Jolocom-Lib Documentation

Jolocom

Nov 17, 2020

Where to go next?

Our Approach

The Jolocom identity solution aims to be a universal, lightweight, open source protocol for decentralized digital identity and access right management. The protocol is built on to leading open source standards standards and relies on distributed / decentralized systems such as Ethereum and IPFS for identity registration and resolution.

The protcol architecture revolves around three main concepts:

- Hierarchical Deterministic Key Derivation , which enables pseudonymous, context-specific interactions through the creation of and control over multiple identities.
- Decentralized Identifiers (DIDs) , which are associated with each identity and used during most interaction flows, such as authentication or data exchange.
- Verifiable Credentials , which are digitally-signed attestations issued by an identity. The specification can be used to develop a simple way of associating attribute information with identifiers.

Cryptographic keys and DIDs enable the existence of a self-sovereign identity. Keys and verifiable credentials provide the tools required to create complex data while simultaneously preserving simplicity at the core.

This approach allows us to keep the protocol generic while facilitating an unlimited number of specific use cases with varying levels of complexity.

A further component of the protocol architecture calls for the integration of a public, censorship-resistant, decentralized network for anchoring and resolving user identifiers. For this we currently use IPFS for storage and Ethereum for anchoring and indexing identifiers.

In its most simplistic form, the Jolocom protocol can be used to:

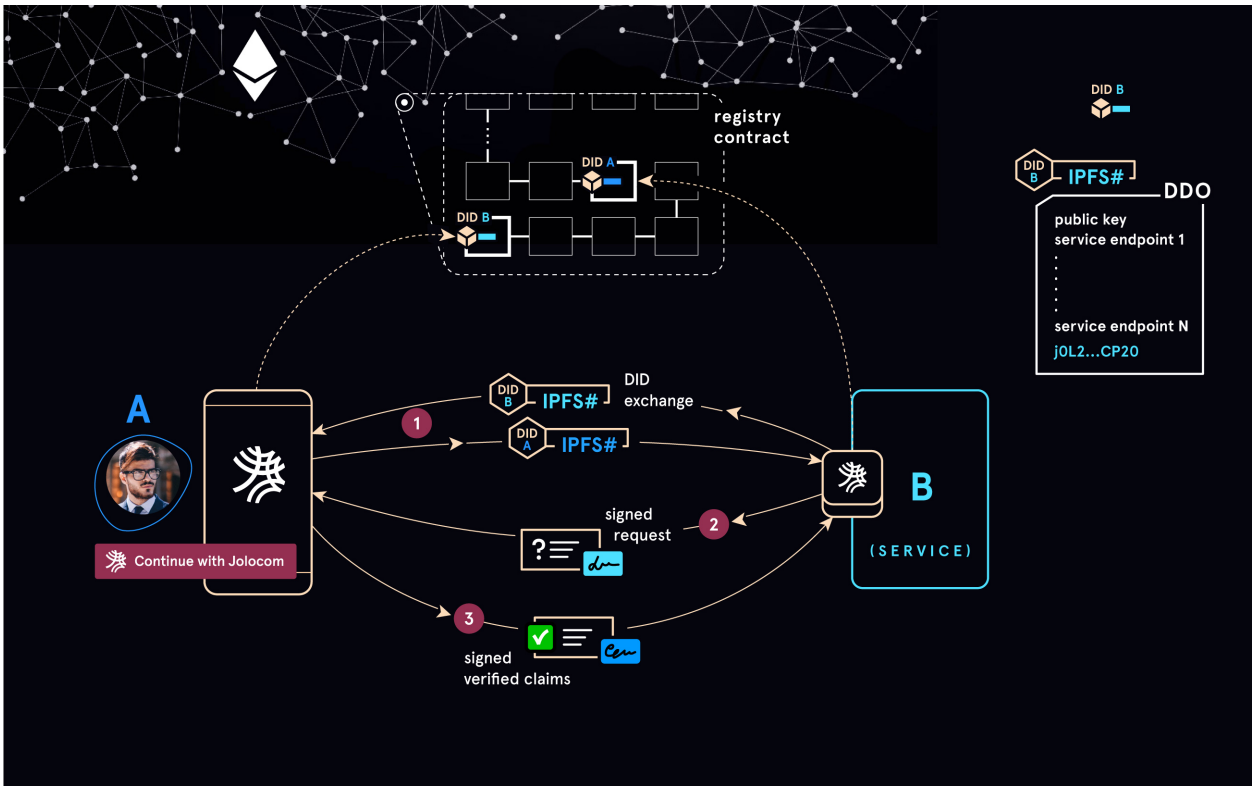
- Create a self-sovereign identity for use by humans, organisations, and smart agents;
- Attach meaningful information to identities in the form of verifiable credentials;
- Easily request and consume verified information about identities in an automated fashoin.

We hope it will serve efforts to decentralize the web and digital identity, and enable people, organisations, and smart agents to own and control the data that defines them.

CHAPTER 1

Introduction

This section provides a very brief overview of the protocol architecture, introduces the concept of self-sovereign identity, and explains how to navigate the Jolocom library.



System Architecture

The Jolocom protocol is built using the following core specifications:

- Hierarchical Deterministic Key Derivation , which enables pseudonymous, context-specific interactions through

the creation of and control over multiple identities.

- Decentralized Identifiers (DIDs) , which are associated with each identity and used during most interaction flows, such as authentication or data exchange.
- Verifiable Credentials , which are digitally-signed attestations issued by an identity. The specification can be used to develop a simple way of associating attribute information with identifiers.

A further component of the protocol architecture calls for the integration of a public, censorship-resistant, decentralized network for anchoring and resolving user identifiers. For this we currently use IPFS for storage and Ethereum for anchoring and indexing identifiers.

Warning: Please be aware that the Jolocom library is still undergoing active develpoment. All identities are currently anchored on the Rinkeby testnet.

Please do not transfer any real ether to your Jolocom identity.

Note: The Jolocom Library is currently only compatible with Node.js versions 10 and 11.

1.1 The Jolocom library at a glance

The Jolocom library exposes an interface with four main entry points:

- `identityManager` - used for generating, deriving, and managing multiple keys;
- `parse` - used for instantiating various classess offered by the Jolocom library from encoded / serialized forms;
- `registry` - used for adding, retrieving, and modifying data persisted on IPFS and indexed on Ethereum;
- `unsigned` - used for generating unsigned versions of various data structures offered by the Jolocom library.

The next section examines the API in more detail.

CHAPTER 2

Getting Started

Warning: Please be aware that the Jolocom library is still undergoing active development. All identities are currently anchored on the Rinkeby testnet. Please do not transfer any real ether to your Jolocom identity.

2.1 How to install the Jolocom library

To begin using the Jolocom protocol, first install the Jolocom library as a dependency in your project. You can use `npm` or `yarn` to do so:

```
# using npm
npm install jolocom-lib --save

# using yarn
yarn add jolocom-lib
```

2.2 Browser and React Native Environments

To use the library in a browser or react native environment, you also need some polyfills as some of the dependencies assume running in a node environment

```
# using npm
npm install --save vm-browserify crypto-browserify assert stream-browserify events

# using yarn
yarn add vm-browserify crypto-browserify assert stream-browserify events
```

Also, you will need to configure your bundler (webpack, parcel, metro, etc) with aliases for the modules named *-browserify

For React Native's metro.config.js:

```
module.exports = {
  resolver: {
    extraNodeModules: {
      // Polyfills for node libraries
      "crypto": require.resolve("crypto-browserify"),
      "stream": require.resolve("stream-browserify"),
      "vm": require.resolve("vm-browserify")
    }
  },
}
```

Also `process.version` must be defined, so you might need to just set it in your index file:

```
process.version = 'v11.13.0'
```

2.3 How to create a self-sovereign identity

In broad strokes, the creation of a self-sovereign identity comprises the following steps:

- Instantiate a `SoftwareKeyProvider`
- Use the instantiated `keyProvider` to derive two keys, one to control your Jolocom identity, and another one to sign Ethereum transactions (e.g. for anchoring the identity, rotating keys, etc.)
- Fuel the second derived key with enough Ether to pay for the transaction anchoring the identity
- Instantiate and use the `JolocomRegistry` to create and anchor the DID document on the Ethereum network

The following sections elaborate on these steps.

Instantiate the Key Provider class

The `SoftwareKeyProvider` class abstracts all functionality related to deriving key pairs and creating / validating cryptographic signatures. Currently two ways of instantiating the class are supported, namely using the constructor or using the static `fromSeed` method:

```
import { JolocomLib } from 'jolocom-lib'
import { crypto } from 'crypto'

// Feel free to use a better rng module
const seed = crypto.randomBytes(32)
const password = 'secret'

const vaultedKeyProvider = JolocomLib.KeyProvider.fromSeed(seed, password)
```

In the snippet above the `fromSeed` method is used. It takes the seed in cleartext, and a password that will be used as a key to encrypt the provided seed on the instance.

Note: The password must be 32 bytes long **(the expected encoding is UTF-8)**. In case a password of a different length is provided (e.g. the example above), it will be hashed using `sha256` internally before usage. An appropriate warning will be printed to the console.

The encrypted seed can be retrieved from the class instance using:

```
const encryptedSeed = vaultedKeyProvider.encryptedSeed
```

Note: The returned value is a 64 byte `Buffer`, containing the initialization vector (IV) (16 bytes) concatenated with the ciphertext (48 bytes). `aes-256-cbc` is used for encryption.

The alternative way to instantiate the class by using it's constructor:

```
import { JolocomLib } from 'jolocom-lib'

const vaultedKeyProvider = new JolocomLib.KeyProvider(encryptedSeed)
```

Note: The expected value for `encryptedSeed` is a 64 byte `Buffer`, containing the initialization vector (IV) (16 bytes) concatenated with the ciphertext (48 bytes). `aes-256-cbc` will be used for decryption.

Derive a key to sign the Ethereum transaction

The `vaultedKeyProvider` just instantiated can be used to derive further key pairs necessary to complete the registration. We need to derive a key for signing the Ethereum transaction, which anchors the newly created identity.

```
const publicEthKey = vaultedKeyProvider.getPublicKey({
  encryptionPass: secret
  derivationPath: JolocomLib.KeyTypes.ethereumKey // "m/44'/60'/0'/0/0"
})
```

See also:

In the event that one of your keys becomes compromised, you only lose that one key. All other derived keys (including the most important master key) remain secure. Go to BIP-32 if you want to find out more about this derivation scheme. We are currently looking at key recovery solutions in case the master key itself is compromised.

The only arguments that need to be passed to `getPublicKey` are the `derivationPath`, in the format defined in BIP-32, and the `encryptionPass` that was used to create the encryption cipher. The Jolocom library comes equipped with a few predefined paths for generating specific key pairs. The list will expand as new use cases are explored. You can view the available paths as follows:

```
console.log(JolocomLib.KeyTypes)
```

The next step involves transferring a small amount of ether to the Rinkeby address corresponding to the created key pair.

Transferring ether to the key

In order to anchor the identity on the Ethereum network, a transaction must be assembled and broadcasted. In order to pay for the assembly and broadcasting, a small amount of ether needs to be present on the signing key. There are a few ways to receive ether on the Rinkeby test network, and the library also expose a helper function to assist:

```
await JolocomLib.util.fuelKeyWithEther(publicEthKey)
```

This will send a request to a fueling service Jolocom is currently hosting.

Anchoring the identity

The final step to creating a self-sovereign identity is anchoring the identity on Ethereum and storing the newly created DID document on IPFS. For these purposes, the `JolocomRegistry` can be used; it is essentially an implementation of a DID resolver. The creation would look as follows:

```
const registry = JolocomLib.registries.jolocom.create()
await registry.create(vaultedKeyProvider, secret)
```

Behind the scenes, two key pairs are derived from the seed. The first key is used to derive the DID and create a corresponding DID document. The second key is used to sign the Ethereum transaction, adding the new DID to the registry smart contract.

Note: We intend to add support for executable signed messages in the next major release, thereby eliminating the need to derive two key pairs.

2.4 Using the identity

The `create` function presented in the previous section eventually returns an instance of the `IdentityWallet` class, which can be used to authenticate against services, issue credentials, and request data from other identities. Later sections will explore the exposed interface in more detail.

In case you have already created your identity, and would like to instantiate an `IdentityWallet`, you can simply run:

```
/**
 * You will need to instantiate a Key Provider using the seed used for identity␣
↪creation
 * We are currently working on simplifying, and optimising this part of the api
 */

const registry = JolocomLib.registries.jolocom.create()
const IdentityWallet = await registry.authenticate(vaultedKeyProvider, {
  derivationPath: JolocomLib.KeyTypes.jolocomIdentityKey,
  encryptionPass: secret
})
```

2.5 What can I do now?

So far, you have successfully created and anchored a digital self-sovereign identity. The subsequent sections cover how to:

- create a public profile and make it available through your DID document;
- issue statements about yourself and others in form of signed verifiable credentials;
- authenticate against other identities, share and receive signed verifiable credentials, and create various interaction tokens;
- use custom connectors for IPFS and Ethereum communication.

CHAPTER 3

Credentials & Signed Credentials

The Jolocom library contains a number of functions and classes that enable the creation and consumption of signed verifiable credentials. Any agent can ensure a given credential is valid by verifying that the associated cryptographic signature is correct and was generated using the expected private key.

3.1 Create a signed credential

The easiest way to create a signed credential is by using an instance of the `IdentityWallet` class. If you have yet not created an identity, check out the Getting Started section. If you have already created an identity, you can obtain an identity wallet by authenticating, as defined in section 2.2.

```
import { JolocomLib } from 'jolocom-lib'
import { claimsMetadata } from '@jolocom/protocol-ts'

const password = 'correct horse battery staple'

const emailAddressSignedCredential = await identityWallet.create.signedCredential({
  metadata: claimsMetadata.emailAddress,
  claim: { email: 'example@example.com' }
  subject: identityWallet.did // Our own DID, referred to as a self-issued credential
}, password)

...
```

Notice the `JSON` form of the newly created `emailAddressSignedCredential` is simply a JSON-LD Verifiable credential. The `SignedCredential` class provides a number of methods to easily consume the data from the credential.

```
// The credential in JSON form

{
  @context: [
```

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```
    {
      id: '@id',
      type: '@type',
      cred: 'https://w3id.org/credentials#',
      ...
      ProofOfEmailCredential: 'https://identity.jolocom.com/terms/
↪ProofOfEmailCredential',
      schema: 'http://schema.org/',
      email: 'schema:email'
    }
  ],
  id: 'claimId:d9f45722872b7',
  name: 'Email address',
  issuer: 'did:jolo:b2d5d8d6cc140033419b54a237a5db51710439f9f462d1fc98f698eca7ce9777',
  issued: '2018-11-16T22:21:28.862Z',
  type: ['Credential', 'ProofOfEmailCredential'],
  expires: '2019-11-16T22:21:28.862Z',
  claim: {
    email: 'example@example.com',
    id: 'did:jolo:b2d5d8d6cc140033419b54a237a5db51710439f9f462d1fc98f698eca7ce9777'
  },
  proof: {
    created: '2018-11-16T22:21:28.861Z',
    type: 'EcdsaKoblitzSignature2016',
    nonce: 'fac9b5937e6f0cbb',
    signatureValue:
↪'922c73134cb81558b337a0b222fac3c7f8418ca46febcd57d903def7134843640644f0086d36a6cf29f975b82eabfa459
↪',
    creator:
↪'did:jolo:b2d5d8d6cc140033419b54a237a5db51710439f9f462d1fc98f698eca7ce9777#keys-1'
  }
}
```

Note: All credential types the library supports by default are made available through the `@jolocom/protocol-ts` npm package. Alternatively, you can check out the GitHub repository.

It's worth noting that in the aforementioned credential, the `issuer`, the `subject`, and the signature `creator` each share the same DID. We refer to this type of credential as *self-signed* or *self-issued*.

To issue a credential to another entity, we simply need to specify the DID of the corresponding `subject`:

```
// You can also pass a custom expiry date for the credential, supported since v3.1.0
const customExpiryDate = new Date(2030, 1, 1)
const emailAddressSignedCredential = identityWallet.create.signedCredential(
{
  metadata: claimsMetadata.emailAddress,
  claim: { email: 'example@example.com' },
  subject: 'did:jolo:6d6f636b207375626a656374206469646d6f636b207375626a65637420646964'
},
password,
customExpiryDate
)
```

Note: The custom expiry date is an optional argument (if not present, will default to 1 year from Date.now())

Taking a look at the newly created credential, we can indeed see that the `subject`, denoted by the `claim.id` key, is different:

```
// The credential in JSON form
// All irrelevant / repeating fields have been ommited.

{
  '@context': [ ... ],
  ...
  issuer: 'did:jolo:b2d5d8d6cc140033419b54a237a5db51710439f9f462d1fc98f698eca7ce9777',
  claim: {
    email: 'example@example.com',
    id: 'did:jolo:6d6f636b207375626a656374206469646d6f636b207375626a65637420646964'
  },
  proof: EcdsaLinkedDataSignature {
    ...
    creator:
↪'did:jolo:b2d5d8d6cc140033419b54a237a5db51710439f9f462d1fc98f698eca7ce9777#keys-1'
    ...
}
```

3.2 Validate a signature on a signed credential

Perhaps you would like to present the newly created signed credential to a service or some other entity with a Jolocom identity as part of an interaction. The (intended) recipient needs to be able to verify that the credential received is valid. Validating a received credential proceeds as follows:

```
import { JolocomLib } from 'jolocom-lib'

// The credential will often be received serialized in its JSON form.
const receivedCredential = JolocomLib.parse.signedCredential(json)
const valid = await JolocomLib.util.validateDigestable(receivedCredential)
```

The previous step amounts to resolving the DID document associated with the credential `issuer` by using the listed public keys to validate the credential signature.

If you already know the public key corresponding to the signing party, it is not necessary to resolve the DID document:

```
import { JolocomLib } from 'jolocom-lib'

const receivedSignedCredential = JolocomLib.parse.signedCredential.fromJSON(received)
const issuerPublicKey = Buffer.from(
↪'030d4792f4165a0a78f7c7d14c42f6f98decfa23d36e8378c30e4291711b31961f', 'hex')

/**
   * Please note that this will NOT fail if the signer has marked the public key as␣
↪compromised or invalid;
   * the signature is simply being verified, without checking against any external␣
↪resources.
 */

console.log(await JolocomLib.keyProvider.verifyDigestable(issuerPublicKey,␣
↪signedCred)) // true
```

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3.3 Working with custom credentials

Users are free to define custom credential types. The number of types of interactions would be quite restricted if only types defined by Jolocom could be used. The following sections delve into why you might want to define custom credentials, and how to do so.

Why would I want to define a custom credential type?

Let's assume you want to use verifiable credentials for managing permissions inside your system. You might have one or more trusted identities that issue access credentials to requesters deemed authentic. For these purposes, none of the credential types we currently provide suffice.

Or consider this scenario: a bar that only allows adults of legal age on the premises. At a certain point, patrons must prove they are over 18 years of age in order to order enter the establishment. Patrons could of course disclose their individual dates of birth, but this is not optimal in light of the fact that more information is disclosed than required for the purposes of the interaction.

An alternative is to adopt an approach based on verifiable credentials. A trusted entity, such as a government authority, could issue signed credentials to all citizens that request such a verification, i.e. an attestation stating that a citizen is of or over a certain age. A citizen could later present such a credential when entering a bar.

This allows citizens to prove that they are allowed to gain entry to the bar, in a verifiable way, without disclosing any additional information.

Defining custom metadata

So far, when creating credentials, `metadata` provided by the `@jolocom/protocol-ts` package has been used. When creating custom credentials, we have to write our own `metadata` definitions.

Let's take another look at the second example use case from the previous section. One of the many possible `metadata` definitions would be:

```
const customMetadata = {
  context: [{
    ageOver: 'https://ontology.example.com/v1#ageOver'
    ProofOfAgeOverCredential: 'https://ontology.example.com/v1
↪#ProofOfAgeOverCredential'
  }],
  name: 'Age Over',
  type: ['Credential', 'ProofOfAgeOverCredential']
  claimInterface: {
    ageOver: 0
  } as { ageOver: number }
}
```

Note: For more documentation on defining custom credential `meatadata`, check out this document. Please note that all examples of **creating credentials** and **creating metadata** are currently outdated (updates already in progress).

The extra typing information - `as {ageOver: number}` is only relevant if you use TypeScript. It enables for auto-completion on the `claim` section when creating a `SignedCredential` of this type. If you develope in JavaScript, remove this line.

Creating and verifying custom credentials

The newly created `metadata` definition can now be used to create a credential:

```
const ageOverCredential = verifierIdentityWallet.create.signedCredential({
  metadata: customMetadata,
  claim: {
    ageOver: 18
  },
  subject: requesterDid
}, servicePassword)
```

(It's that simple!)

It is worth noting that the custom `metadata` definition is only needed for creating credentials. Validating custom credentials is still as simple as:

```
const valid = await JolocomLib.util.validateDigestable(ageOverCredential)
```

CHAPTER 4

Public Profile

A public profile can be attached to an identity to make it easy for any identity with which you interact to easily resolve your identity. This is especially relevant for interactions with online services, as a public profile can be used to advertise interaction conditions, as well as various attestations.

Before you start, be sure to initialize the `IdentityWallet` class as outlined in the Getting Started section.

4.1 Adding a public profile

We currently model public profiles as simple `SignedCredential` instances, each containing the following claims: `about`, `url`, `image`, and `name`.

Before we can publish the credential, we need to first create it:

```
import { claimsMetadata } from 'jolocom-lib'

const myPublicProfile = {
  name: 'Jolocom',
  about: 'We enable a global identity system'
}

const credential = await identityWallet.create.signedCredential({
  metadata: claimsMetadata.publicProfile,
  claim: myPublicProfile,
  subject: identityWallet.did
}, password)
```

Add the newly created public profile to your identity:

```
/**
* Typescript accessors are used to get
* and set values on the identityWallet instance
* @see https://www.typescriptlang.org/docs/handbook/classes.html
```

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```
*/

identityWallet.identity.publicProfile = publicProfileCred
```

Note: Typescript accessors are used to get and set values on the `identityWallet` instance

So far you have been making changes to your identity only locally. Now, you can commit the changes to IPFS and Ethereum.

```
await registry.commit({
  identityWallet,
  vaultedKeyProvider,
  keyMetadata: {
    encryptionPass: secret,
    derivationPath: JolocomLib.KeyTypes.ethereumKey
  }
})
```

In order to update your public profile, simply create a new credential, add it to your `identityWallet`, and commit the changes.

4.2 Removing your public profile

```
identityWallet.identity.publicProfile = undefined

await registry.commit({
  identityWallet,
  vaultedKeyProvider,
  keyMetadata: {
    encryptionPass: secret,
    derivationPath: JolocomLib.KeyTypes.ethereumKey
  }
})
```

Please note that due to the way that IPFS handles the concept of deletion, this delete method simply unpins your public profile from its corresponding pin set, and allows the unpinned data to be removed by the "garbage collection" process. Accordingly, if the data has been pinned by another IPFS gateway, complete removal of stored information on the IPFS network cannot be ensured.

4.3 View the public profile

Viewing the public profile associated with an identity is easy:

```
console.log(identityWallet.identity.publicProfile)
```

An instance of the `SignedCredential` class is returned.

CHAPTER 5

Credential-based Communication Flows

This section offers an overview of the interaction flows supported by the Jolocom Library.

Identities can interact in incredibly complex ways. We currently support a number of quite simple interaction flows, and intend to greatly expand the list in future releases.

Note: The following sections assume you have already created an identity. If you have not yet created an identity, check out the Getting Started section.

5.1 Credential requests

Many services require their users to provide certain information upon signing up. The Jolocom library provides a simple way for services to present their requirements to users who wish to authenticate through. This is done by creating and broadcasting what we refer to as a "Credential Request". First, the aforementioned request must be generated:

Create a Credential Request

```
// An instance of an identityWallet is required at this point
const credentialRequest = await identityWallet.create.interactionTokens.request.share(
↪{
  callbackURL: 'https://example.com/authentication/',
  credentialRequirements: [{
    type: ['Credential', 'ProofOfEmailCredential'],
    constraints: []
  }],
}, password)
```

Note: Documentation on `constraints` and how they can be used to create even more specific constraints will be added soon.

We also allow for simple constraints to be encoded as part of the credential request. If we want to communicate that only credentials issued by a particular `did` should be provided, we can do the following:

```
import {constraintFunctions} from 'jolocom-lib/js/interactionTokens/credentialRequest'

// An instance of an identityWallet is required at this point
  const credentialRequest = await identityWallet.create.interactionTokens.request.
↪share({
    callbackURL: 'https://example.com/authentication/',
    credentialRequirements: [{
        type: ['Credential', 'ProofOfEmailCredential'],
        constraints: [constraintFunctions.is('issuer', 'did:jolo:abc...')]
      }]
  },
  password)
```

By default the generated credential request will be valid for 1 hour. Attempting to scan or validate the requests after the expiry period will fail. In case you would like to specify a custom expiry date, the following is supported:

```
// You can also pass a custom expiry date for the credential, supported since v3.1.0
const customExpiryDate = new Date(2030, 1, 1)

// An instance of an identityWallet is required at this point
  const credentialRequest = await identityWallet.create.interactionTokens.request.
↪share({
    expires: customExpiryDate
    callbackURL: 'https://example.com/authentication/',
    credentialRequirements: [{
        type: ['Credential', 'ProofOfEmailCredential'],
        constraints: []
      }]
  },
  password)
```

Note: The expiration date can be passed in a similar manner when creating other interaction token types as well (e.g. Authentication, Credential Offer, etc. . .)

Note: For further documentation and examples explaining how to create and send credential requests, check the API documentation, the generic backend documentation, the integration tests, and finally this collection of simple snippets.

The easiest way to make the credential request consumable for the client applications is to encode it as a JSON Web Token. This allows us to easily validate signatures on individual messages, and prevent some replay attacks.

In order to make the credential request consumable by the Jolocom SmartWallet the `JSON Web Token` must further be encoded as a QR code that can be scanned by the wallet application. The `credentialRequest` can be encoded as follows:

```
// Will be deprecated in future releases in favor of more user-friendly and intuitive␣
↪ways to encode data

const jwtEncoded = credentialRequest.encode()
const QREncoded = new SSO().JWTtoQR(jwtEncoded)
```

Note: The `JWT` encoded interaction token can also be sent to the Jolocom SmartWallet via "Deep Links"..

Consume a Signed Credential Request

Once the encoded credential request has been received on the client side, a corresponding credential response should be prepared and sent:

```
const credentialRequest = JolocomLib.parse.interactionToken.fromJWT(enc)
identityWallet.validateJWT(credentialRequest)
```

Note: The `validateJWT` method will ensure the credential is not expired, and that it contains a valid signature.

Create a Credential Response

Once the request has been decoded, we can create the response:

```
/**
 * The callback url has to match the one in the request,
 * will be populated autmoatically based on the request starting from next major␣
↪release
 */

const credentialResponse = awaitidentityWallet.create.interactionTokens.response.
↪share({
    callbackURL: credentialRequest.payload.interactionToken.callbackURL,
    suppliedCredentials: [signedEmailCredential.toJSON()] // Provide signed␣
↪credentials of requested type
  },
  encryptionPass, // The password to decrypt the seed for key generation as part of␣
↪signing the JWT
  credRequest // The received request, used to set the 'nonce' and 'audience' field␣
↪on the created response
)
```

The credential supplied above (conveniently) matches what the service requested. To ensure that no credentials other than those corresponding to the service requirements are provided, the following method to filter can be used:

```
// We assume the client application has multiple credentials persisted in a local␣
↪database
const localCredentials = [emailAddressSignedCredential, phoneNumberCredential]
const localCredentialsJSON = localCredentials.map(credential => credential.toJSON())

// The api will change to take instances of the SignedCredential class as opposed to␣
↪JSON encoded credentials
const validCredentials = credentialRequest.applyConstraints(localCredentialsJSON)

console.log(validCredentials) // [emailAddressSignedCredential]
```

Once the credential response has been assembled, it can be encoded and sent to the service's callback url:

```
const credentialResponseJWT  = credentialResponse.encode()
```

Consume a Signed Credential Response

Back to the service side! The credential response encoded as a `JSON Web Token` has been received and the provided data is ready to consume. First, decode the response:

```
const credentialResponse = await JolocomLib.parse.interactionToken.
↪fromJWT(receivedJWTEncodedResponse)
await identityWallet.validateJWT(credentialResponse, credentialRequest)
```

Note: The `validate` method will ensure the response contains a valid signature, is not expired, lists our `did` in the `aud` (audience) section, and contains the same `jti` (nonce) as the request.

After decoding the credential response, verify that the user passed the credentials specified in the request:

```
/**
 * We check against the request we created in a previous step
 * this requires the server to be stateful. We are currently
 * expolring alternatives.
 */

const validResponse = credentialResponse.satisfiesRequest(credentialRequest)
const registry = JolocomLib.registries.jolocom.create()

if (!validResponse) {
  throw new Error('Incorrect response received')
}

const providedCredentials = credentialResponse.getSuppliedCredentials()

const signatureValidationResults = await JolocomLib.util.
↪validateDigestables(providedCredentials)

if (signatureValidationResults.every(result => result === true)) {
  // The credentials can be used
}
```

5.2 Credential issuance

The Jolocom Library also allows for the issuance of verifiable credentials. Similarly to the flow outlined in the previous subsection, a "Credential Offer" needs to be created and broadcast.

Create a Credential Offer

Firstly, a credential offer needs to be created:

```
const credentialOffer = await identityWallet.create.interactionTokens.request.offer({
  callbackURL: 'https://example.com/receive/',
  offeredCredentials: [{
   type: 'idCard'
  }, {
   type: 'otherCredential'
  }]
})
```

The endpoint denoted by the `callbackURL` key will be pinged by the client device with a response to the offer.

The CredentialOffer objects may also contain additional information in the form of `requestedInput`, `renderInfo` and `metadata` (which currently supports only a boolean `asynchronous` key).

A more complex offer can be created as follows:

```
import {CredentialRenderTypes} from 'jolocom-lib/interactionTokens/interactionTokens.
↪types'

const idCardOffer: CredentialOffer = {
  type: 'idCard',
  renderInfo: {
    renderAs: CredentialRenderTypes.document,
    logo: {
      url: 'https://miro.medium.com/fit/c/240/240/1*jbb5WdcAvaY1uVdCjX1XVg.png'
    },
    background: {
      url: 'https://i.imgur.com/0Mrldei.png',
    },
    text: {
      color: '#05050d'
    }
  }
  metadata: {
    asynchronous: false // Is the credential available right away?
  },
  requestedInput: {} // What is required to receive the credential, e.g. residence␣
↪permit credential, etc.
  }
}
```

Note: The `metadata.asynchronous` and `requestedInput` keys are not currently used, and act as placeholders. We are awaiting further standardisation efforts. An example of such standardisation initiatives is the Credential Manifest proposal.

The `renderInfo` is used to describe how a credential should be rendered and is currently supported by the Jolocom Smartwallet. It allows for a variety of graphical descriptors in it's format:

```
enum CredentialRenderTypes {
  document = 'document',
  permission = 'permission',
  claim = 'claim',
}
export interface CredentialOfferRenderInfo {
  renderAs?: CredentialRenderTypes
  background?: {
    color?: string // Hex value
    url?: string // URL to base64 encoded background image
  }
  logo?: {
    url: string // URL to base64 encoded image
  }
  text?: {
    color: string // Hex value
  }
}
```

Consume a Credential Offer

On the client side, we can decode and validate the received credential request as follows:

```
const credentialOffer = JolocomLib.parse.interactionToken.fromJWT(enc)
identityWallet.validateJWT(credentialRequest)
```

Note: The `validateJWT` method will ensure the credential is not expired, and that it contains a valid signature.

Create a Credential Offer Response

To create a response for a credential offer, the callbackURL and the selected credentials must be used:

```
const offerResponse = await identityWallet.create.interactionTokens.response.offer({
  callbackURL: credentialOffer.callbackURL,
  selectedCredentials: [
    {
      type: 'idCard'
    },
    {
      type: 'otherCredential'
    }
  ]
}, secret, credentialOffer)
```

Note: The structure of the response will change as we add support for the aforementioned `requestedInput` field.

Transferring the credential to the user

The credential offer response is sent back to the `callbackURL` provided by the service. At this point, the service can generate the credentials and transfer them to the user. There are a few way to accomplish the last step, currently the service simply issues a `CredentialResponse` JWT containing the credentials. We intend to use Verifiable Presentations for this step once the specification matures.

An example implementation for an issuance service can be found here.

5.3 What next?

Some additional bits of high level documentation related to the supported interaction flows are available here

With the reasoning behind the credential request and response flows unpacked, it's time to put it all to the test! Head to the next section to learn how to set up your own service for interacting with Jolocom identities.

CHAPTER 6

Using custom connectors

By default, all identities created using the Jolocom library are indexed in a contract deployed on the Rinkeby test network, and the corresponding DID documents are stored on IPFS.

The interaction with the corresponding networks is delegated to two components:

- IPFS connector
- Ethereum connector

Using custom connectors (e.g. to experiment on a private network) is also supported.

You can also supply your custom implementations of both connectors, in case your identities are indexed on a private Ethereum deployment, or you would like to connect to a custom IPFS cluster. A custom implementation might look as follows:

```
class CustomEthereumConnector implements IEthereumConnector {
  async resolveDID(did: string) {
    console.log(`Intercepted request for ${did}`)
    return fetchFromCacheIfAvailable(did)
  }

  async updateDIDRecord(args: IEthereumResolverUpdateDIDArgs) {
    console.log(`Intercepted request for ${args.did}, updating to ${args.newHash}`)
    return queueUpdateRequest(args)
  }
}

class CustomIpfsConnector implements IIpfsConnector {
  async storeJSON({ data, pin }: { data: object; pin: boolean }) {
    ...
  }

  async catJSON(hash: string) {
    ...
  }
```

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```
  async removePinnedHash(hash: string) {
    ...
  }
}

const customRegistry = JolocomLib.registries.jolocom.create({
  ethereumConnector: new CustomEthereumConnector(),
  ipfsConnector: new CustomIpfsConnector()
})
```

Note: Using only one custom connector is also supported.

In the event a connector is not provided when instantiating the `registry`, the default implementation provided by Jolocom will be used.

In some cases, it might make sense to define connectors that rely fully on databases maintained in a centralised manner. The current library API supports this use case as well.