Clockwork
The Recurring Payments Protocol

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Abstract
Clockwork is a decentralized protocol built on the Ethereum blockchain that enables recurring payments and enables users to manage them entirely on chain. Clockwork unlocks the use of cryptocurrency for repeat payment models, including software as a service, media subscriptions, and others, including some that have not been possible before.

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Introduction

The decentralized financial infrastructure ecosystem has seen a rapid growth in protocols and capabilities. Protocols for stable coins, decentralised money markets and exchanges, among many others have drastically increased the design space for distributed applications. Unfortunately there has been no easy way to undertake trustless, recurring payments with cryptocurrency.

Recurring payments are the backbone of Software as a Service (SaaS) models and are a necessary component of any financial infrastructure. Traditional solutions in the fiat ecosystem are ubiquitous but have a number of inherent problems, for example they are expensive; credit card transaction fees regularly exceed 4%. Recurring payments are also fragmented from an end-user perspective, and each payment is managed separately with the individual service provider. As a consumer this means there is no easy way to track or budget your recurring monthly payments. This also means cancelling, changing or suspending recurring payments is difficult and laborious, especially in the case of lost or stolen cards. A consumer has to manually update billing information for every service provider.

Service providers and other payees, on the other hand, must accommodate for expiring payment cards, and denied payments due to insufficient funds.

In this paper we introduce a decentralised and crypto-native repeat payments solution. The clockwork protocol enables decentralised recurring payments by incentivising the execution of transactions while keeping all payment schedule information on chain. This will allow SaaS platforms to accept recurring crypto payments at much lower fees without having to build custom software, and gives users control of all their subscriptions in a single place. Clockwork enables more efficient, secure, and reliable repeat payments for both payer and payee.

Use cases

Clockwork is a generalized recurring transaction protocol that fits a number of use cases. Version 1 of the protocol will focus on use cases for SaaS and subscription service providers.

SaaS providers

SaaS providers define a set of payment schedules with billing duration, payment amounts and billing schedule. These payment schedules are then made available on the service provider website either through open source Clockwork widgets or via custom integration .

Subscribers enter into a subscription contract with the service provider and set a source of funds (more on this later). Subscribers can now view and manage all of their subscriptions in the "Clockwork Subscriptions DApp".

Service providers can use the Clockwork API to integrate payment details into their existing back office systems or manage their clockwork subscriptions from the "Clockwork Service Providers DApp".

Example of Clockwork dApp running as a Metamask Snap browser plugin
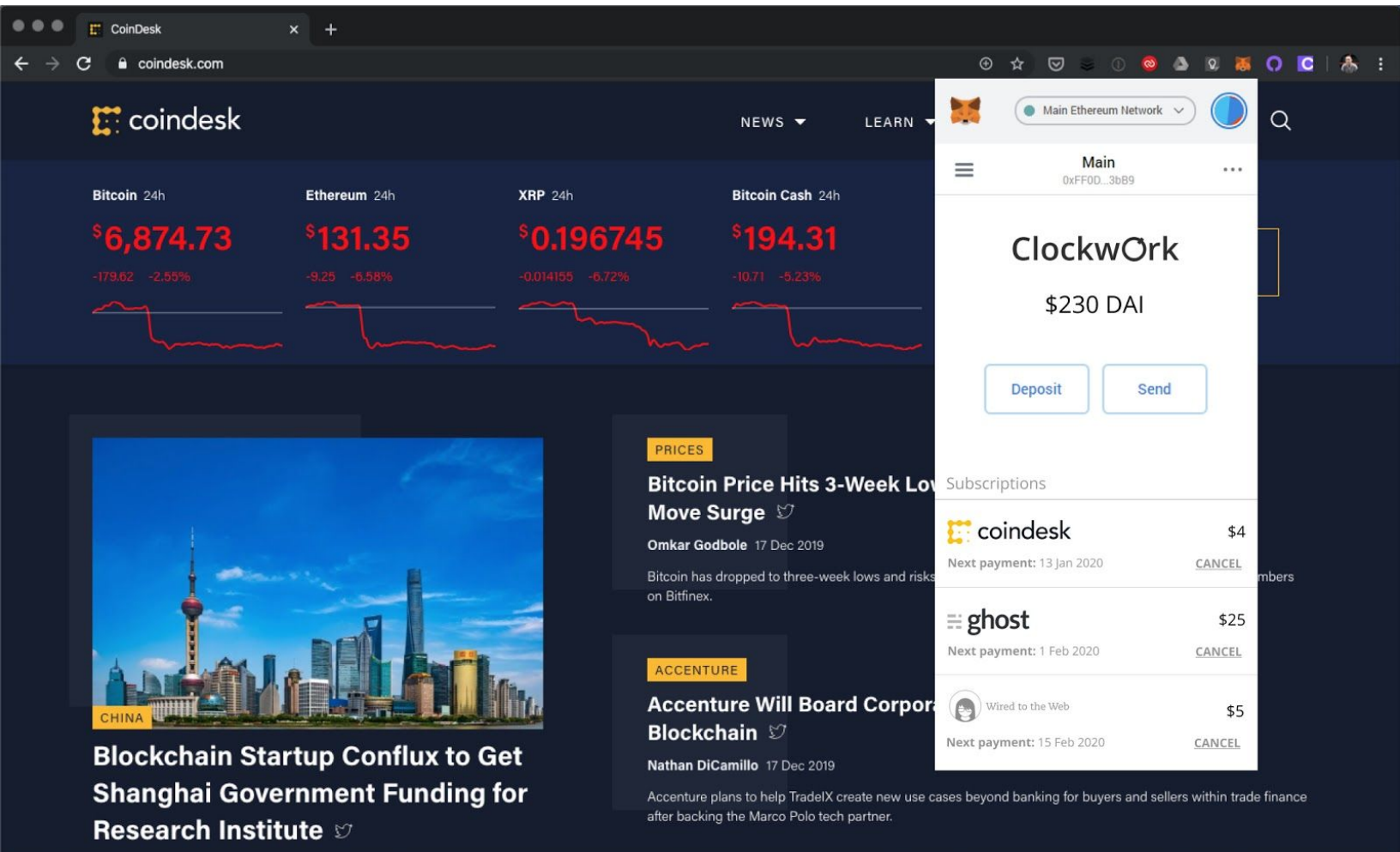
Payroll

DAOs and companies that would like to pay regular salaries in crypto can use the Clockwork protocol for their payroll. Companies create payment schedules for each employee and set the source of funds to an address controlled by the organisation. They would set destination addresses controlled by employees, service providers, and other payroll payees.

While a payroll DApp is out of scope for v1, the Clockwork protocol is open-source and permissionless so any third party can build an interface dedicated to this use case.

Clockwork Protocol

Clockwork is a protocol on the Ethereum blockchain that establishes a market for executing recurring payments. It does so by defining a relationship between payers, payees, transaction executors and management interfaces. Payments are denominated in DAI to avoid vollatility.

Smart contracts

RecurringPaymentWallet

Users send DAI to a funding contract that is shared by all recurring payments. The RecurringPaymentWallet contract acts like a prepaid debit card for all recurring payments. This allows users to set budgets and manages the risk of having large amounts of funds locked up in a contract.

This contract keeps track of all the payment schedules the user has signed up for and funds payments generated by these payment schedules. The RecurringPaymentWallet contract can cancel or suspend payment schedules at any time on instruction from the account that owns the wallet. The RecurringPaymentWallet contract is also responsible for creating new payment schedules.

PaymentSchedule

PaymentSchedules are always owned by a funding contract and can only be cancelled by the owner. On construction the terms of the payment schedule are set and are immutable. To change the terms the old schedule must be cancelled and a new one created.

The terms managed by a payment schedule include the following :

Term	Description
Owner	The funding contract that owns and funds this payment schedule.
Destination	The payment destination.
Payment value	The payment amount
First due date	The first date the payment was due
Next due date	The next date the payment is due
Number of payments	How many payments to make
Schedule	Daily, weekly, monthly, quarterly, yearly
Payment Leeway	Number of days leeway before payment is overdue

In addition to setting payment terms the payment schedule creates and funds payments that can then be executed. It also keeps track of all historical payments and the payment status (Overdue, cancelled, suspended).

Payment

Once a Payment is created and funded by a payment schedule it is available publicly for execution. On execution it pays out a fee to the address set by the executor. This incentivises third parties to execute transactions on the Clockwork protocol for a fee.

User interfaces

Users will be able to manage payment schedules through: The Clockwork payments DApp, third party wallets that implement the protocol, wallet plugins, and at the service provider's site.

Third parties can also build custom interfaces for a variety of use cases because of the protocol's open source and permissionless nature. The protocol has built in incentives that provide an ongoing revenue stream to management interfaces to encourage this behavior. We hope the community will build interfaces for novel use cases as the protocol develops.

Reference user interfaces

Clockwork protocol will provide a reference implementation of a payment management DApp as well as service provider DApp.

The payment management DApp is an end user app that allows users to manage their funding wallets and recurring payments.

It will provide :
- a single view of all active recurring payments
- a funding interface to manage wallet balance
- a payment management interface to suspend, cancel and resume payment schedules

The Clockwork service providers DApp is aimed at service providers and allows them to manage their subscription plans.

It will provide :
- data export for integration with existing subscription management systems
- subscriptions overview and history
- overdue subscription management
- subscriptions management to set payment terms etc.

Continuous funding model

Clockwork protocol will use a native token (CWG) minted through an Augmented Bonding Curve, as used in The Commons Stack, to provide a continuous funding model for the protocol. Augmented bonding curves are based off of Michael Zargham's complex system research at BlockScience and introduce a Reserve Pool (a Reserve of bonded DAI and a Supply of tokens) and a Funding Pool (floating supply of DAI available for use) that work together to create a self-sustaining funding mechanism for a continuous organization.

Unlike traditional bonding curves when tokens are burned (withdrawn for DAI → $), an exit tax is enacted on liquidation. As Members "cash out" and liquidate their tokens for DAI, a small percentage of their returns are sent back into the Funding Pool, allowing for continuous funding that can be used for protocol maintenance and development.

This mechanism aims to be minimally extractive but must provide funding for
- DApp development and maintenance
- Protocol development and maintenance
- Keeper technical support
- Business development
- Marketing
- Legal
- etc.

Native token: Clockwork Gears (CWG)

Transaction generation, transaction execution and management interface incentives are paid in CWG. This creates demand for the token, ecosystem participants would need to burn these tokens to receive DAI. As stated above this will generate an "exit tax" that will be used to fund ongoing protocol development.

Incentive structure

The Clockwork protocol uses the CWG token to incentivise the following actions:

Payment generation
Transactions are generated through the generateTransactions method on the ClockworkManager contract. On transaction generation the generator is stored and a generator fee is paid to the generator address apon transaction execution.

Payment execution
Apon transaction execution a transaction execution fee is paid to the executor.

Management interface integration
Funding contracts keep track of the fraction of remaining funds deposited through each management interface used to interact with the contract. A management fee is paid out to management interfaces in proportion to this fraction.

All of these are key to protocol success and health over the long term.

Keepers

Keepers are third parties that perform the actions that are incentivised by the protocol. The Clockwork protocol will provide open source middleware to make it as easy as possible for keepers to participate.

The keeper middleware consists of 3 main components:

Eventeum
Eventeum by ConsenSys is an Ethereum event listener that bridges smart contract events and backend microservices. Eventeum listens for specified event emissions from the Ethereum network, and broadcasts these events into the middleware layer. This provides a distinct separation of concerns and means that keeper microservices do not have to subscribe to events directly on an Ethereum node.

Keepers

There are 2 types of keepers in the Clockwork protocol. **Payment generators** that periodically poll the smart contracts to find due payments and then generate and fund them if enough funds are available. **Payment executors** that listen for PaymentGenerated events and execute payments as they get added.
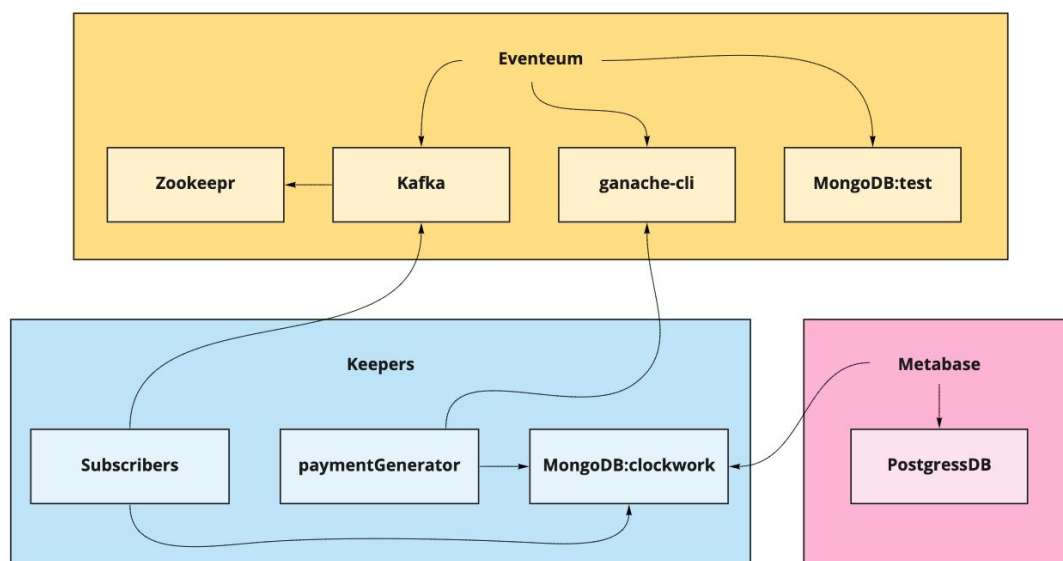
Metabase
Metabase is an open source Business Intelligence platform that is used to give visibility into the keeper infrastructure and overall network state.

Governance

The clockwork platform will begin with centralized control of the protocol overseen by the administration board, and over time, will transition to complete community and stakeholder control.

The following rights in the protocol are controlled by the admin:
- Setting transaction fees
- Setting fee split between management interface and keepers
- Ability to choose a new admin board
- Ability to register new payment schedule contracts

Once control has moved fully to the community CLK tokens can be used to vote on protocol governance. Governance will most likely take the form of Conviction Voting.

Illustration of protocol structure

Stock and flow diagram
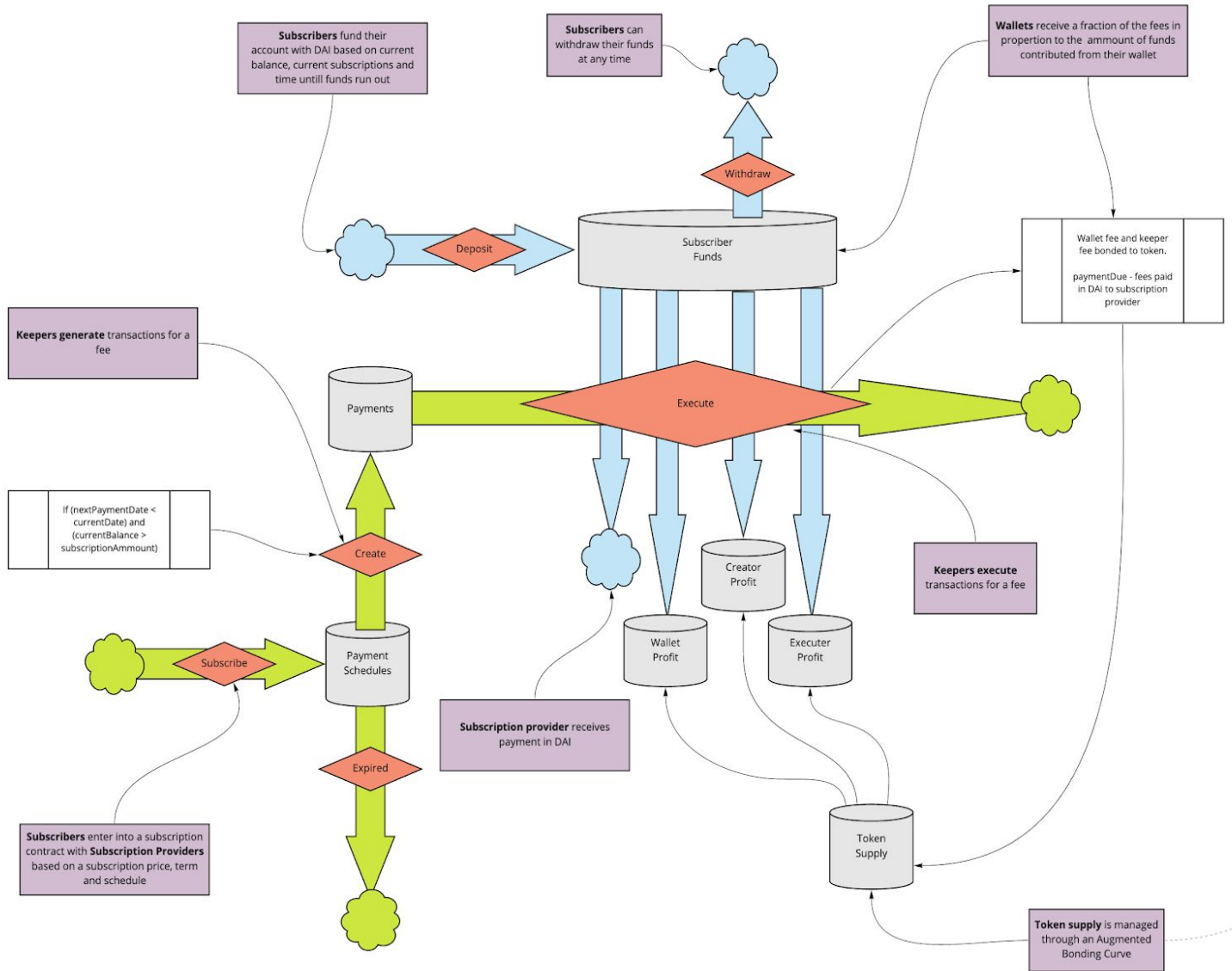
Summary

Clockwork provides an efficient, robust protocol and incentive structure to facilitate recurring cryptocurrency payments for individuals and organisations, solving one of cryptocurrency's biggest challenges to date.