Transaction context

Audience: Architects, application and smart contract developers

A transaction context performs two functions. Firstly, it allows a developer to define and maintain user variables across transaction invocations within a smart contract. Secondly, it provides access to a wide range of Fabric APIs that allow smart contract developers to perform operations relating to detailed transaction processing. These range from querying or updating the ledger, both the immutable blockchain and the modifiable world state, to retrieving the transaction-submitting application's digital identity.

A transaction context is created when a smart contract is deployed to a channel and made available to every subsequent transaction invocation. A transaction context helps smart contract developers write programs that are powerful, efficient and easy to reason about.

- Why a transaction context is important
- How to use a transaction context
- What's in a transaction context
- Using a context `stub`
- Using a context `clientIdentity`

Scenario

In the commercial paper sample, papercontract initially defines the name of the list of commercial papers for which it's responsible. Each transaction subsequently refers to this list; the issue transaction adds new papers to it, the buy transaction changes its owner, and the redeem transaction marks it as complete. This is a common pattern; when writing a smart contract it's often helpful to initialize and recall particular variables in sequential transactions.

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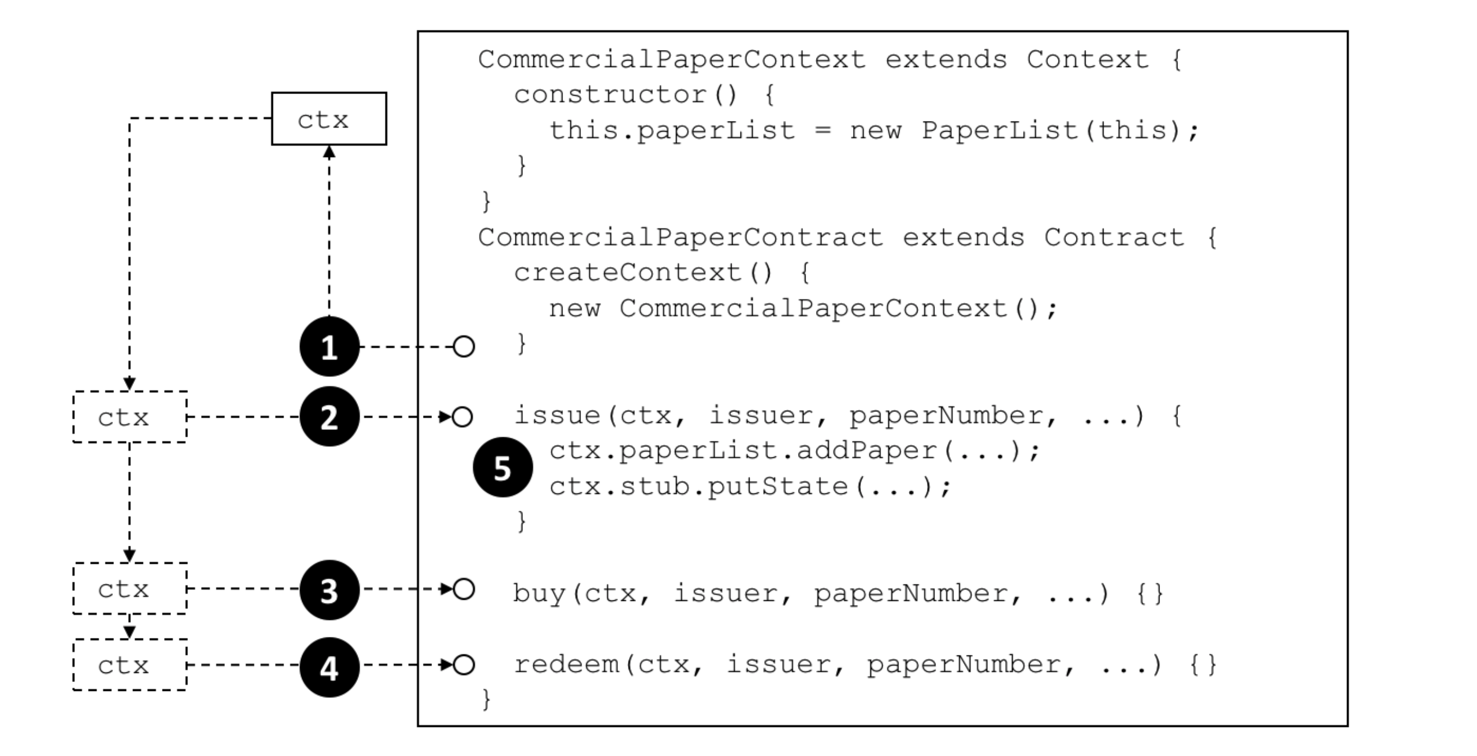

A smart contract transaction context allows smart contracts to define and maintain user variables across transaction invocations. Refer to the text for a detailed explanation.

Programming

When a smart contract is constructed, a developer can optionally override the built-in `Context` class `createContext` method to create a custom context:

```
createContext() {
    new CommercialPaperContext();
}
```

In our example, the `CommercialPaperContext` is specialized for `CommercialPaperContract`. See how the custom context, addressed through `this`, adds the specific variable `PaperList` to itself:

```
CommercialPaperContext extends Context {
    constructor () {
        this.paperList = new PaperList(this);
    }
}
```

When the createContext() method returns at point **(1)** in the diagram above, a custom context `ctx` has been created which contains `paperList` as one of its variables.

Subsequently, whenever a smart contract transaction such as issue, buy or redeem is called, this context will be passed to it. See how at points **(2)**, **(3)** and **(4)** the same commercial paper context is passed into the transaction method using the `ctx` variable.

See how the context is then used at point **(5)**:

```
ctx.paperList.addPaper(...);
ctx.stub.putState(...);
```

Notice how `paperList` created in `CommercialPaperContext` is available to the issue transaction. See how `paperList` is similarly used by the **redeem** and **buy** transactions; `ctx` makes the smart contracts efficient and easy to reason about.

You can also see that there's another element in the context – `ctx.stub` – which was not explictly added by `CommercialPaperContext`. That's because `stub` and other variables are part of the built-in context. Let's now examine the structure of this built-in context, these implicit variables and how to use them.

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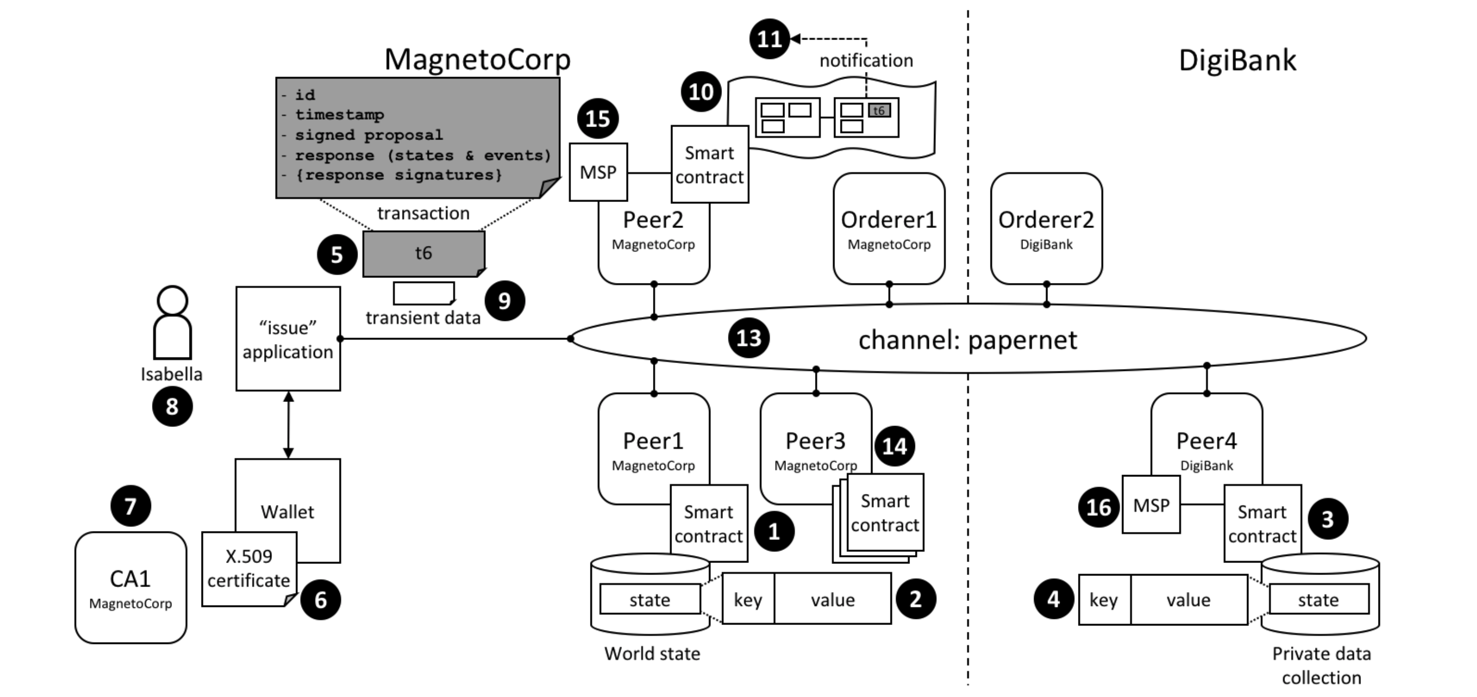
Structure

As we've seen from the example, a transaction context can contain any number of user variables such as `paperList`.

The transaction context also contains two built-in elements that provide access to a wide range of Fabric functionality ranging from the client application that submitted the transaction to ledger access.

- `ctx.stub` is used to access APIs that provide a broad range of transaction processing operations from `putState()` and `getState()` to access the ledger, to `getTxID()` to retrieve the current transaction ID.
- `ctx.clientIdentity` is used to get information about the identity of the user who submitted the transaction.

We'll use the following diagram to show you what a smart contract can do using the `stub` and `clientIdentity` using the APIs available to it:



A smart contract can access a range of functionality in a smart contract via the transaction context `stub` *and* `clientIdentity`*. Refer to the text for a detailed explanation.*

Stub

The APIs in the stub fall into the following categories:

- **World state data APIs**. See interaction point **(1)**. These APIs enable smart contracts to get, put and delete state corresponding to individual objects from the world state, using their key:
  - getState()
  - putState()
  - deleteState()
  - getState()
  - putState()
  - deleteState()

  These basic APIs are complemented by query APIs which enable contracts to retrieve a set of states, rather than an individual state. See interaction point **(2)**. The set is either defined by a range of key values, using full or partial keys, or a query according to values in the underlying world state database. For large queries, the result sets can be paginated to reduce storage requirements:
  - getStateByRange()
  - getStateByRangeWithPagination()
  - getStateByPartialCompositeKey()
  - getStateByPartialCompositeKeyWithPagination()
  - getQueryResult()
  - getQueryResultWithPagination()
  - getStateByRange()
  - getStateByRangeWithPagination()
  - getStateByPartialCompositeKey()

    - getStateByPartialCompositeKeyWithPagination()
    - getQueryResult()
    - getQueryResultWithPagination()

- **Private data APIs**. See interaction point **(3)**. These APIs enable smart contracts to interact with a private data collection. They are analogous to the APIs for world state interactions, but for private data. There are APIs to get, put and delete a private data state by its key:
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    - getPrivateData()
    - putPrivateData()
    - deletePrivateData()
    - getPrivateData()
    - putPrivateData()
    - deletePrivateData()

  This set is complemented by set of APIs to query private data **(4)**. These APIs allow smart contracts to retrieve a set of states from a private data collection, according to a range of key values, either full or partial keys, or a query according to values in the underlying world state database. There are currently no pagination APIs for private data collections.

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    - getPrivateDataByRange()
    - getPrivateDataByPartialCompositeKey()
    - getPrivateDataQueryResult()
    - getPrivateDataByRange()
    - getPrivateDataByPartialCompositeKey()
    - getPrivateDataQueryResult()
- **Transaction APIs**. See interaction point **(5)**. These APIs are used by a smart contract to retrieve details about the current transaction proposal being processed by the smart contract. This includes the transaction identifier and the time when the transaction proposal was created.

```
* [getTxID()](https://hyperledger.github.io/fabric-chaincode-node/master/api/fabric-shim.Chaincod
  returns the identifier of the current transaction proposal **(5)**.
* [getTxTimestamp()](https://hyperledger.github.io/fabric-chaincode-node/master/api/fabric-shim.C
  returns the timestamp when the current transaction proposal was created by
  the application **(5)**.
* [getCreator()](https://hyperledger.github.io/fabric-chaincode-node/master/api/fabric-shim.Chain
  returns the raw identity (X.509 or otherwise) of the creator of
  transaction proposal. If this is an X.509 certificate then it is often
  more appropriate to use [`ctx.ClientIdentity`](#clientidentity).
* [getSignedProposal()](https://hyperledger.github.io/fabric-chaincode-node/master/api/fabric-shi
  returns a signed copy of the current transaction proposal being processed
  by the smart contract.
* [getBinding()](https://hyperledger.github.io/fabric-chaincode-node/master/api/fabric-shim.Chain
  is used to prevent transactions being maliciously or accidentally replayed
```

```
  using a nonce. (For practical purposes, a nonce is a random number
  generated by the client application and incorporated in a cryptographic
  hash.) For example, this API could be used by a smart contract at **(1)**
  to detect a replay of the transaction **(5)**.
* [getTransient()](https://hyperledger.github.io/fabric-chaincode-node/master/api/fabric-shim.Cha
  allows a smart contract to access the transient data an application passes
  to a smart contract. See interaction points **(9)** and **(10)**.
  Transient data is private to the application-smart contract interaction.
  It is not recorded on the ledger and is often used in conjunction with
  private data collections **(3)**.
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- **Transaction APIs**. See interaction point **(5)**. These APIs are used by a smart contract to retrieve details about the current transaction proposal being processed by the smart contract. This includes the transaction identifier and the time when the transaction proposal was created.

  - getTxID() returns the identifier of the current transaction proposal **(5)**.
  - getTxTimestamp() returns the timestamp when the current transaction proposal was created by the application **(5)**.
  - getCreator() returns the raw identity (X.509 or otherwise) of the creator of transaction proposal. If this is an X.509 certificate then it is often more appropriate to use `ctx.ClientIdentity`.
  - getSignedProposal() returns a signed copy of the current transaction proposal being processed by the smart contract.
  - getBinding() is used to prevent transactions being maliciously or accidentally replayed using a nonce. (For practical purposes, a nonce is a random number generated by the client application and incorporated in a cryptographic hash.) For example, this API could be used by a smart contract at **(1)** to detect a replay of the transaction **(5)**.
  - getTransient() allows a smart contract to access the transient data an application passes to a smart contract. See interaction points **(9)** and **(10)**. Transient data is private to the application-smart contract interaction. It is not recorded on the ledger and is often used in conjunction with private data collections **(3)**.
- **Key APIs** are used by smart contracts to manipulate state key in the world state or a private data collection. See interaction points **2** and **4**.

  The simplest of these APIs allows smart contracts to form and split composite keys from their individual components. Slightly more advanced are the `ValidationParameter()` APIs which get and set the state based endorsement policies for world state **(2)** and private data **(4)**. Finally, `getHistoryForKey()` retrieves the history for a state by returning the set of stored values, including the transaction identifiers that performed the state update, allowing the transactions to be read from the blockchain **(10)**.
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  - splitCompositeKey()
  - setStateValidationParameter()
  - getStateValidationParameter()
  - getPrivateDataValidationParameter()

- setPrivateDataValidationParameter()
- getHistoryForKey()

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- **Event APIs** are used to manage event processing in a smart contract.

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Smart contracts use this API to add user events to a transaction response.
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blockchain and sent to listening applications at interaction point
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  - getChannelID()

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See interaction point **(13)**.  A smart contract running on any peer can
use this API to determined on which channel the application invoked the
smart contract.
```

- getChannelID()
- invokeChaincode()

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- getFunctionAndParameters()
- getStringArgs()
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ClientIdentity

In most cases, the application submitting a transaction will be using an X.509 certificate. In the example, an X.509 certificate **(6)** issued by `CA1` **(7)** is being used by `Isabella` **(8)** in her application to sign the proposal in transaction `t6` **(5)**.

ClientIdentity

`ClientIdentity` takes the information returned by `getCreator()` and puts a set of X.509 utility APIs on top of it to make it easier to use for this common use case.

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- getX509Certificate() returns the full X.509 certificate of the transaction submitter, including all its attributes and their values. See interaction point **(6)**.

- getAttributeValue() returns the value of a particular X.509 attribute, for example, the organizational unit `OU`, or distinguished name `DN`. See interaction point **(6)**.
- assertAttributeValue() returns `TRUE` if the specified attribute of the X.509 attribute has a specified value. See interaction point **(6)**.
- getID() returns the unique identity of the transaction submitter, according to their distinguished name and the issuing CA's distinguished name. The format is `x509::{subject DN}::{issuer DN}`. See interaction point **(6)**.
- getMSPID() returns the channel MSP of the transaction submitter. This allows a smart contract to make processing decisions based on the submitter's organizational identity. See interaction point **(15)** or **(16)**.

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