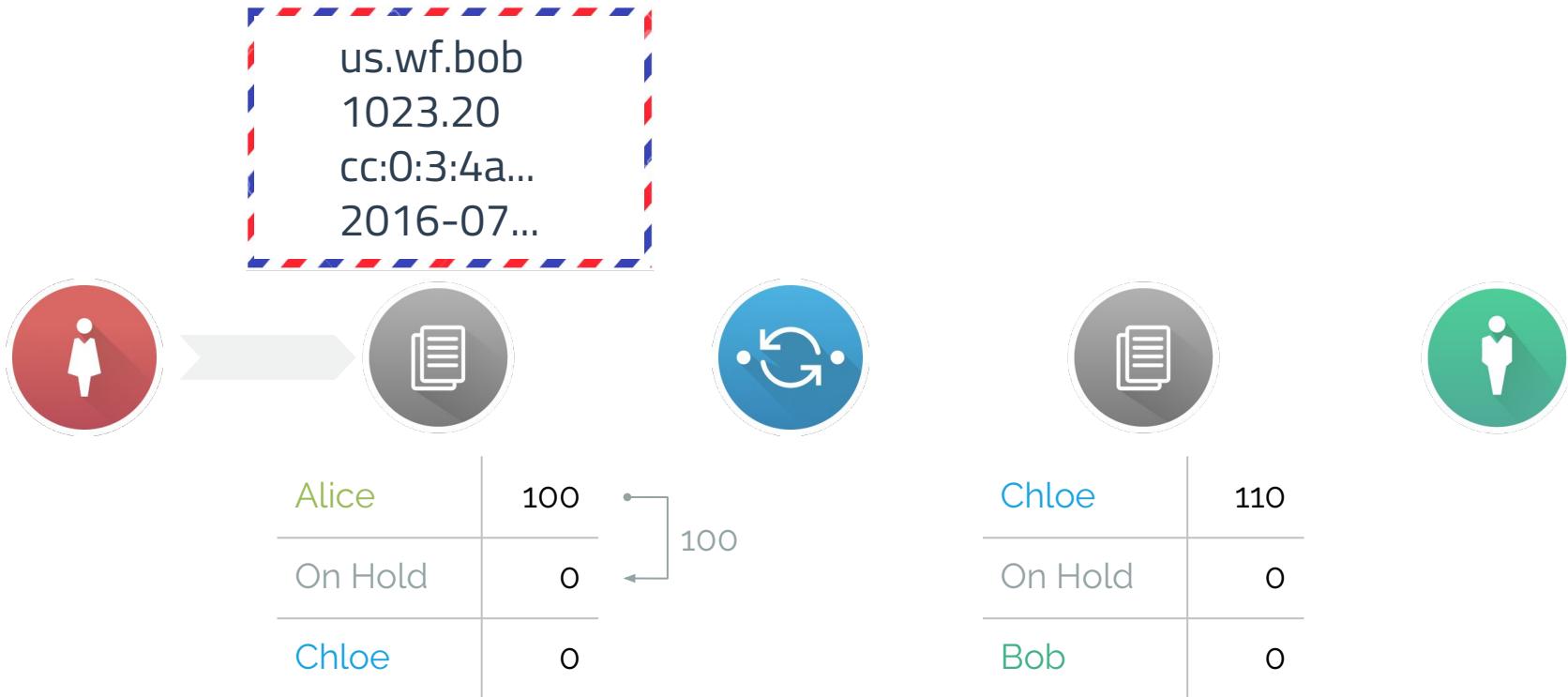
expiry: "2016-07-06T09:00:10Z"

condition: "cc:0:3:4a7DEpj8f9..." Crypto Condition

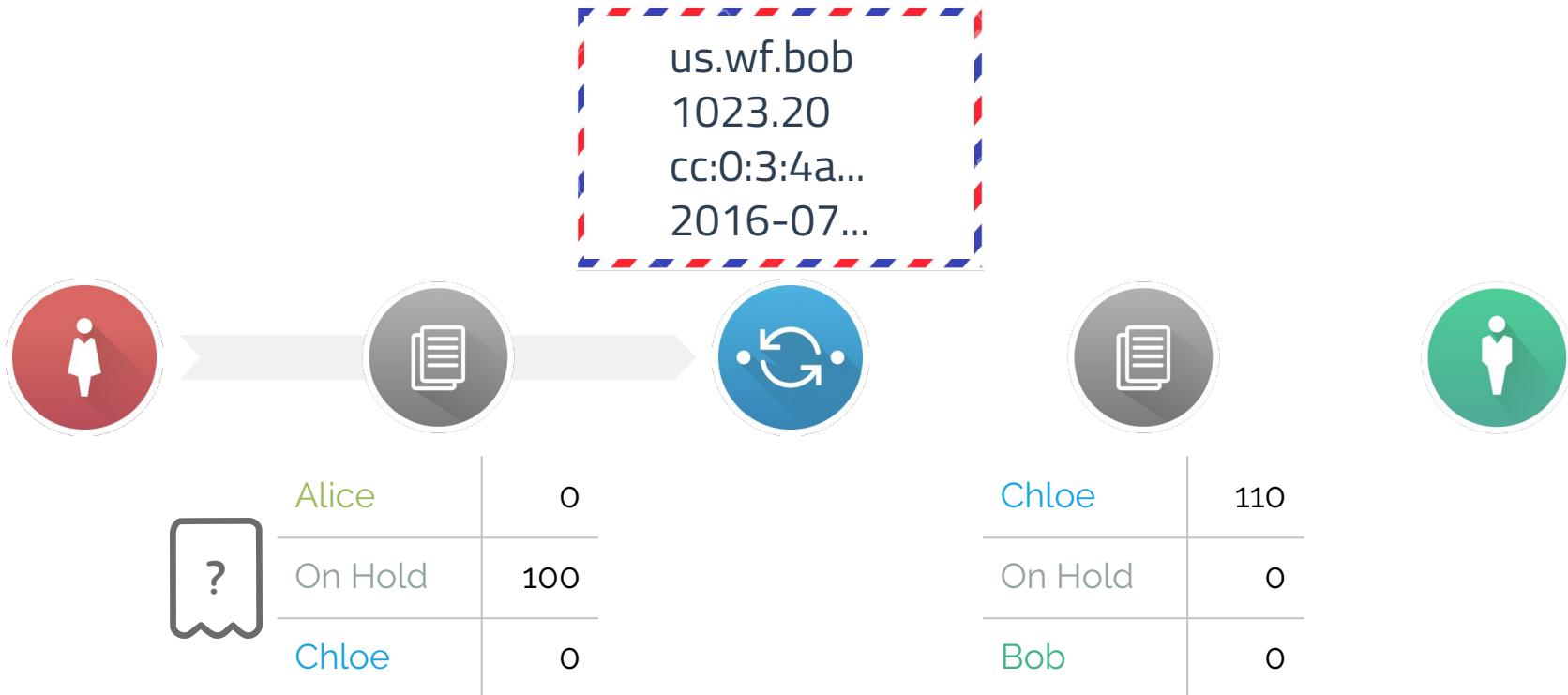
Funds Are Committed From Left to Right



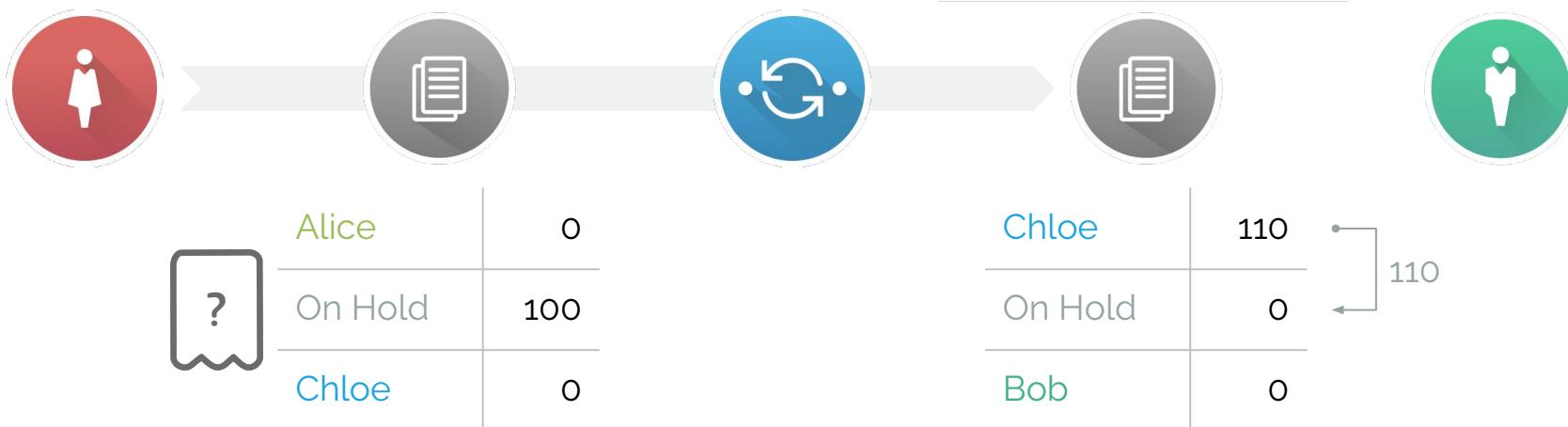
Sender Puts Funds On Hold



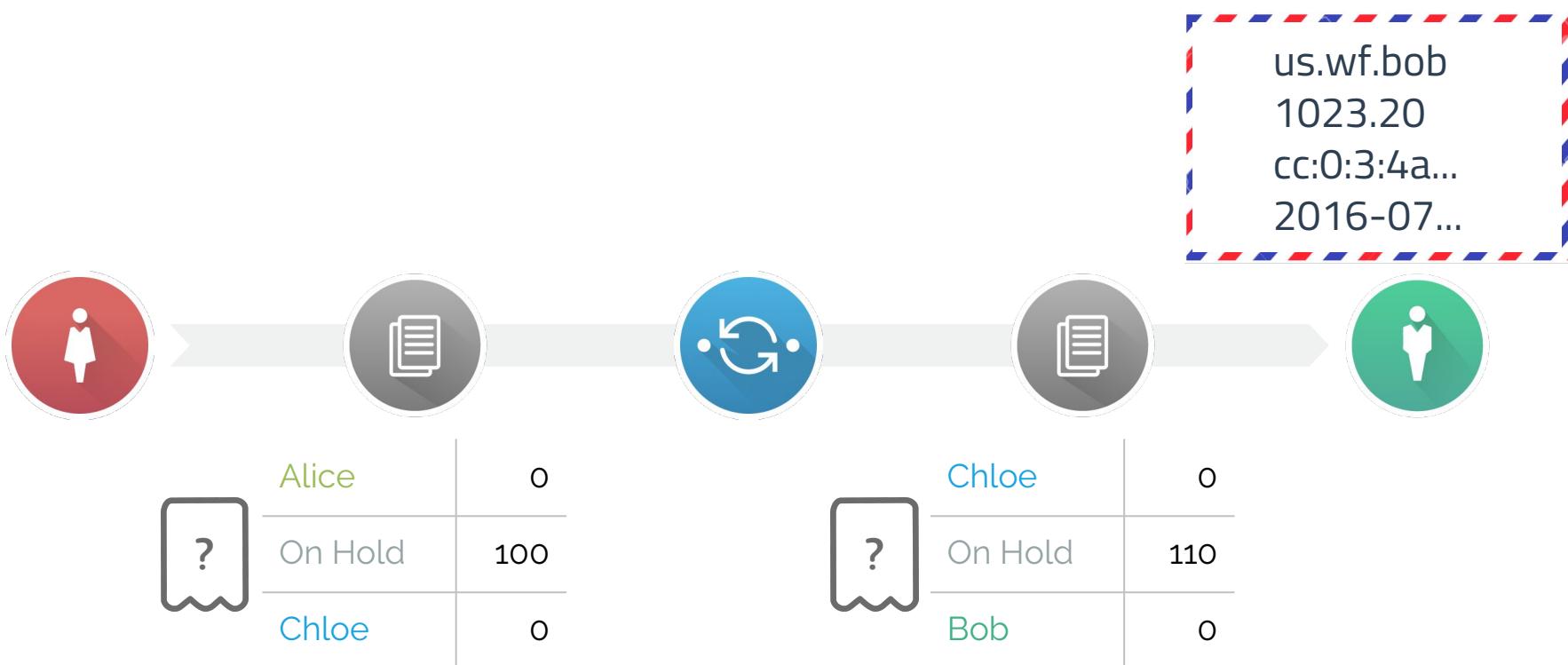
Connector Gets Notification of Funds on Hold



Connector Puts Funds on Hold

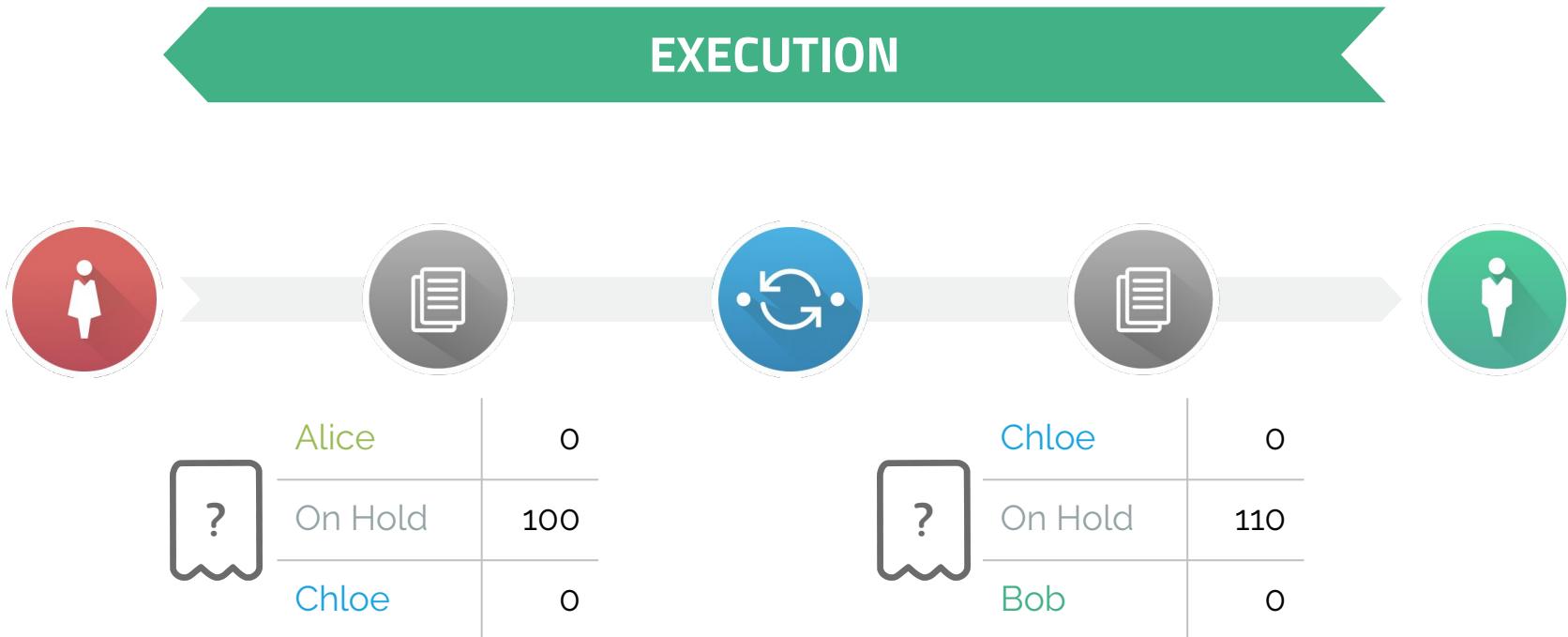


Recipient Gets Notification of Funds on Hold

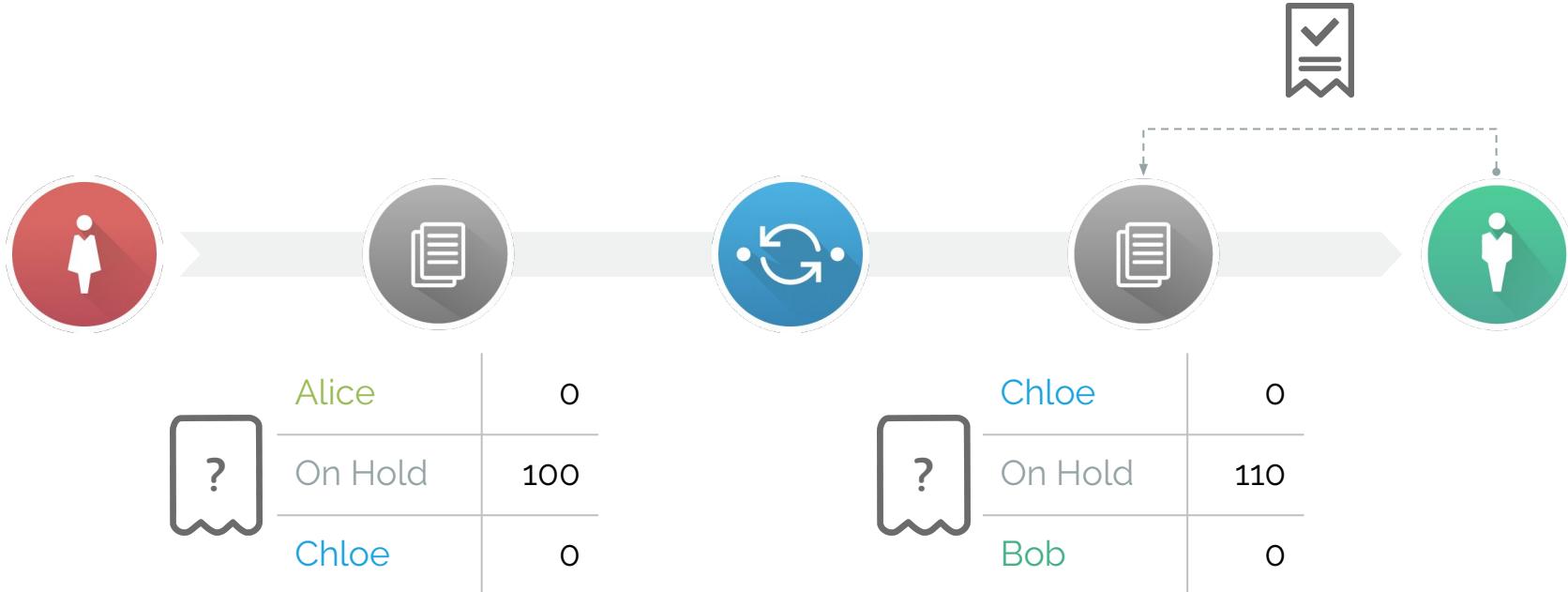


Recipient **Triggers Payment** by
Fulfilling the Condition

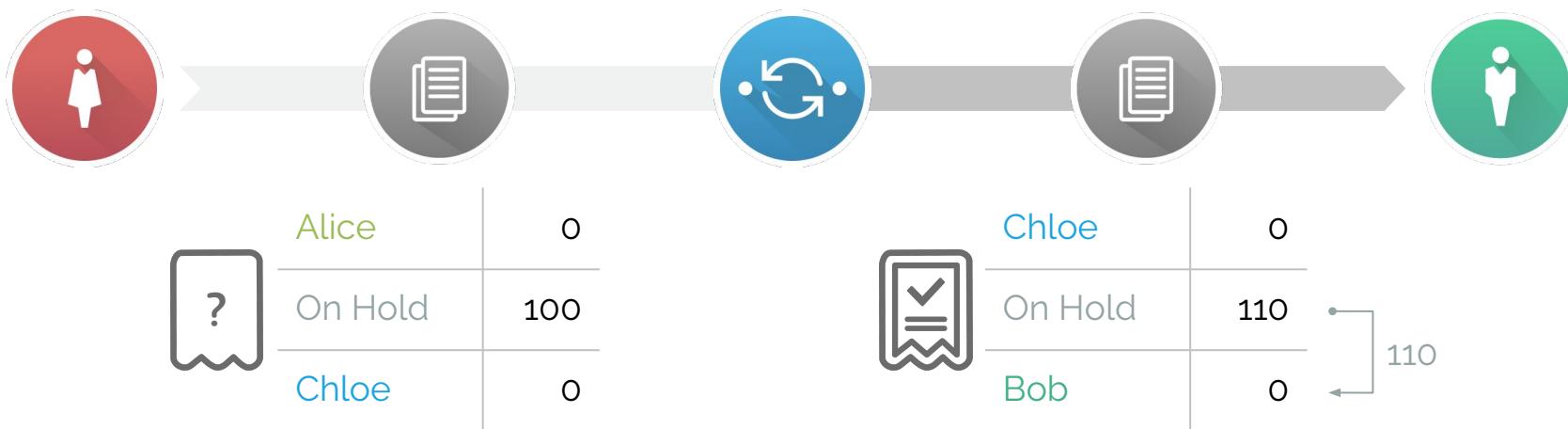
Transfers Are Executed Right to Left



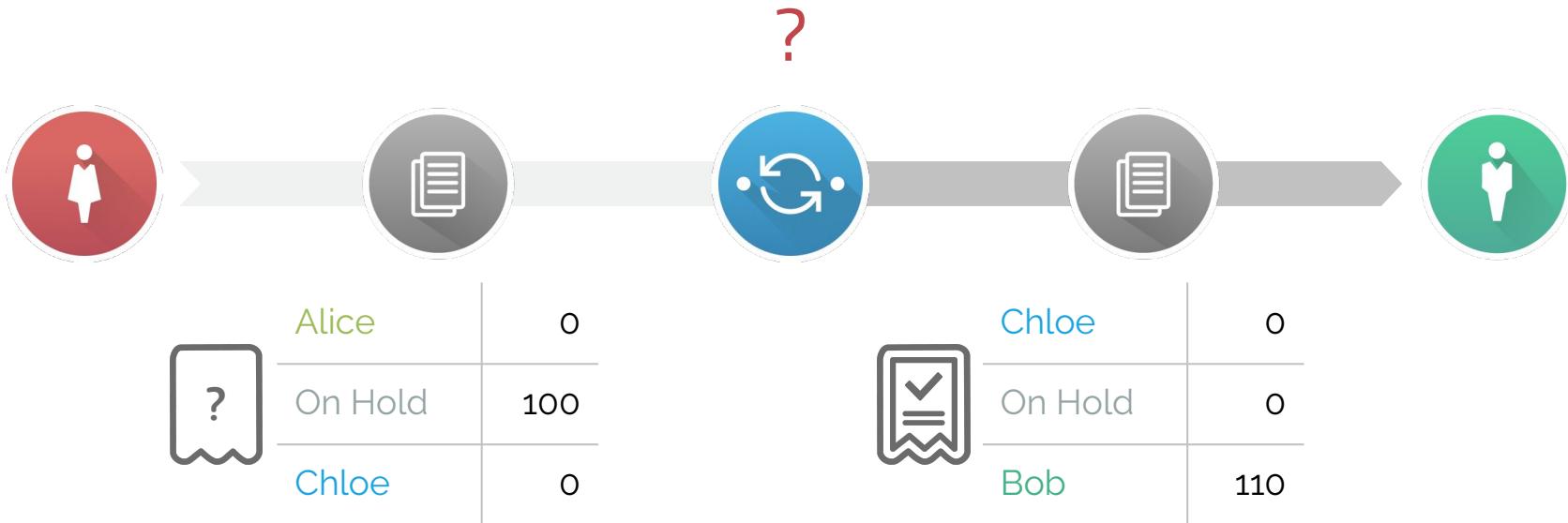
Recipient Signs Receipt



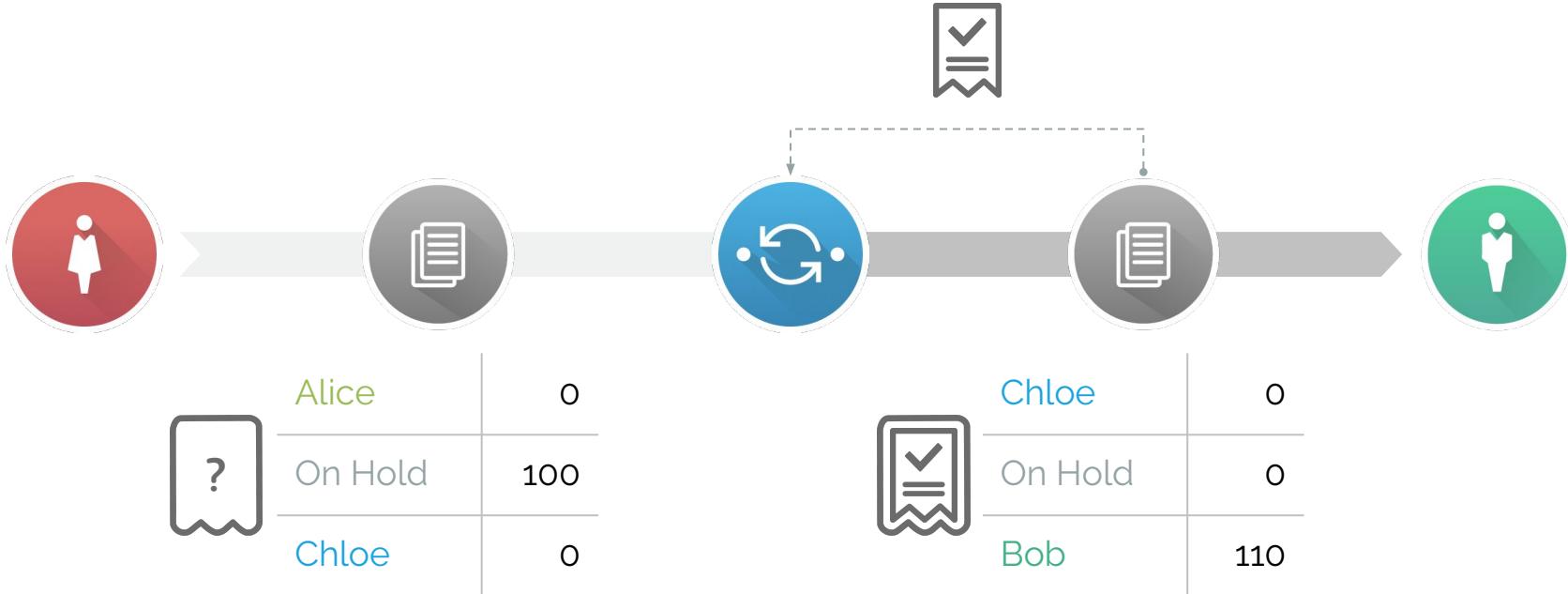
Signature Fulfills Condition, Ledger Releases Held Funds



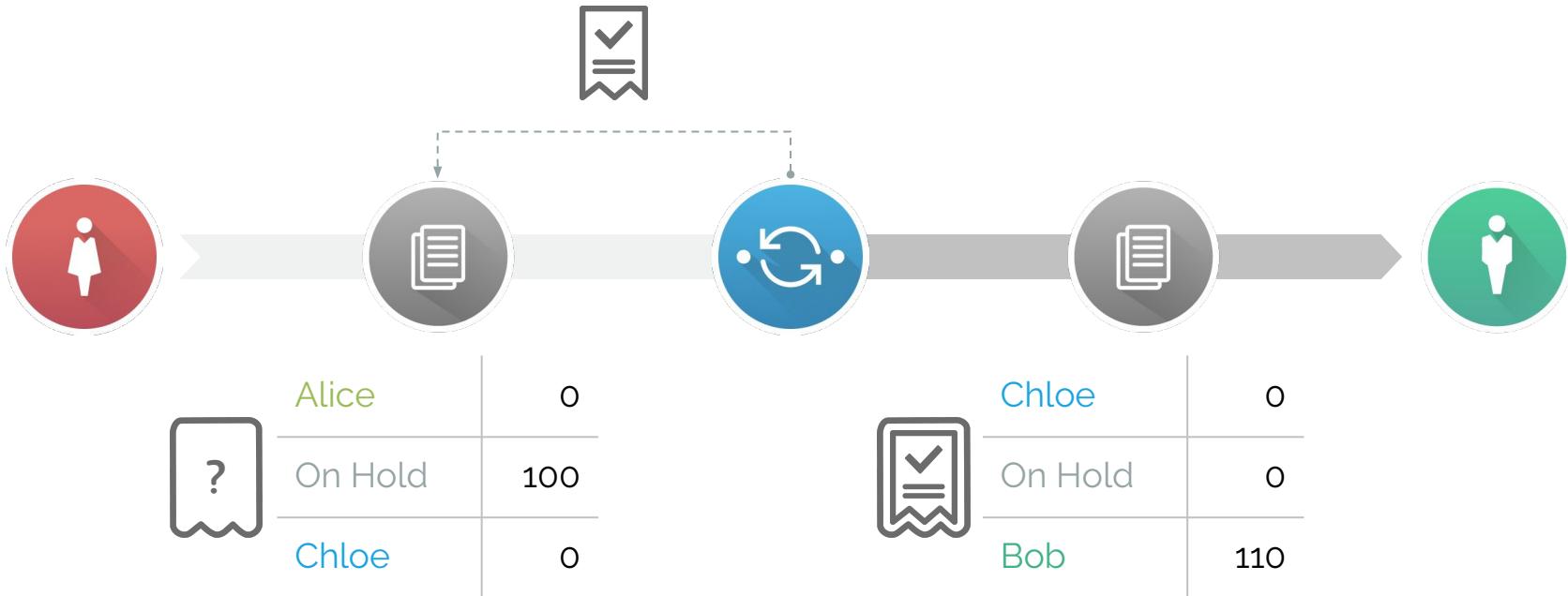
How Does the Connector Get Reimbursed?



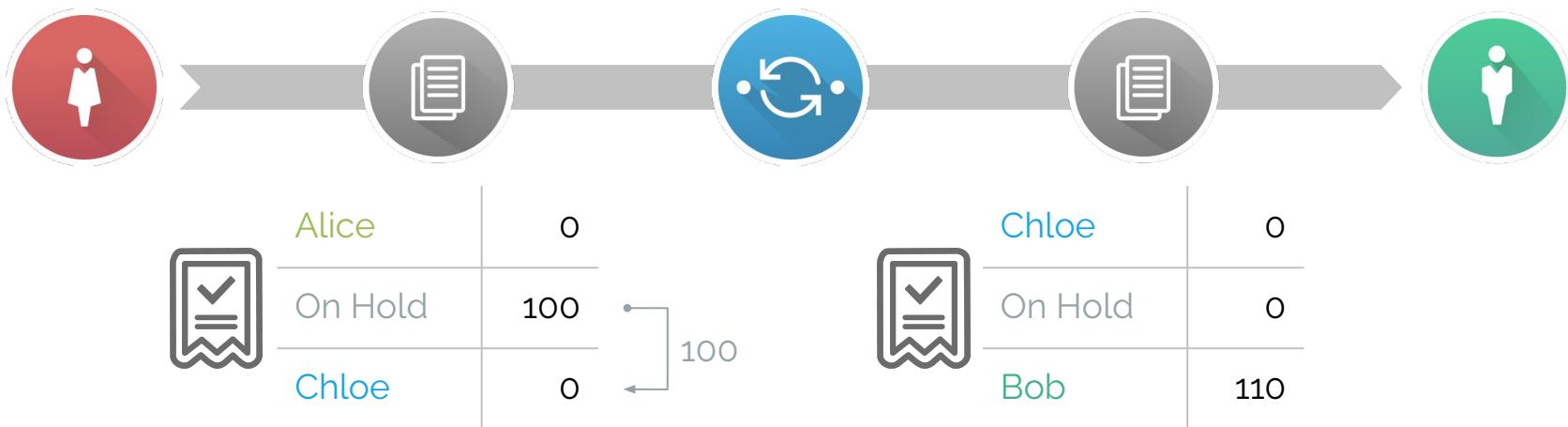
Connector is Notified That Funds Have Been Released



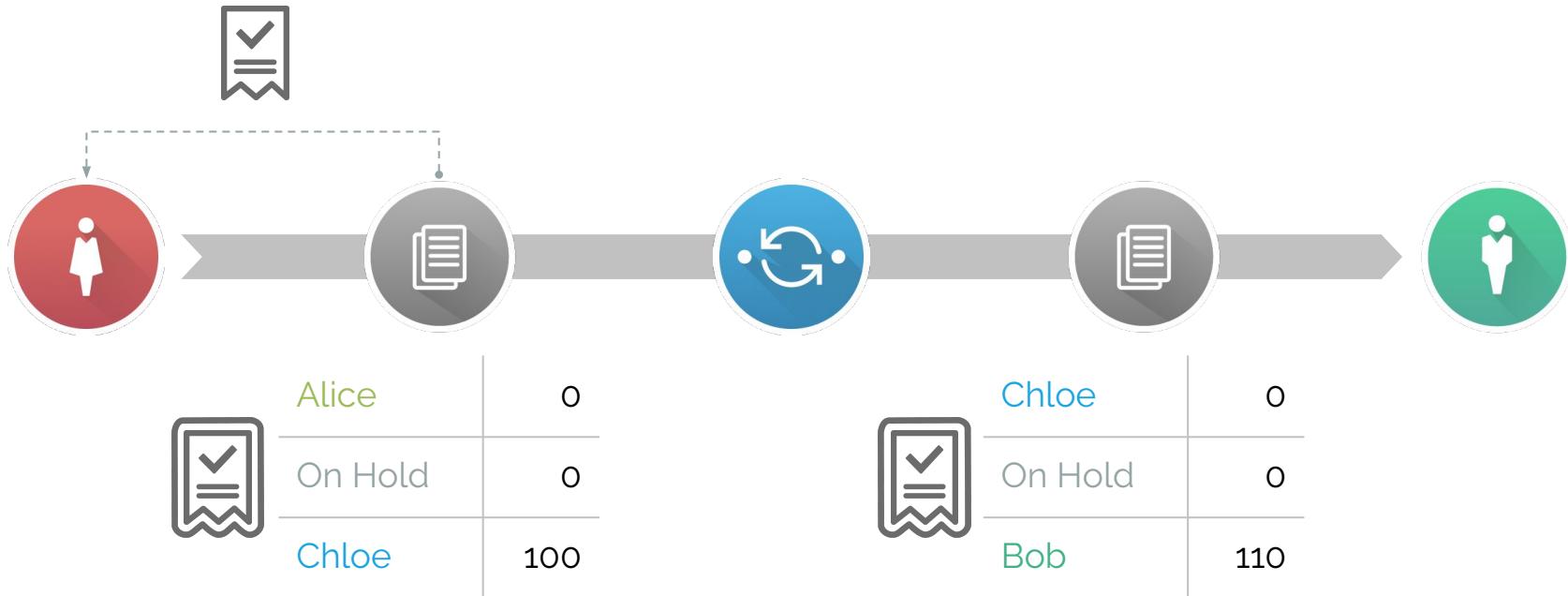
Connector Passes on the Recipient's Signature



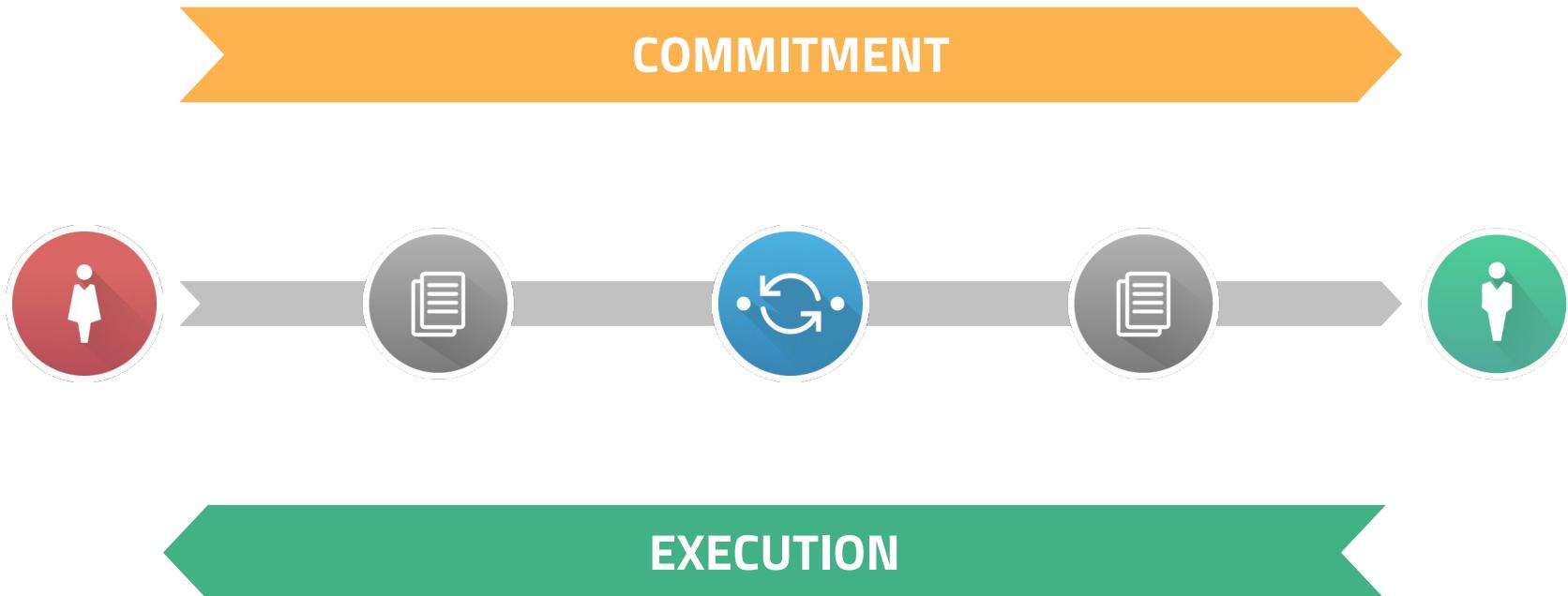
Receipt Releases Funds from Hold



Sender Gets Non-Repudiable Proof of Payment



Transfers Are Committed L2R, Executed R2L



(Now) Paths Can Be Short



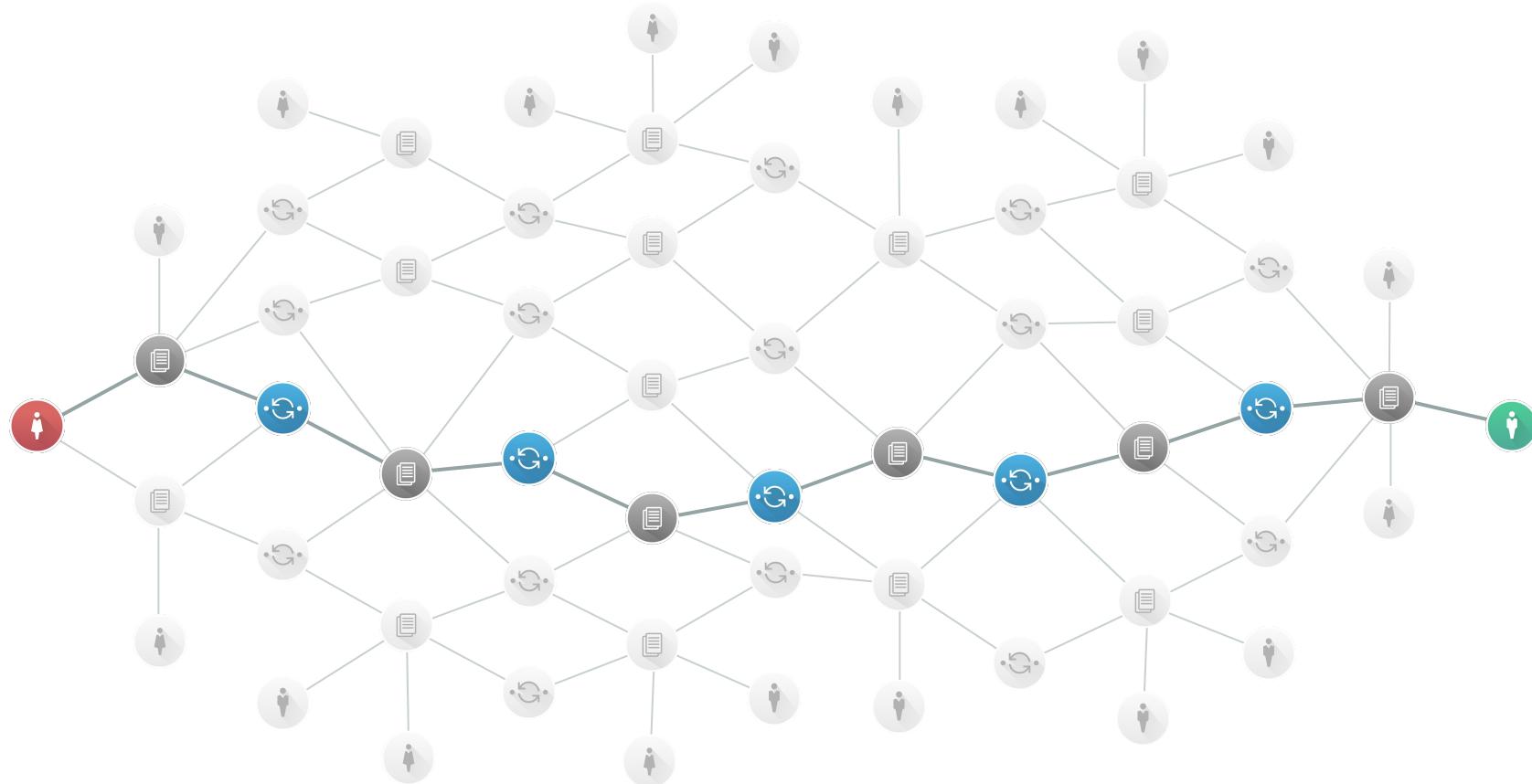
Or Long



Or Long (And Still Secure)



The Interledger



Enabled By a Simple Packet Format

```
address:      "us.wf.bob"  
amount:       "1023.20"  
expiry:       "2016-07-06T09:00:10Z"  
condition:    "cc:0:3:4a7DEpj8f9..."
```

How do those addresses work?



Interledger Addresses

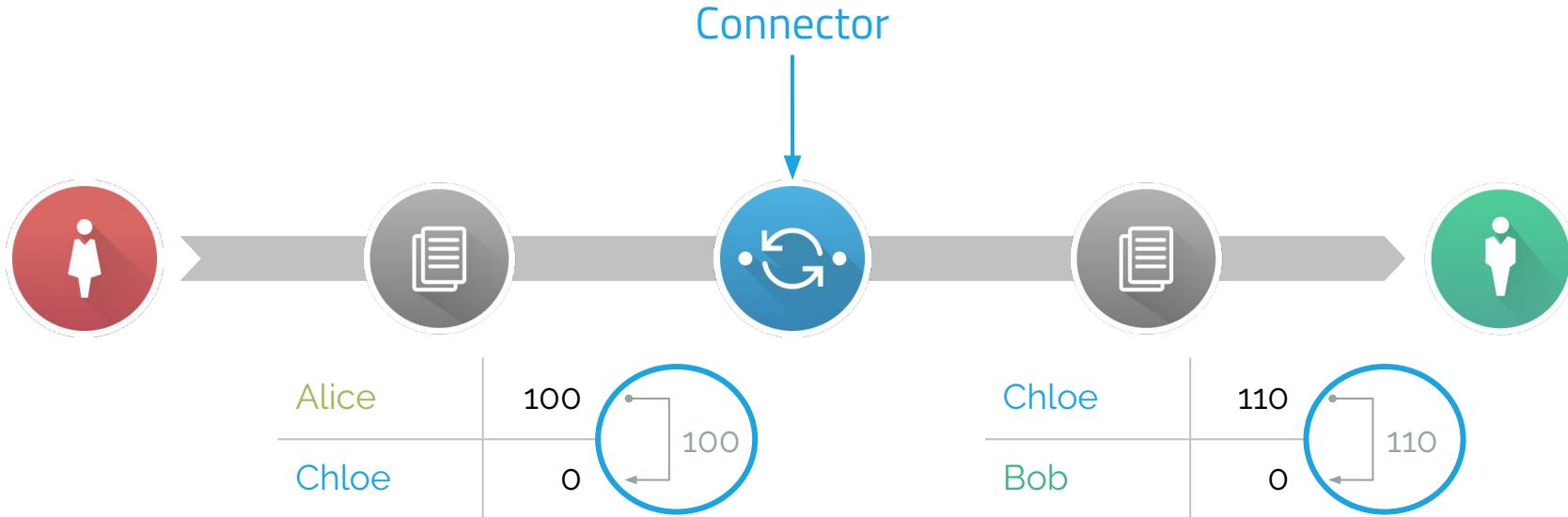
The diagram illustrates the structure of an Interledger address. At the top, the words "ledger" and "account" are written in blue. Below them, a horizontal blue bracket groups the two words together. Below this bracket, the word "address" is followed by a colon, and then the address "us.wf.bob" is shown in large white letters. The "us" part of the address is positioned under the "ledger" label, and the ".wf.bob" part is positioned under the "account" label.

address: "us.wf.bob"

Interledger Addresses

address: "us.wf.bob.mary"
ledger subledger account

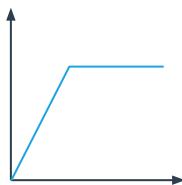
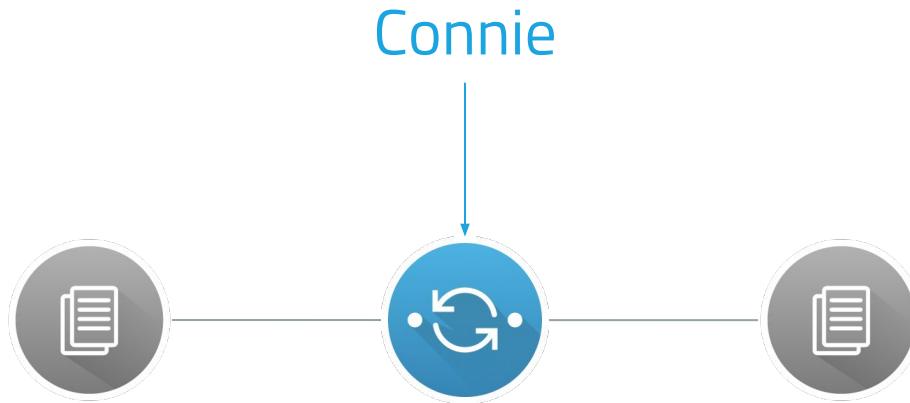
Connectors Convert Currencies



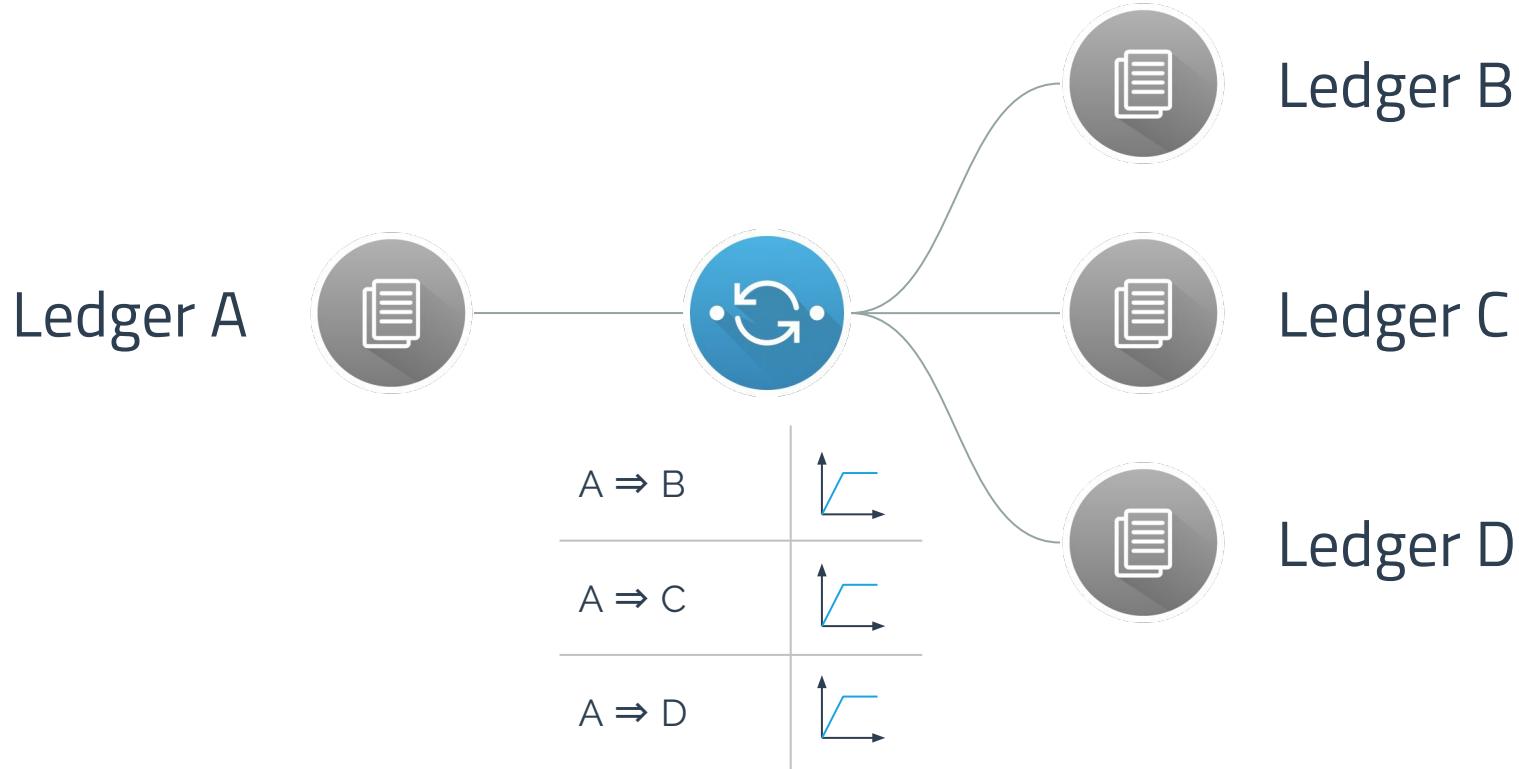
Where does this rate come
from?



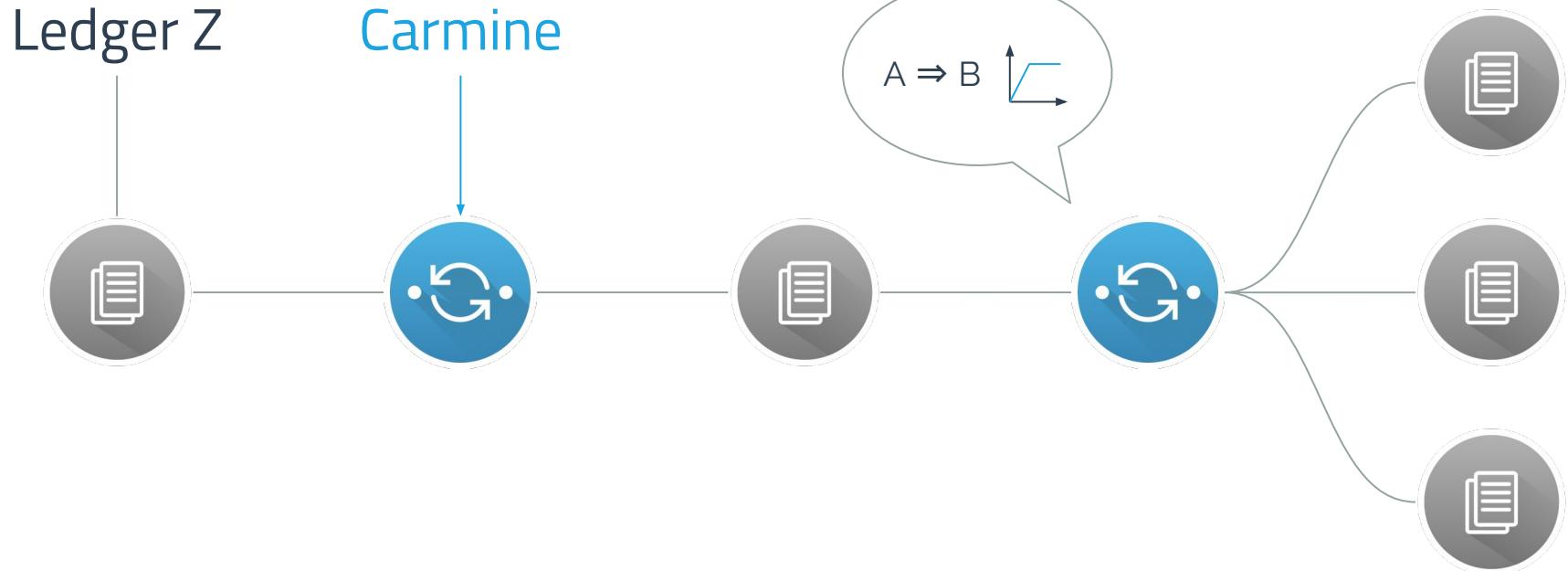
Liquidity Curves Determine Exchange Rates



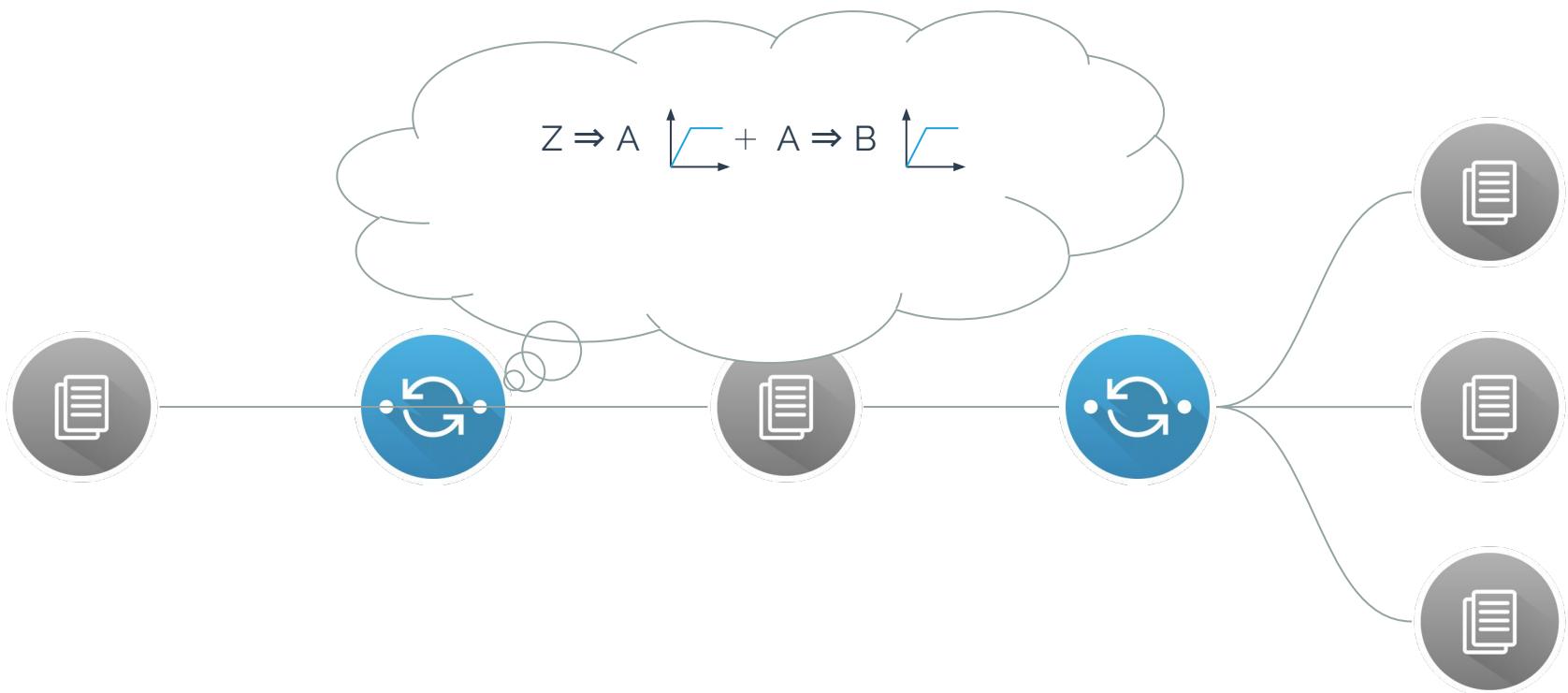
Connectors Set Rates per Ledger Pair



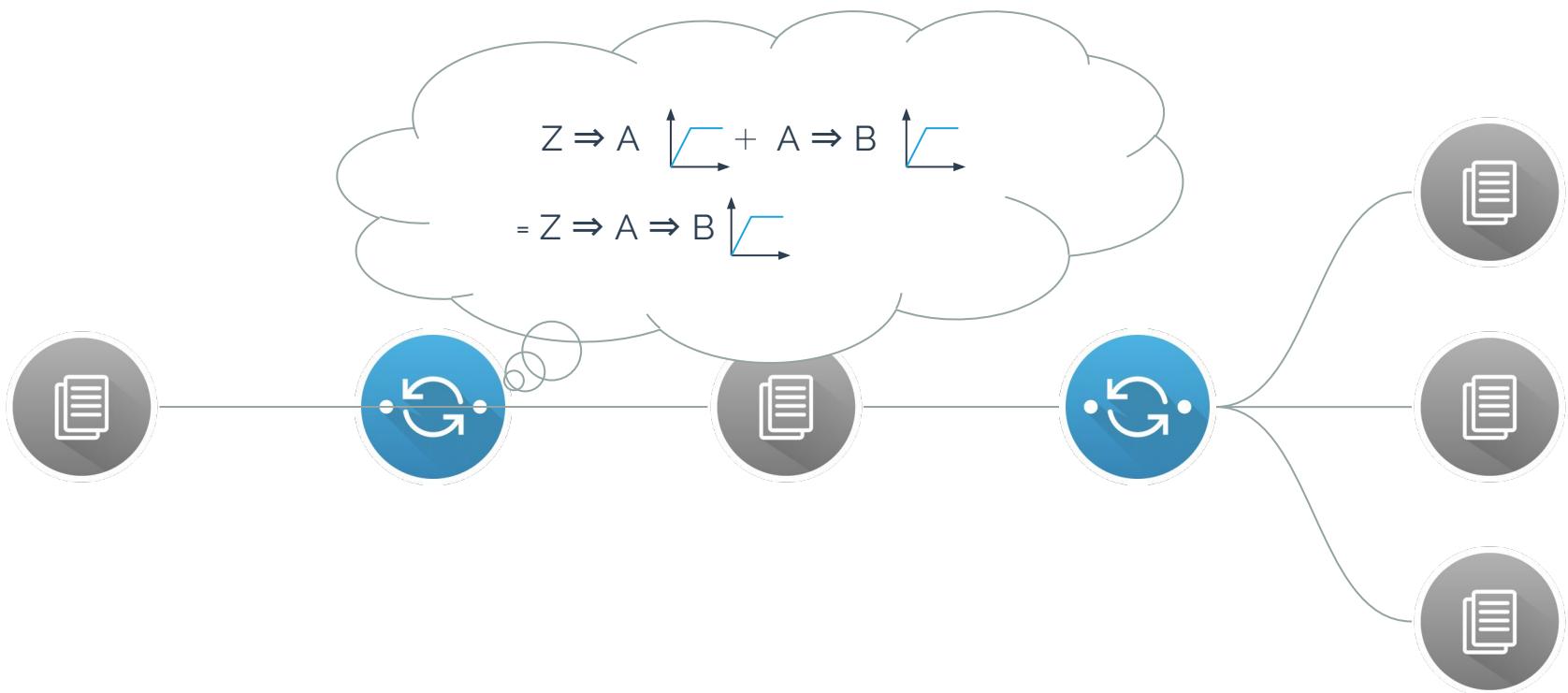
Connectors Advertise Their Routes



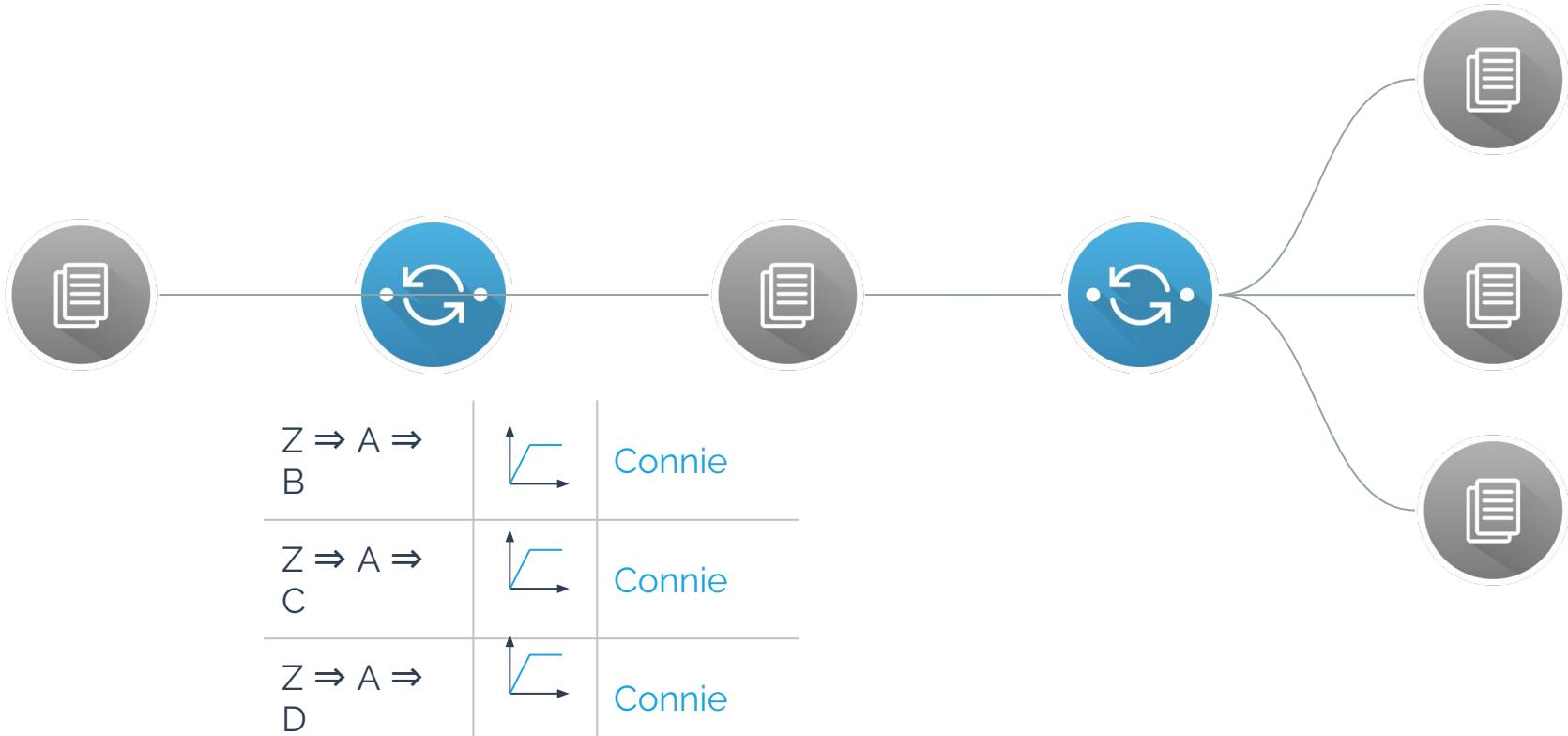
Synthetic Routes Are Created



Synthetic Routes Are Created



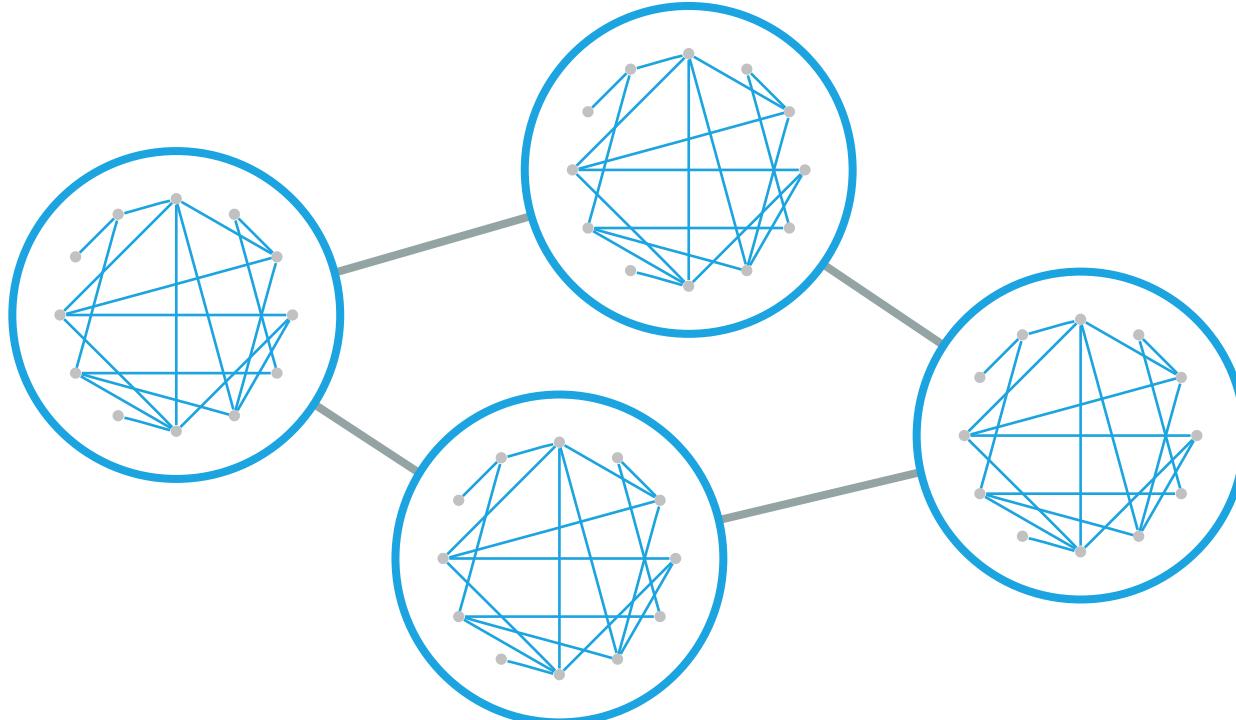
And Added to the Routing Table



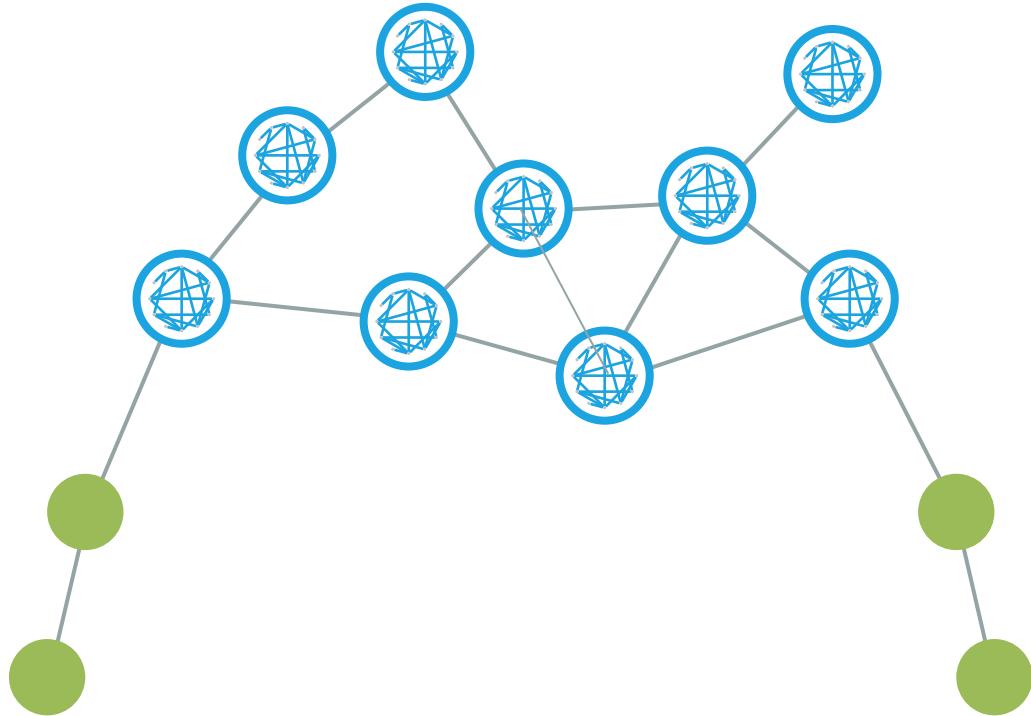
Routing Tables Grow Quickly

$Z \Rightarrow A$		Local
$Z \Rightarrow A \Rightarrow B$		Connie
$Z \Rightarrow A \Rightarrow C$		Connie
$Z \Rightarrow A \Rightarrow D$		Connie
$Z \Rightarrow C$		Local
$Z \Rightarrow C \Rightarrow E$		Chao
$Z \Rightarrow C \Rightarrow F$		Carl

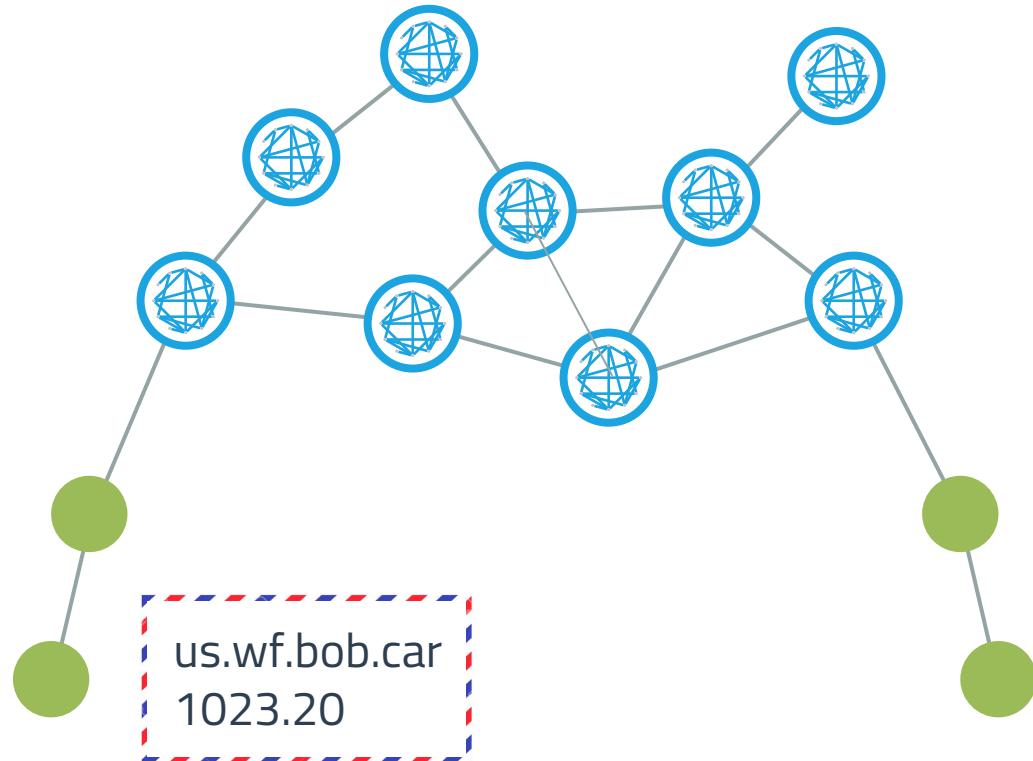
Autonomous Systems



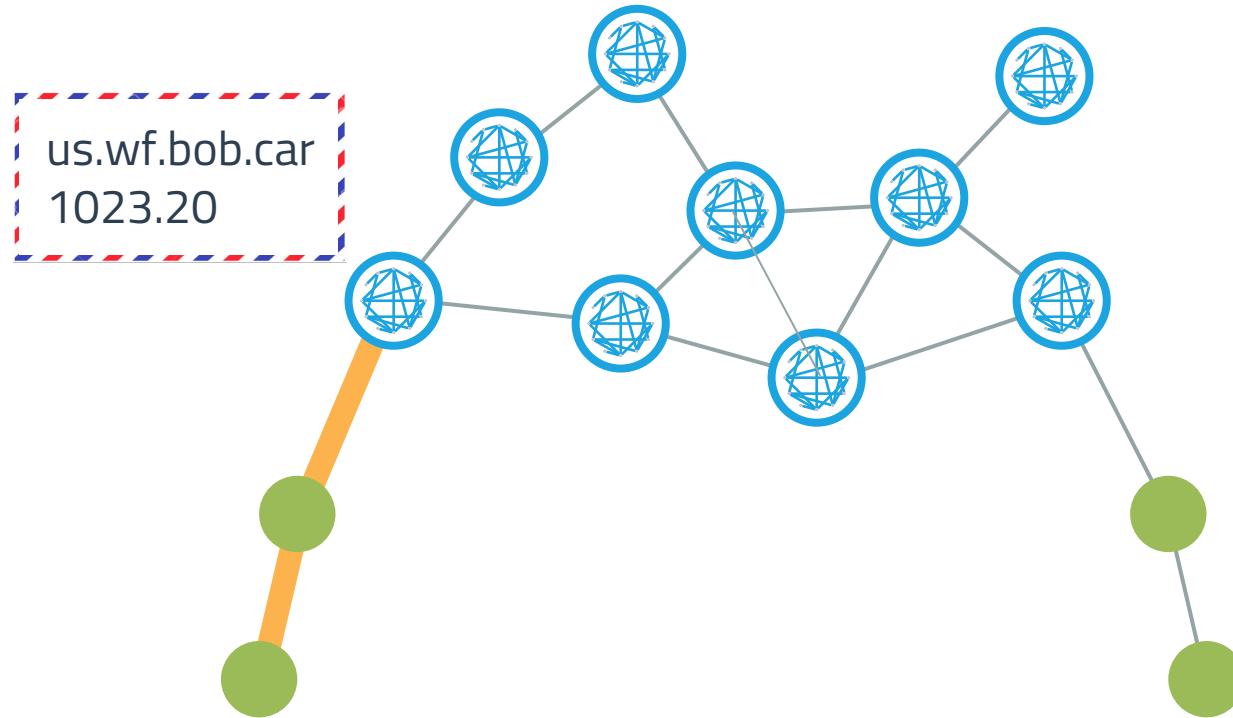
Core vs. Periphery



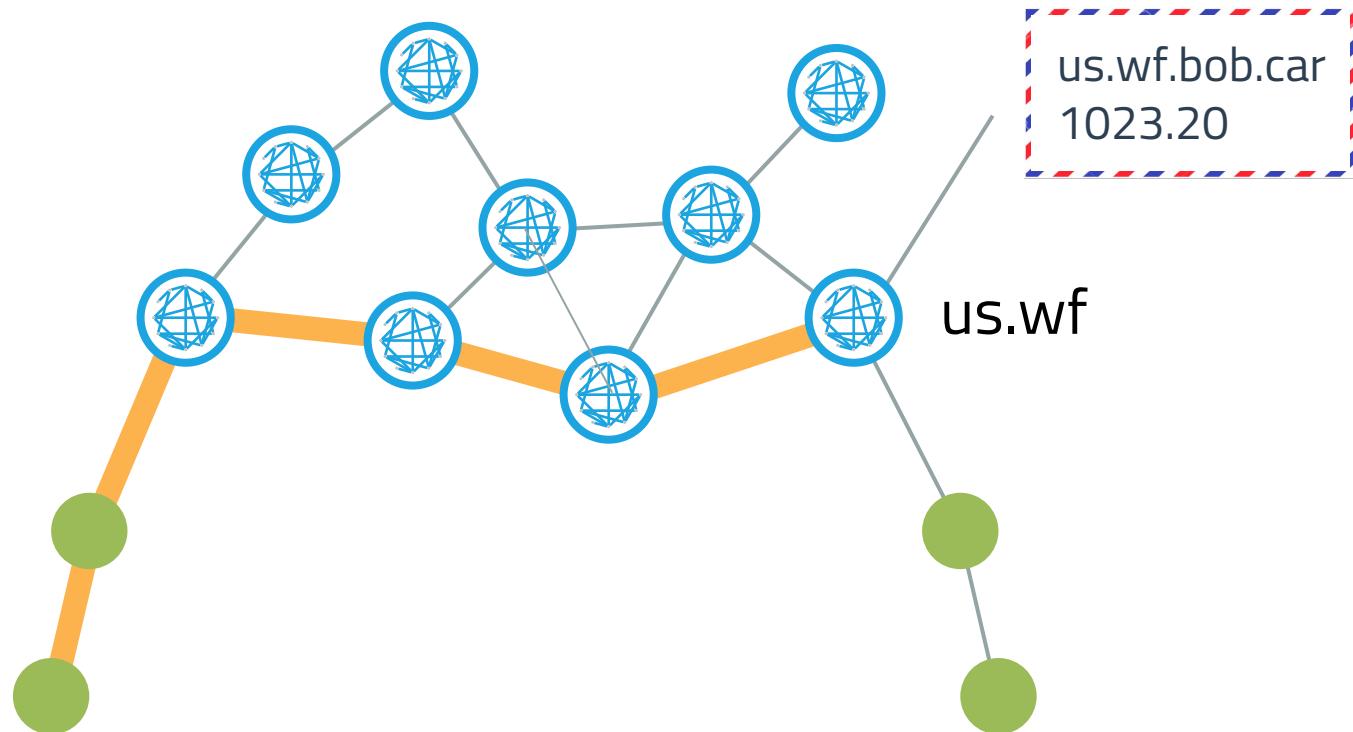
Routing a Payment



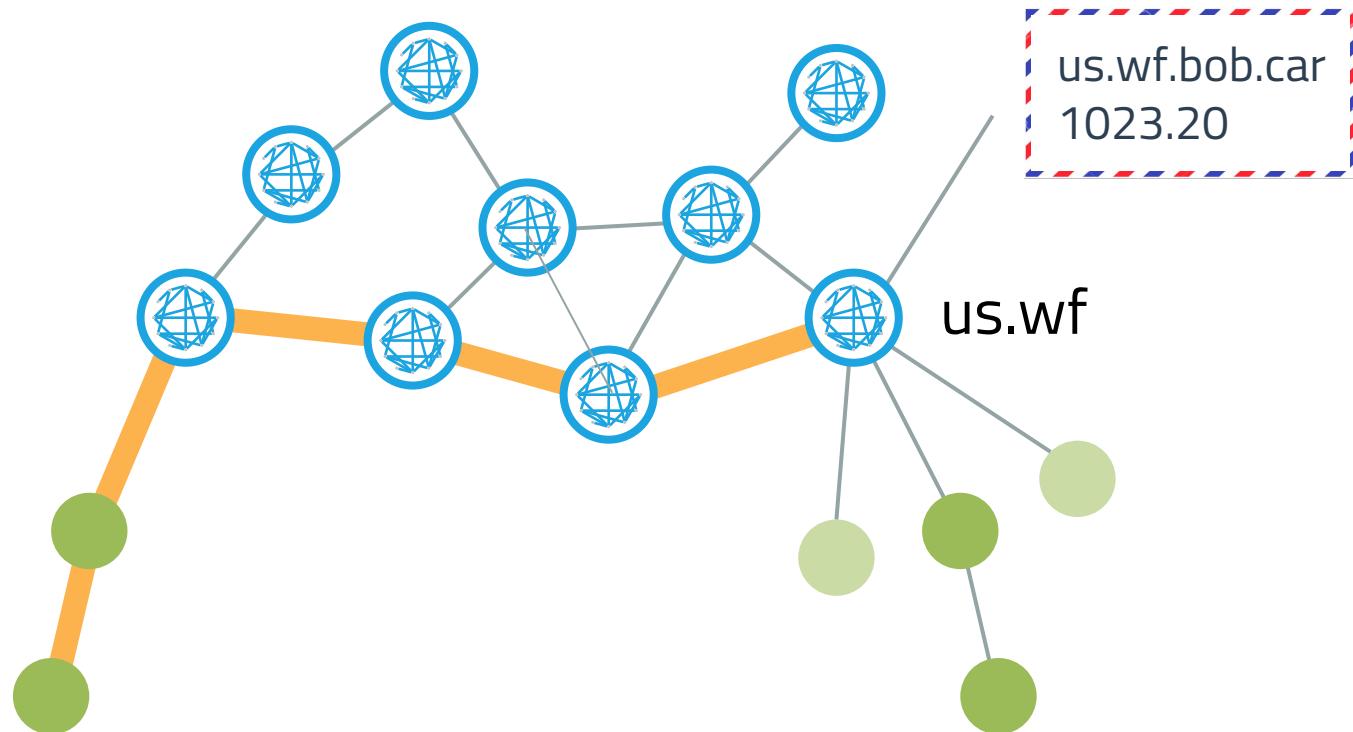
First We Route Up



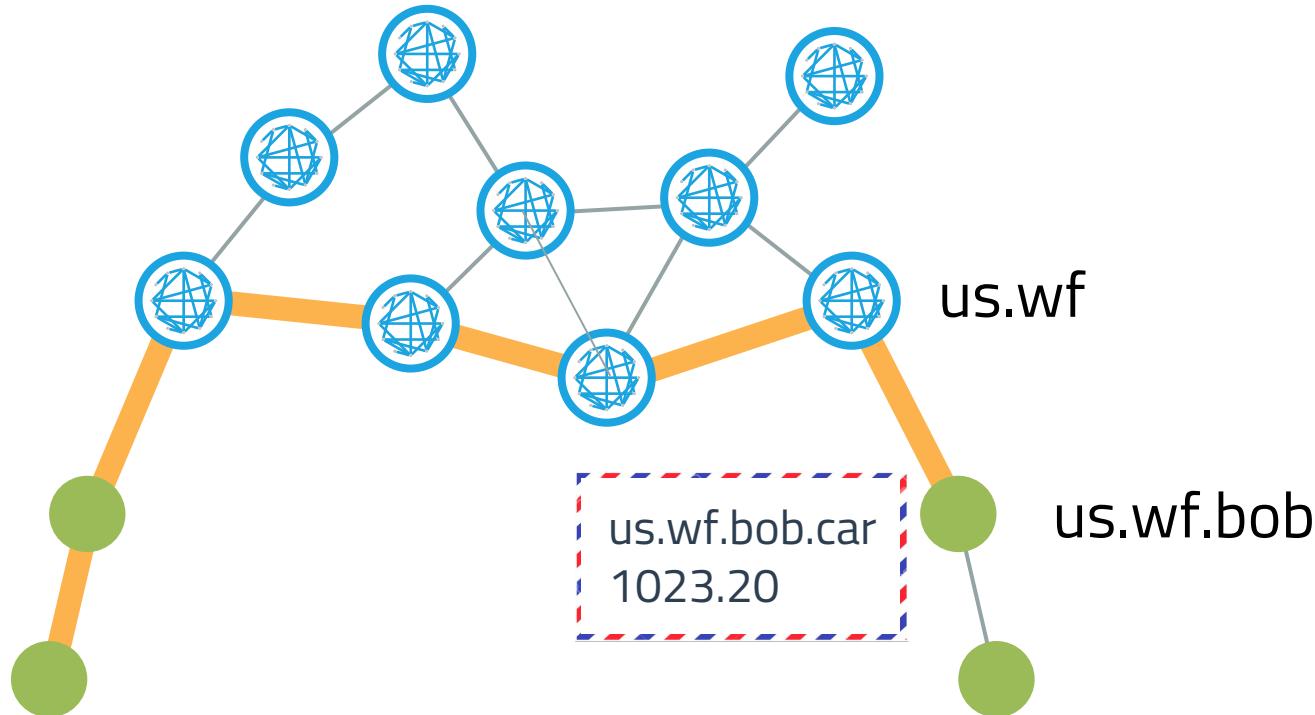
Then Across



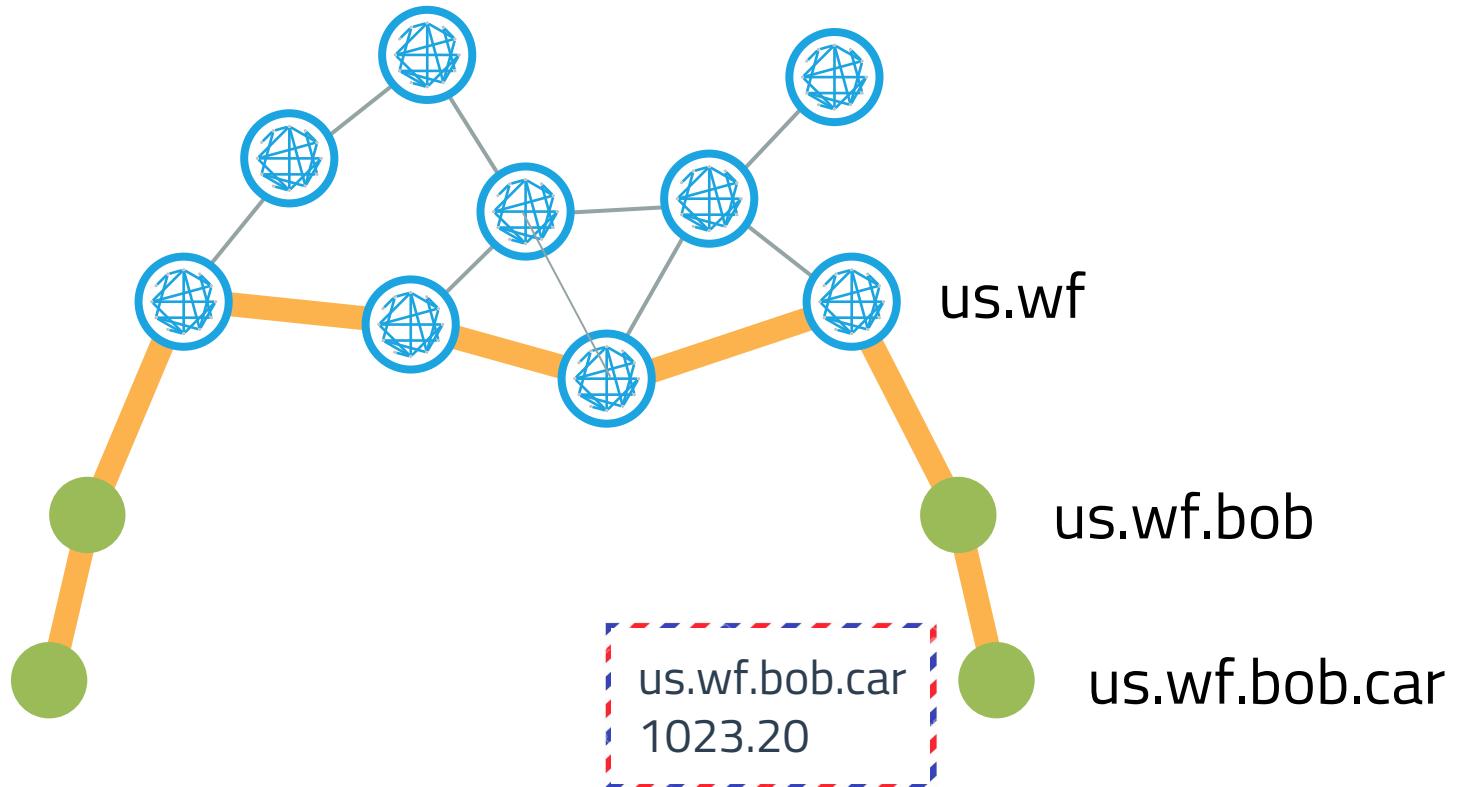
Then Across



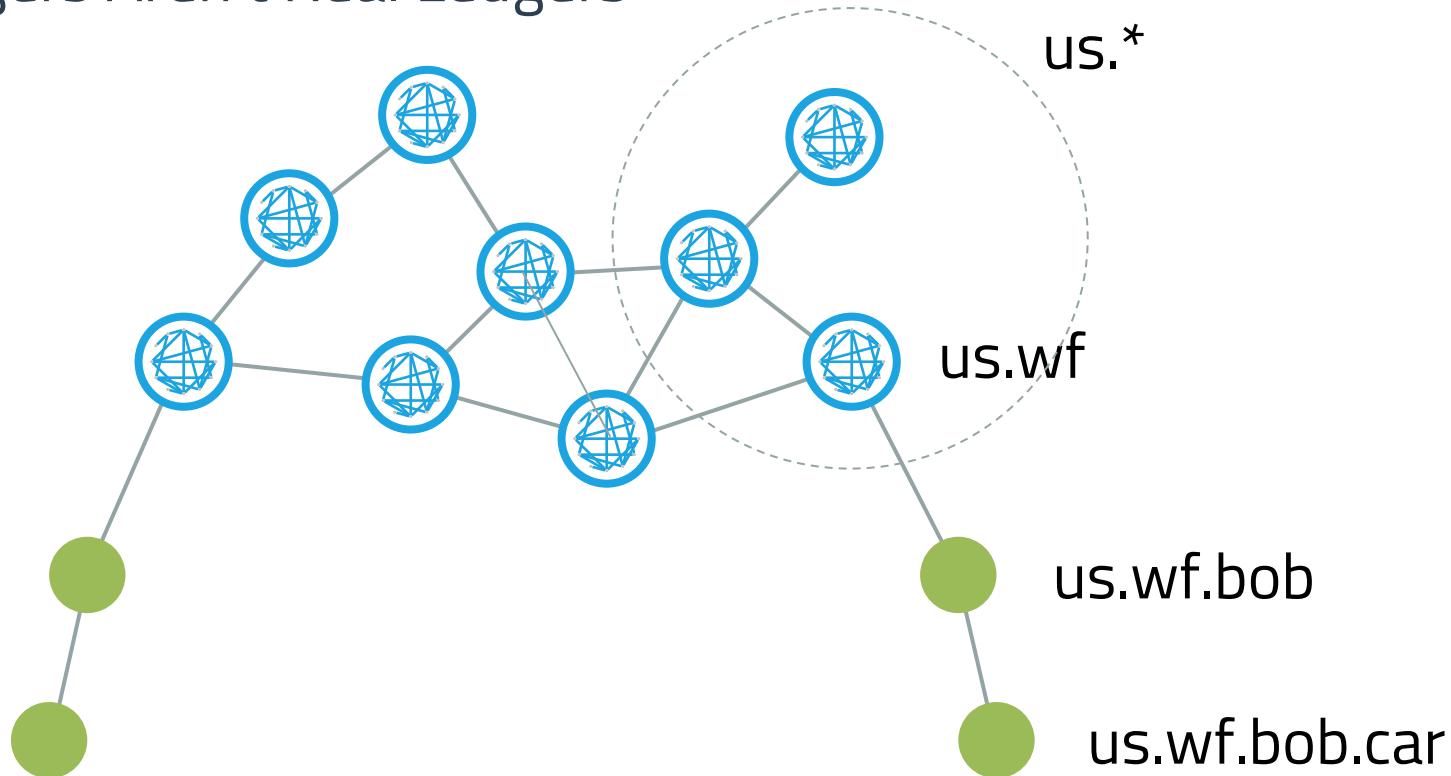
And Finally Down



And Finally Down



Some Ledgers Aren't Real Ledgers



Questions?





Coffee
Break!



Building with ILP

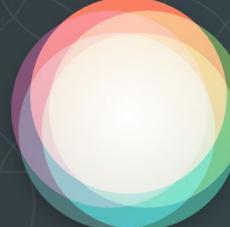
Stack, Clients, Ledger Plugins

Evan Schwartz

Welcome | Interledger 

<https://interledger.org>

Docs Community News Github



Interledger

The protocol for connecting ledgers.

[Get Started](#)

Join us for the next **Interledger Workshop** in London on Wednesday, July 6 2016



Code With Money

Add payments without being tied to a single currency or payment provider.



Multi-Hop Routing

Send payments to other ledgers, even if they are multiple hops away.



Simple Protocol

Inspired by TCP/IP, Interledger is easy to implement and use.

Getting Started | Interledger X

https://interledger.org/getting-started.html

Docs Community News Github

QUICK START

Overview Getting Started Why Interledger

COMMUNITY RESOURCES

Videos Libraries & Tools

SPECS

Interledger Architecture Interledger Protocol Ledger Plugin Interface

TECHNICAL DOCUMENTATION

five-bells-ledger five-bells-connector five-bells-wallet five-bells-condition

Getting Started

Sending Your First Interledger Payment

Sign up for the demo wallets and start sending Interledger payments between them in under 3 minutes.

First, create an account on the [Red Demo Wallet](#) and the [Blue Demo Wallet](#) (one for sending and the other for receiving).

LOGIN REGISTER

USERNAME
alice

PASSWORD

➡ Register

Or login using

Github

interledger/five-bells-wallet x

GitHub, Inc. [US] https://github.com/interledger/five-bells-wallet-client

README.md



Five Bells Wallet Client

A high-level JS library for sending and receiving [Interledger](#) payments.

[npm v1.0.1](#) [code style standard](#) [build passing](#)

Installation

```
npm install five-bells-wallet-client --save
```

Usage

This is a client for the [five-bells-wallet](#).

To use it with a hosted demo wallet, create an account on [red.ilpdemo.org](#) or [blue.ilpdemo.org](#) (it doesn't matter which because they're connected via the [Interledger Protocol](#)).

Sending

The “Five Bells” Stack

Application

f-b-wallet-client

f-b-wallet

f-b-wallet-client

f-b-wallet

Interledger

f-b-connector

Ledger

f-b-ledger

f-b-ledger

What about other ledgers?

Supporting Different Ledger Types

Interledger

js-ilp

f-b-connector

Ledger

f-b-ledger



Plugins Provide Abstractions Over Different Ledgers

Interledger

js-ilp

f-b-connector

js-ilp-
plugin-bells

js-ilp-
plugin-bells

Ledger

f-b-ledger



IL-RFC-4: **Ledger Plugin Interface**

An abstraction interface for Interledger clients and connectors to communicate and route payments across different ledger protocols.

Class: LedgerPlugin

```
class LedgerPlugin
```

Methods

	Name
static	canConnectToLedger (auth) \Rightarrow Boolean
new	LedgerPlugin (opts)
	connect () \Rightarrow Promise.<null>
	disconnect () \Rightarrow Promise.<null>
	isConnected () \Rightarrow Boolean
	getInfo () \Rightarrow Promise.<LedgerInfo>
	getBalance () \Rightarrow Promise.<String>
	getConnectors () \Rightarrow Promise.<Array.<String>>
	send () \Rightarrow Promise.<null>
	fulfillCondition (transferId, fulfillment) \Rightarrow Promise.<null>
	replyToTransfer (transferId, replyMessage) \Rightarrow Promise.<null>

Events

Name	Handler
connect	() \Rightarrow
disconnect	() \Rightarrow
error	() \Rightarrow
receive	(transfer:IncomingTransfer) \Rightarrow
fulfill_execution_condition	(transfer:Transfer, fulfillment:Buffer)
fulfill_cancellation_condition	(transfer:Transfer, fulfillment:Buffer)
reject	(transfer:OutgoingTransfer, rejectionReason:Error) \Rightarrow
reply	(transfer:OutgoingTransfer, replyMessage:Buffer) \Rightarrow

Plugins For Any Type of Ledger

Interledger

js-ilp

f-b-connector

js-ilp-
plugin-???

js-ilp-
plugin-???

Ledger

???-ledger



What if there is no ledger?



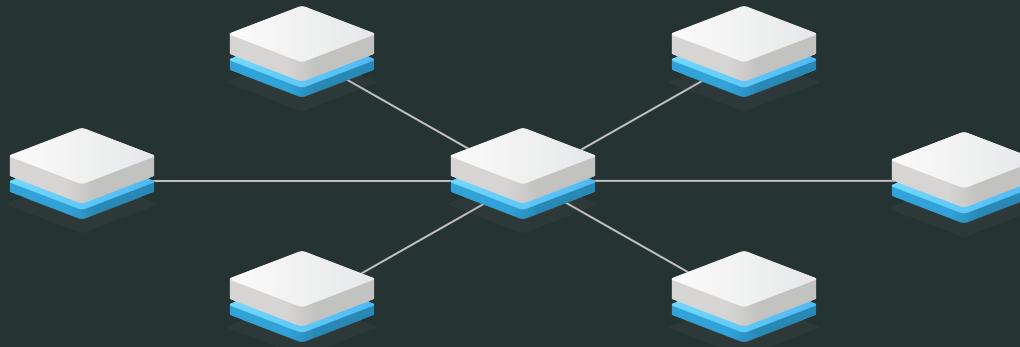
ILP Trustlines

“Dial-Up” ILP Using Credit

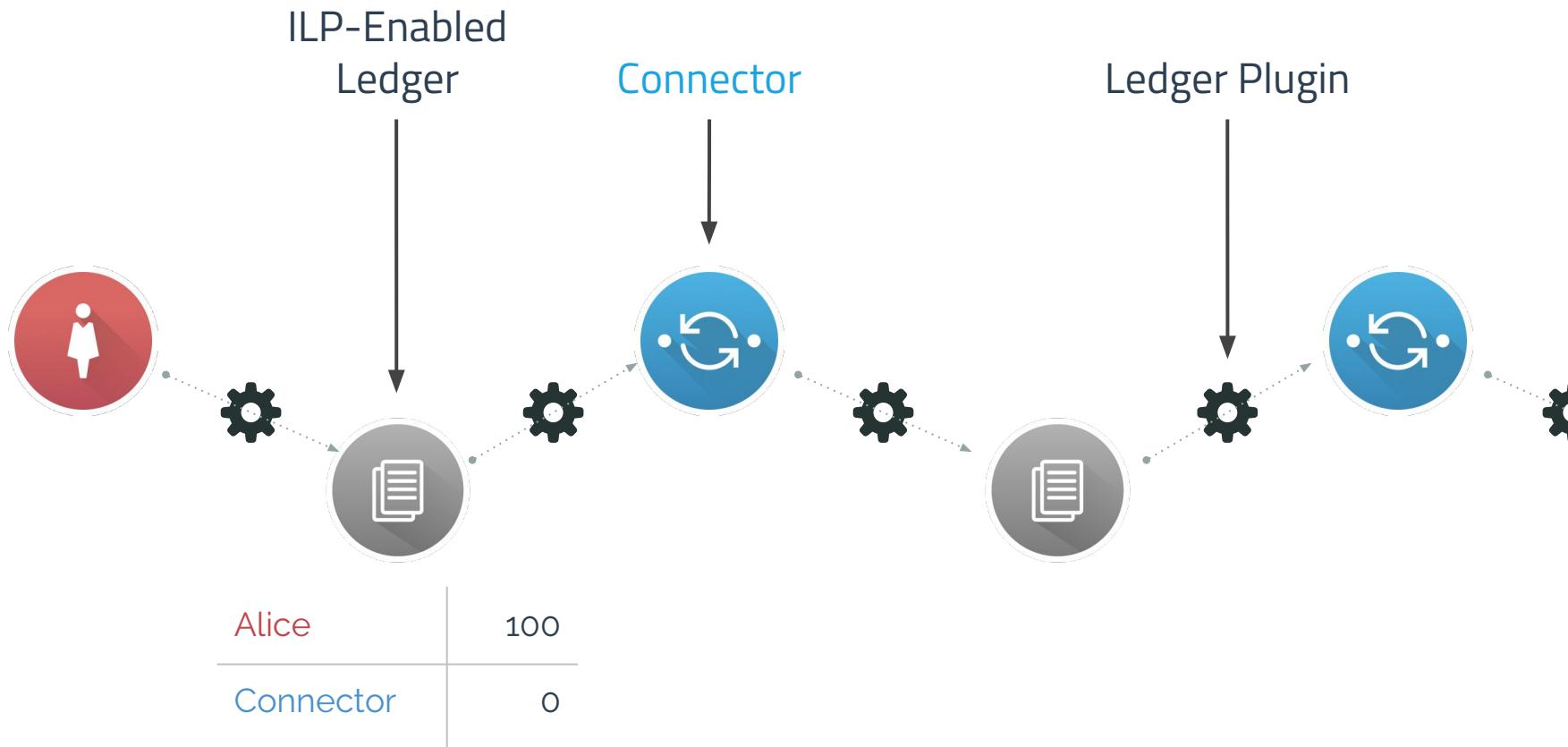
Ben Sharafian

ILP-Enablement

Doing It '*The Right Way*'

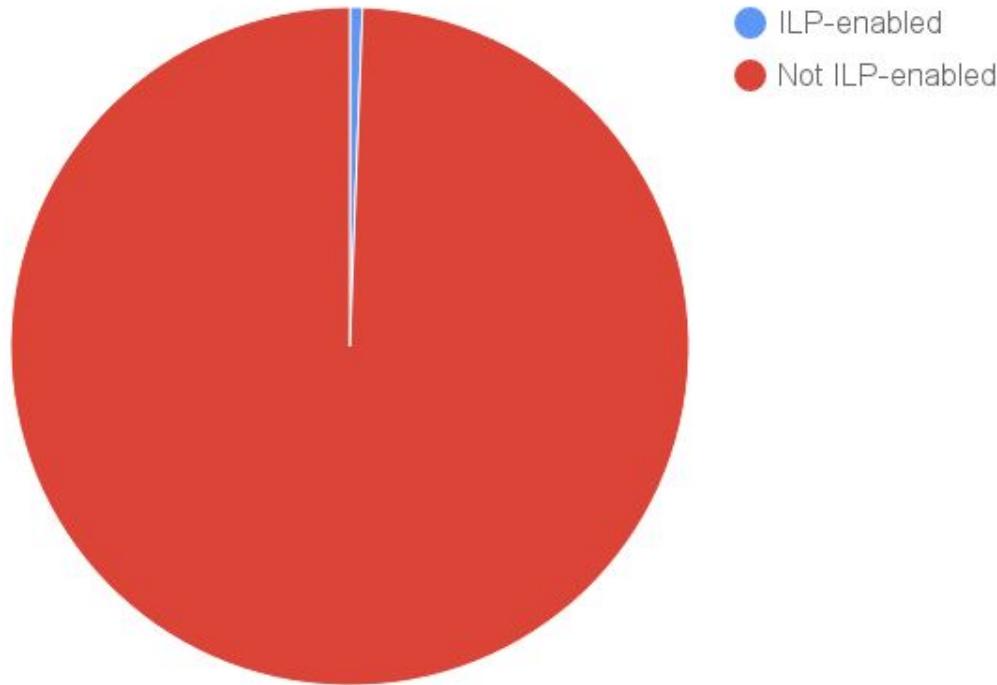


The Normal ILP Flow (No Trustlines)



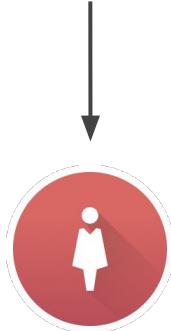
Adoption To-Date

Status: Not Great

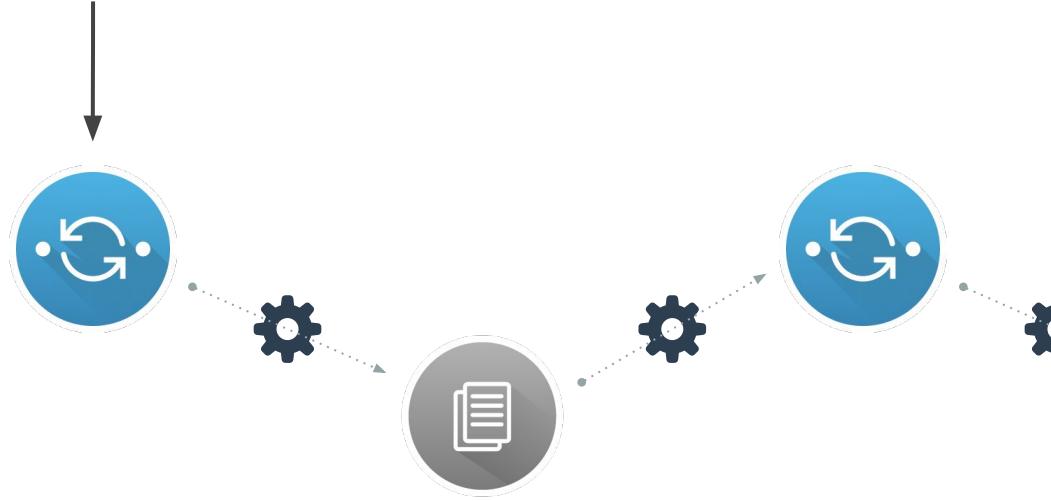


An ILP Ledger Is Not Always Available

Developer
(The Noob)



Connector
(The Nerd)

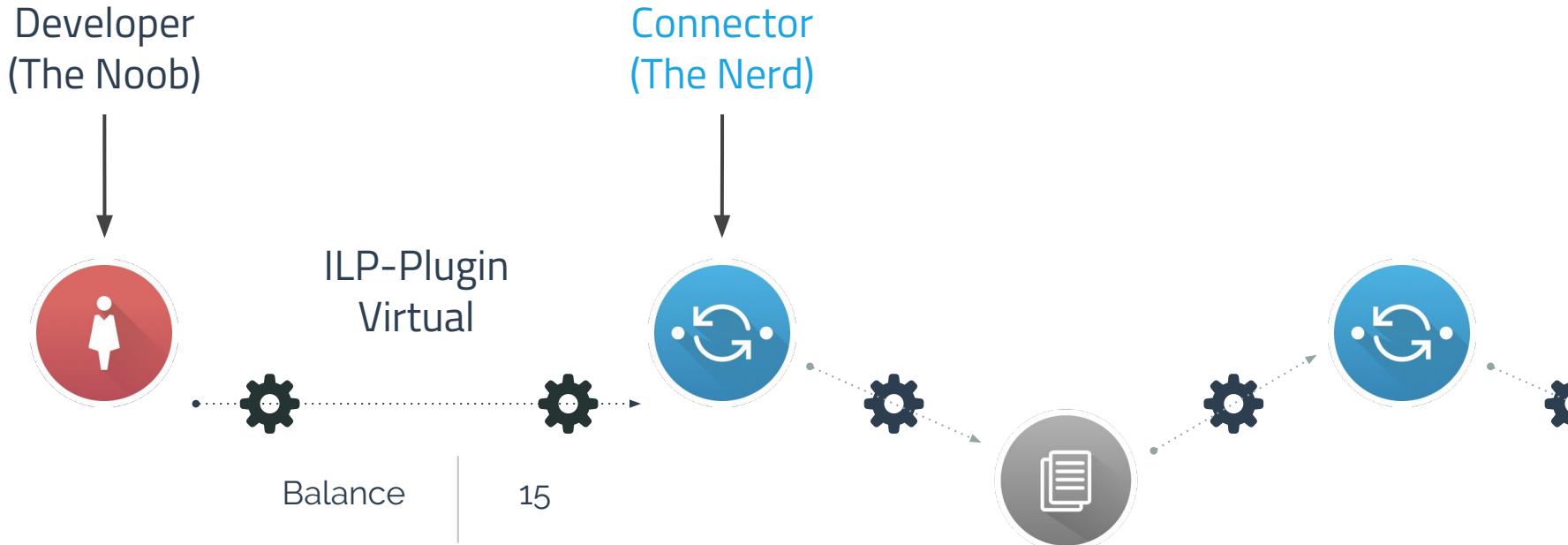


???

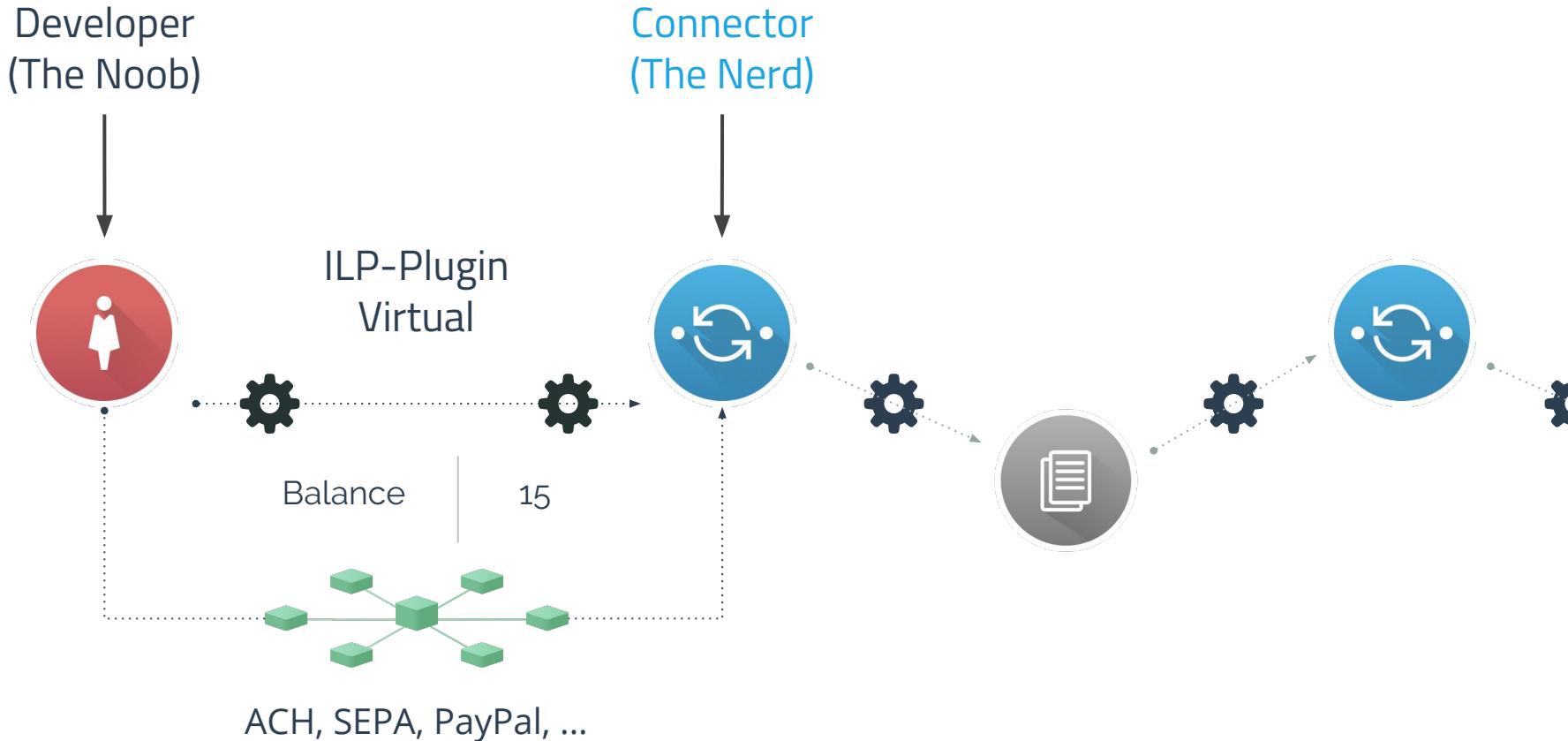
Protocols Have Humble Beginnings



ILP Flow With Trust-lines



ILP Flow With Trust-lines



ILP Flow With Trust-lines

