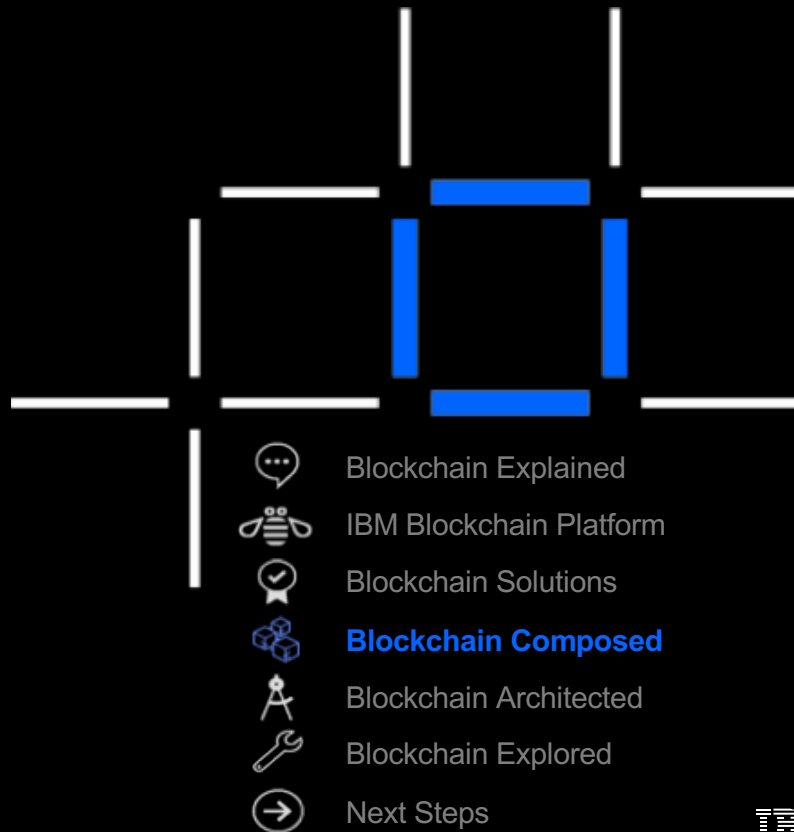


Blockchain Composed

A Technical Introduction to Hyperledger Composer



V2.07, 23 January 2018

IBM **Blockchain**





What is Hyperledger
Composer?



Application Development

Writing the application
Modeling the business network

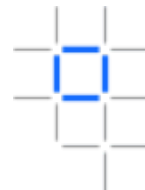


Effective Administration

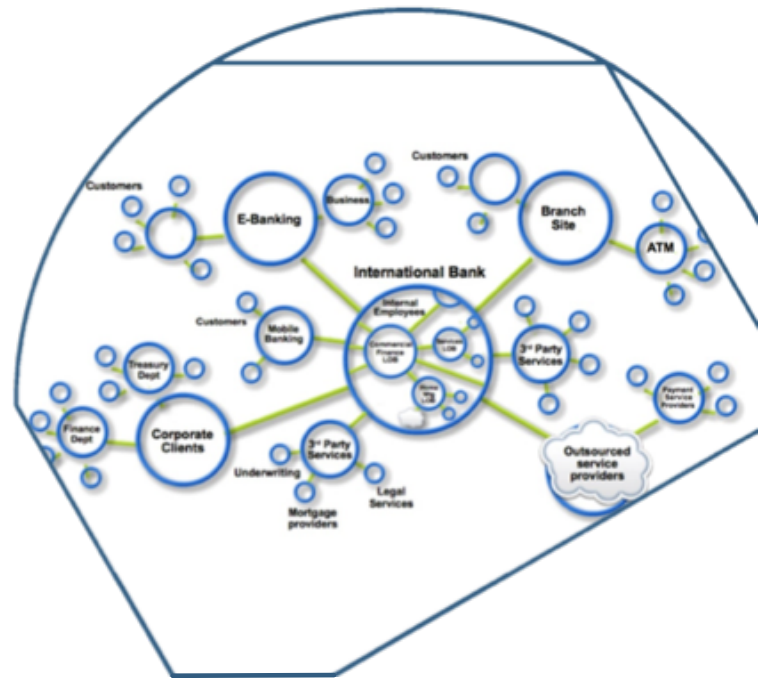
Deploying to a blockchain
Interacting with systems of record



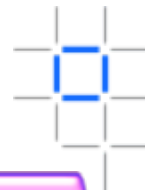
Blockchain Recap



- Blockchain builds on basic business concepts
 - **Business Networks** connect businesses
 - **Participants** with Identity
 - **Assets** flow over business networks
 - **Transactions** describe asset exchange
 - **Contracts** underpin transactions
 - The **ledger** is a log of transactions
- Blockchain is a shared, replicated ledger
 - Consensus, immutability, finality, provenance



Hyperledger Composer: Accelerating time to value

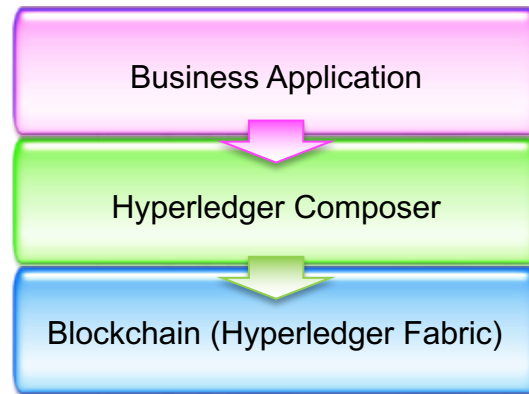


<https://hyperledger.github.io/composer/>

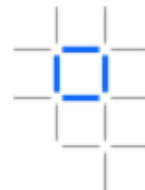
- A suite of high level application **abstractions** for business networks
- Emphasis on business-centric vocabulary for quick solution creation
- Reduce risk, and increase understanding and flexibility



- Features
 - Model your business networks, test and expose via APIs
 - Applications invoke APIs transactions to interact with business network
 - Integrate existing systems of record using loopback/REST
- Fully open and part of Linux Foundation Hyperledger
- Try it in your web browser now: <http://composer-playground.mybluemix.net/>



Benefits of Hyperledger Composer



Increases understanding

Bridges simply from
business concepts to
blockchain



Saves time

Develop blockchain
applications more
quickly and cheaply



Reduces risk

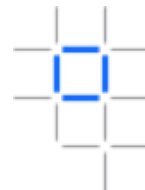
Well tested, efficient
design conforms to
best practice



Increases flexibility

Higher level
abstraction makes it
easier to iterate

Extensive, Familiar, Open Development Toolset



```
asset Animal identi
  o String animal
  o AnimalType sp
  o MovementStatu
  o ProductionTyp
```

Data modelling



JavaScript
business logic



Web playground

```
composer-client
composer-admin
```



Client libraries



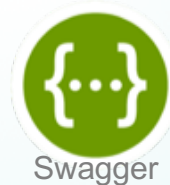
Editor support

```
$ composer
```

CLI utilities



Code generation



Existing systems and
data

User Roles in a Blockchain Project



- **Network Service Provider**
 - **Governs** the network: channels, membership etc.
 - A consortium of network members or designated authority



- **Network Service Consumer**
 - **Operates** a set of peers and certificate authorities on the network
 - Represents an organization on the business network



- **Business Service Provider**
 - **Develops** blockchain business applications
 - Includes transaction, app server, integration and presentation logic



- **Business Service Consumer**
 - Hosts application and integration logic which invokes blockchain transactions



- **End-user**
 - Runs presentation logic e.g. on mobile device or dashboard

A single organization may play multiple roles!

The Developer Role in a Blockchain Project



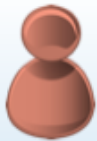
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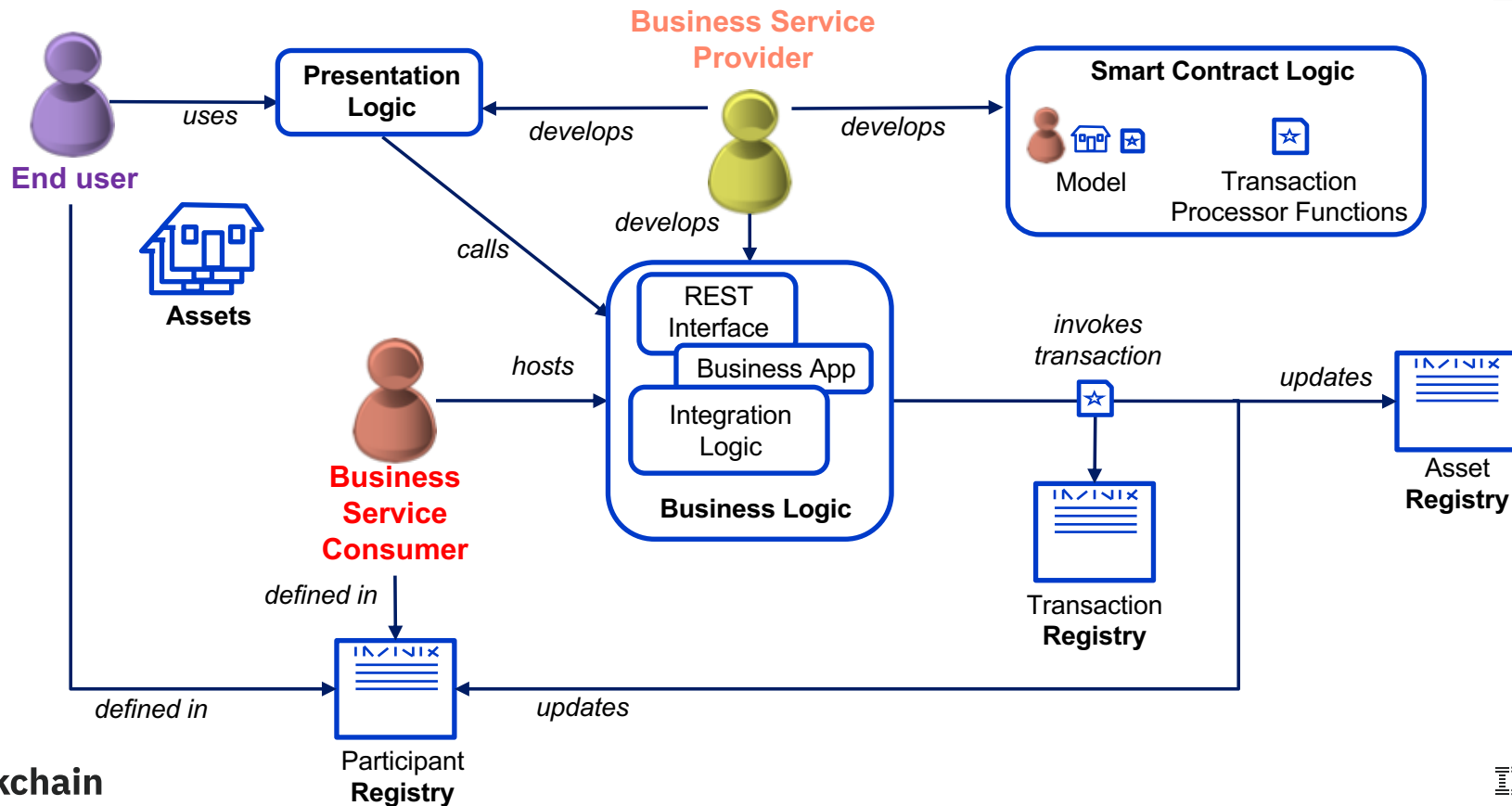
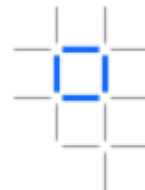


Effective Administration

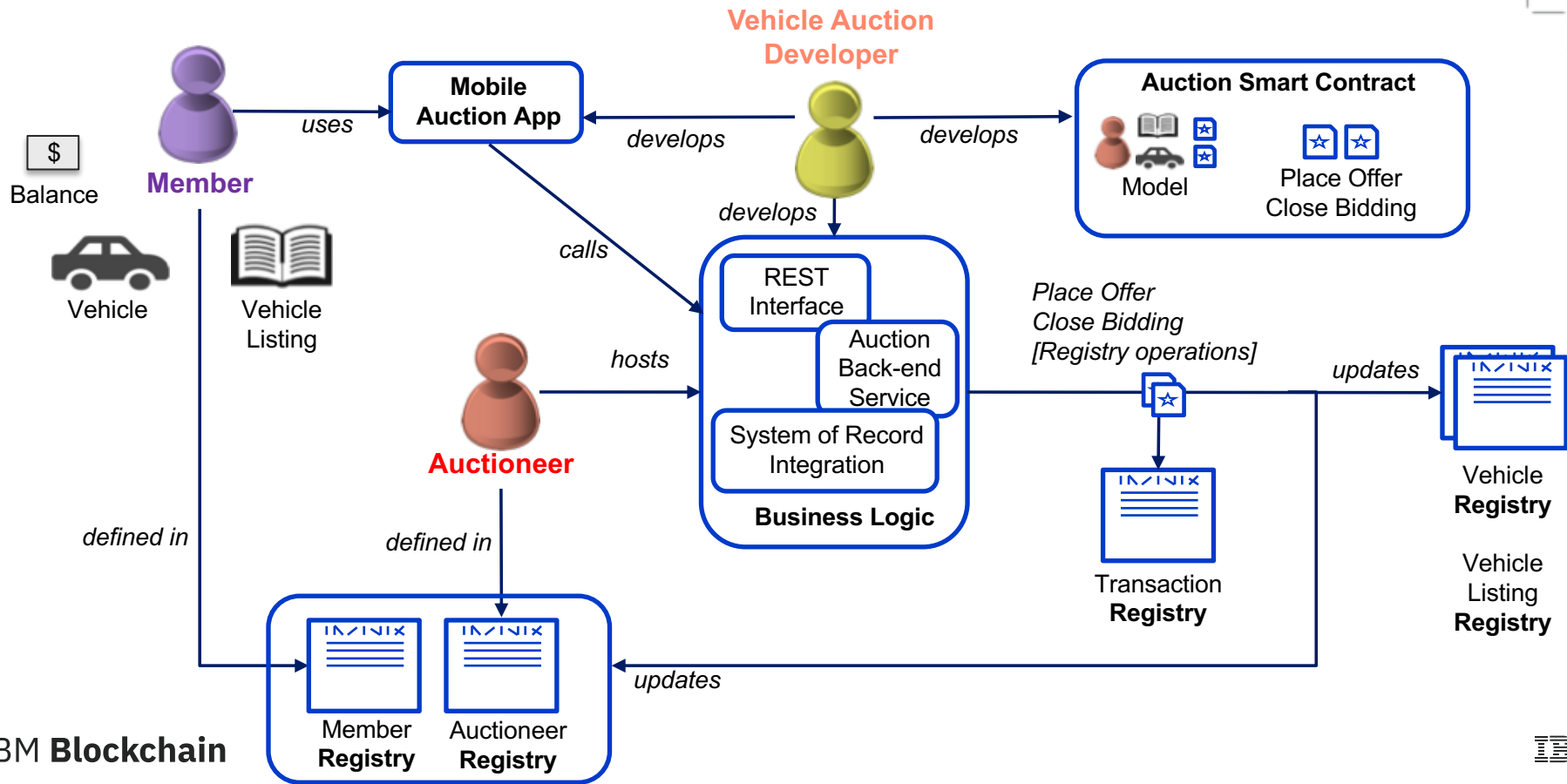
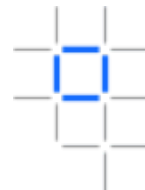
Deploying to a blockchain
Interacting with systems of record



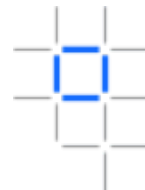
Key Concepts for the Business Service Provider



Key Concepts for a Vehicle Auction Developer



The Business Service Provider develops three components



Smart Contracts

- Implements the logic deployed to the blockchain
 - **Models** describe assets, participants & transactions
 - **Transaction processors** provide the JavaScript implementation of transactions
 - **ACLs** define privacy rules
 - May also define events and registry queries



Business Logic

- **Services** that interact with the registries
 - Create, delete, update, query and invoke smart contracts
 - Implemented inside business applications, integration logic and REST services
- Hosted by the Business Application Consumer



Presentation Logic

- Provides the **front-end** for the end-user
 - May be several of these applications
- Interacts with business logic via standard interfaces (e.g. REST)
- Composer can generate the REST interface from model and a sample application

Assets, Participants and Transactions



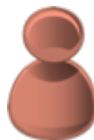
Vehicle



Vehicle Listing



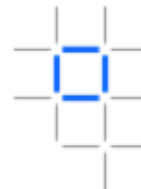
Member



Auctioneer



Place Offer
Close Bidding



```
asset Vehicle identified by vin {  
  o String vin  
  --> Member owner  
}
```

```
asset VehicleListing identified by listingId {  
  o String listingId  
  o Double reservePrice  
  o String description  
  o ListingState state  
  o Offer[] offers optional  
  --> Vehicle vehicle  
}
```

```
abstract participant User identified by email {  
  o String email  
  o String firstName  
  o String lastName  
}  
  
participant Member extends User {  
  o Double balance  
}  
  
participant Auctioneer extends User {  
}
```

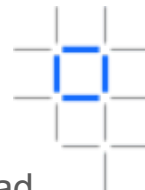
```
transaction Offer {  
  o Double bidPrice  
  --> VehicleListing listing  
  --> Member member  
}  
  
transaction CloseBidding {  
  --> VehicleListing listing  
}
```

Transaction
Processors

```
/**  
 * Close the bidding for a vehicle listing and choose the  
 * highest bid that is  
 * @param {org.acme.vehicle.auction.VehicleListing} listing - the listing  
 * @transaction  
 */  
function closeBidding(listing) {  
  var listing = closeBidding(listing);  
  if (listing.state != 'FOR_SALE') {  
    return;  
  }  
  var highestBid = null;  
  for (offer in listing.offers) {  
    if (offer.bidPrice > highestBid) {  
      highestBid = offer.bidPrice;  
      highestBidder = offer.member;  
    }  
  }  
  listing.state = 'SOLD';  
  listing.soldPrice = highestBid;  
  listing.soldTo = highestBidder;  
}
```

```
/**  
 * Make an Offer for a VehicleListing  
 * @param {org.acme.vehicle.auction.Offer} offer - the offer  
 * @transaction  
 */  
function makeOffer(offer) {  
  var listing = offer.listing;  
  if (listing.state != 'FOR_SALE') {  
    return;  
  }  
  listing.offers.push(offer);  
}
```

Access Control



```
rule EverybodyCanReadEverything {
  description: "Allow all participants read access to all resources"
  participant: "org.acme.sample.SampleParticipant"
  operation: READ
  resource: "org.acme.sample.*"
  action: ALLOW
}
```

```
rule OwnerHasFullAccessToTheirAssets {
  description: "Allow all participants full access to their assets"
  participant(p): "org.acme.sample.SampleParticipant"
  operation: ALL
  resource(r): "org.acme.sample.SampleAsset"
  condition: (r.owner.getIdentifier() == p.getIdentifier())
  action: ALLOW
}
```

```
rule SystemACL {
  description: "System ACL to permit all access"
  participant: "org.hyperledger.composer.system.Participant"
  operation: ALL
  resource: "org.hyperledger.composer.system.*"
  action: ALLOW
}
```

- It is possible to restrict which resources can be read and modified by which participants
 - Rules are defined in an .acl file and deployed with the rest of the model
 - Transaction processors can also look up the current user and implement rules programmatically
- ACL rules can be simple (e.g. everybody can read all resources) or more complex (e.g. only the owner of an asset can do everything to it)
- Application supplies credentials (userid/secret) of the participant when connecting to the Fabric network
 - This also applies to Playground!
 - Remember to grant System ACL all access if necessary

Events and Queries



- Events allow applications to take action when a transaction occurs
 - Events are **defined** in models
 - Events are **emitted** by transaction processor scripts
 - Events are **caught** by business applications
- Caught events include transaction ID and other relevant information
- Queries allow applications to perform complex registry searches
 - They can be statically defined in a separate .qry file or generated dynamically by the application
 - They are invoked in the application using *buildQuery()* or *query()*
 - Queries require the blockchain to be backed by CouchDB

```
event SampleEvent {  
  --> SampleAsset asset  
  o String oldValue  
  o String newValue  
}
```

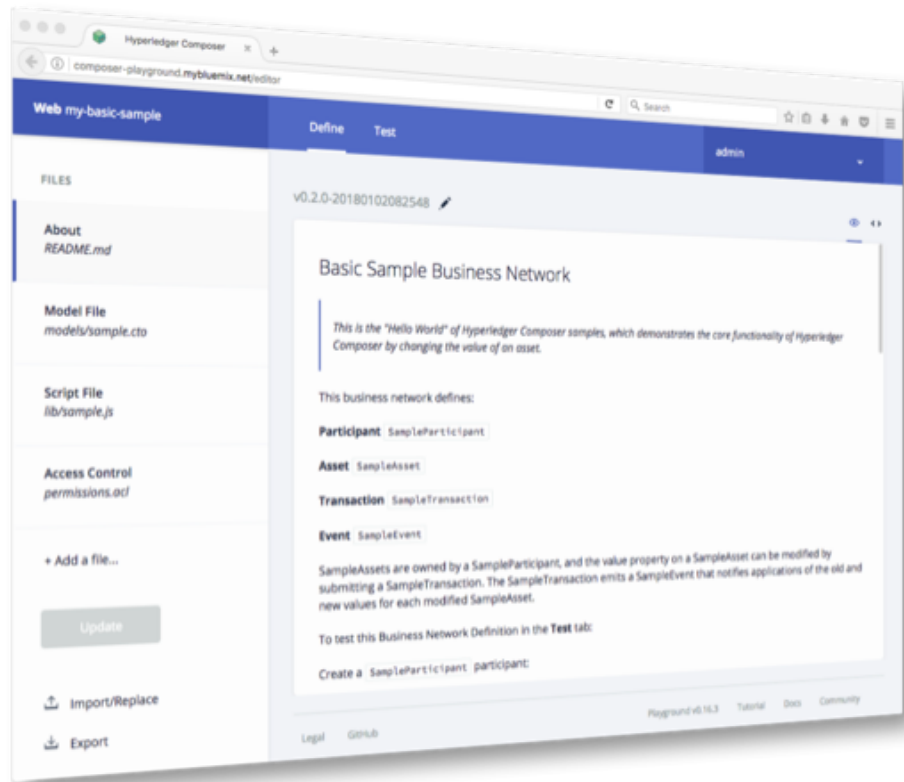
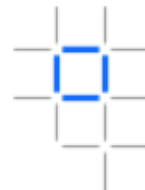
```
// Emit an event for the modified asset.  
var event = getFactory().newEvent('org.acme.sample', 'SampleEvent');  
event.asset = tx.asset;  
event.oldValue = oldValue;  
event.newValue = tx.newValue;  
emit(event);
```

```
businessNetworkConnection.on('SampleEvent', (event) => {  
  console.log(event);  
})
```

```
query selectCommoditiesWithHighQuantity {  
  description: "Select commodities based on quantity"  
  statement:  
    | SELECT org.acme.trading.Commodity  
    | WHERE (quantity > 60)  
}
```

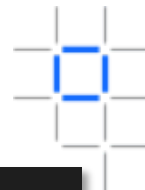
```
return query('selectCommoditiesWithHighQuantity', {})
```

Smart Contract Development: Composer Playground



- Web tool for defining and testing Hyperledger Composer models and scripts
- Designed for the application developer
 - Define assets, participants and transactions
 - Implement transaction processor scripts
 - Test by populating registries and invoking transactions
- Deploy to instances of Hyperledger Fabric V1, or simulate completely within browser
- Install on your machine or run online at <http://composer-playground.mybluemix.net>

General purpose development: Visual Studio Code



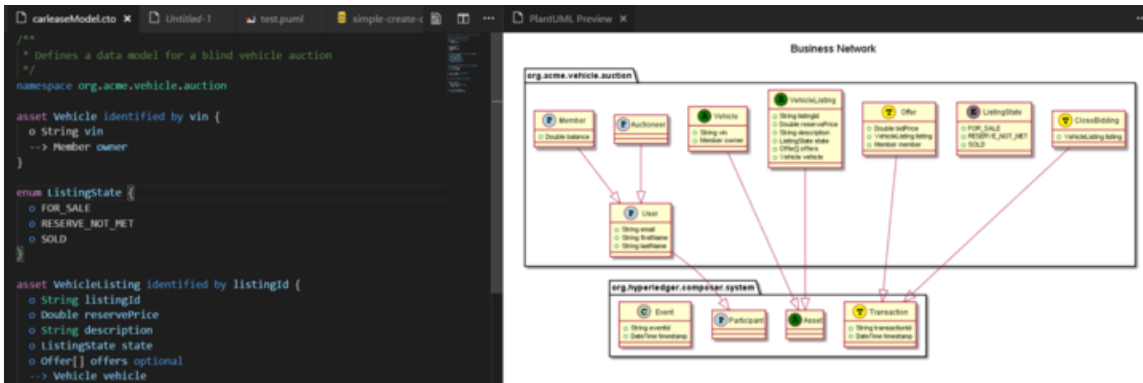
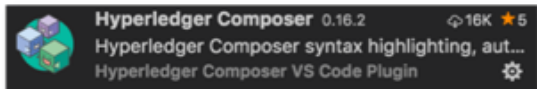
- Composer extension available for this popular tool
- Features to aid rapid Composer development
 - Edit all Composer file types with full syntax highlighting
 - Validation support for models, queries and ACLs
 - Inline error reporting
 - Snippets (press Ctrl+Space for code suggestions)
 - Generate UML diagrams from models
- Install directly from Code Marketplace

```
namespace org.acme.vehicle.lifecycle

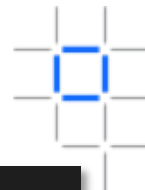
import composer.base.Person
import composer.business.Business

participant PrivateOwner identified by email extends Person {
  o String email
}
```

```
[Composer] IllegalModelException: Could not find super type Person
participant PrivateOwner identified by email extends Person {
  o String email
}
```



Creating the Business and End-User Applications



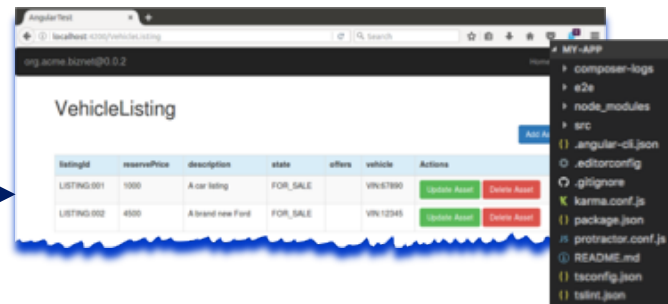
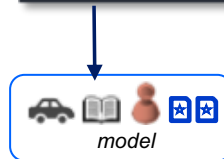
- JavaScript **business applications** *require()* the NPM “composer-client” module
 - This provides the API to access assets, participants and transactions
 - RESTful API (via Loopback) can also be generated... see later
- Command-line tool available to generate **end-user** command-line or Angular2 applications from model
 - Also helps with the generation of unit tests to help ensure quality code

```
const BusinessNetworkConnection = require('composer-client')
    .BusinessNetworkConnection;

this.bizNetworkConnection = new BusinessNetworkConnection();
this.titlesRegistry = this.bizNetworkConnection.getAssetRegistry
    ('net.biz.digitalPropertyNetwork.LandTitle')

let landTitle1 = factory.newResource
    ('net.biz.digitalPropertyNetwork', 'LandTitle', 'LID:1148');
landTitle1.owner = ownerRelation;
landTitle1.information = 'A nice house in the country';
this.titlesRegistry.add(landTitle1);
```

```
yo hyperledger-composer
```



Debugging

- Playground Historian allows you to view all transactions
 - See what occurred and when
- Diagnostics framework allows for application level trace
 - Uses the *Winston* Node.js logging framework
 - Application logging using DEBUG env var
 - Composer Logs sent to stdout and `./logs/trace_<processid>.trc`
- Fabric chaincode tracing also possible (see later)
- More information online:
<https://hyperledger.github.io/composer/problems/diagnostics.html>

The screenshot shows the 'Default Historian Registry' interface. It features a table with columns: ID, Time, Participant ID, and Transaction Type. Below the table, a 'Transaction Data' modal is open, displaying a JSON object representing a transaction record.

ID	Time	Participant ID	Transaction Type
af9faaf-d973-4647-9fad-0f58c0b...	17:15:00	emma	Offer
74e63603-7c7f-4bf2-b917-4c9707...	17:14:34	<system>	ActivateCurrentIdentity

```
1 {
2   "$class": "org.hyperledger.composer.system.HistorianRecord",
3   "transactionId": "af9faaf-d973-4647-9fad-0f58c0ba7d15",
4   "transactionType": "Offer",
5   "transactionInvoked":
6     "resource:org.hyperledger.composer.system.Transaction#af9faaf-d973-4647-9fad-0f58c0ba7d15",
7   "participantInvoking":
8     "resource:org.hyperledger.composer.system.Participant#emma",
9   "identityUsed":
10     "resource:org.hyperledger.composer.system.Identity#8d0fd5ef7c0062f67853ecf9b36544b2e2c36f0e9b9536166dc0f056a62a032",
11   "eventsEmitted": [],
12   "transactionTimestamp": "2017-08-11T16:15:00.161Z"
13 }
```



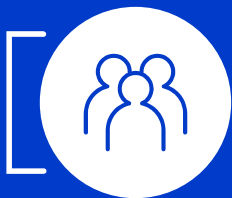
What is Hyperledger
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Application Development

Writing the application

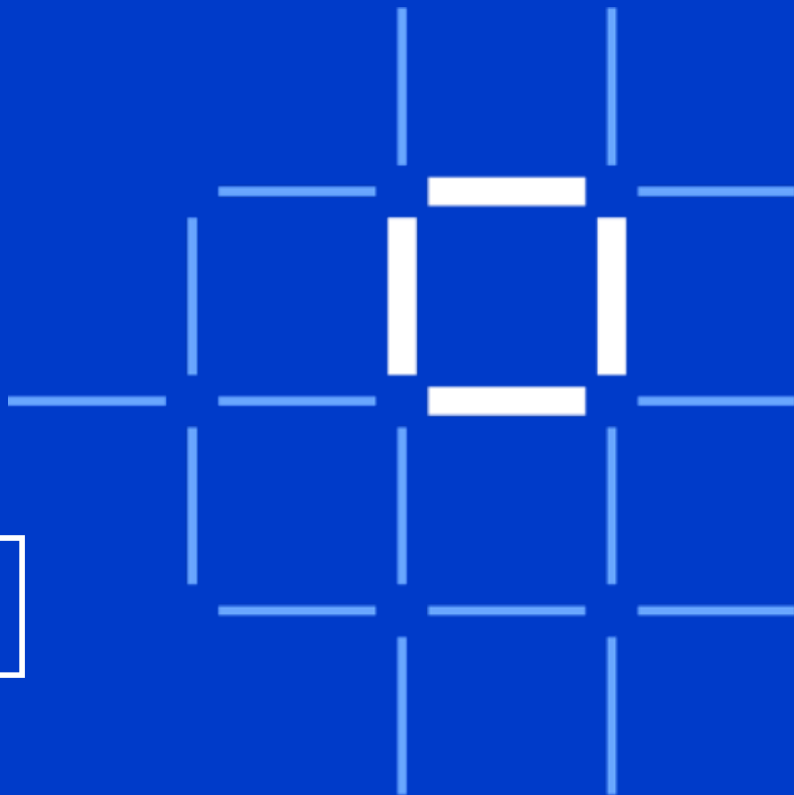
Modeling the business network



Effective Administration

Deploying to a blockchain

Interacting with systems of record



There are Two User Roles with “Administration” Responsibility



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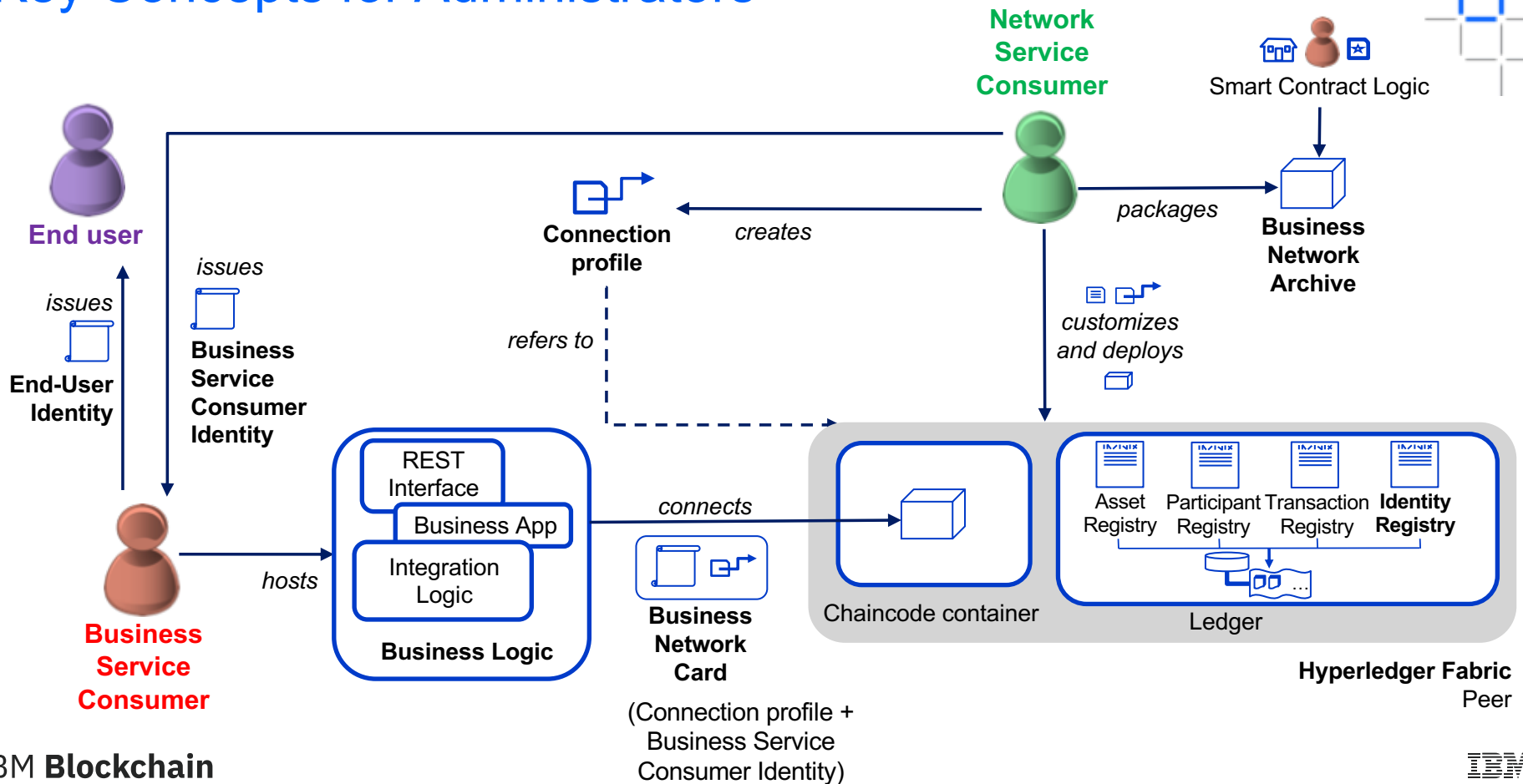
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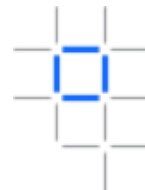
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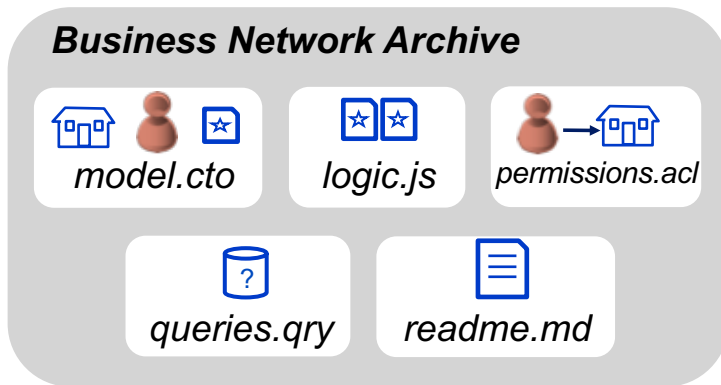
Key Concepts for Administrators



The Network Service Consumer packages resources into a BNA file

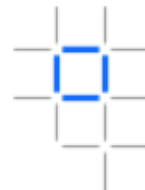


- Business Network Archive (.BNA) is a package of the resources used by Fabric:
 - Model files (.CTO)
 - Transaction processors (.JS)
 - Access Control Lists (.ACL)
 - Static queries (.QRY)
 - Documentation and versioning (.MD)
 - It does *not* contain the client application
- The BNA simplifies deployment of blockchain and promotion between environments
 - c.f. TAR, WAR, EAR, JAR, BAR...
- Create BNA files from Playground or command line
 - Build from filesystem or NPM module



```
composer archive create --archiveFile my.bna  
--sourceType module --sourceName myNetwork
```

Connection Profiles to Hyperledger Fabric



Basic Configuration

Connection Profile Name	hifabric
Orderer(s)	<div>Orderer URL <code>grpc://orderer.example.com:7050</code></div>
Channel	composerchannel
MSP ID	Org1MSP
Certificate Authority (CA)	<div>URL <code>http://ca.org1.example.com:7054</code></div> <div>Name <code>ca.org1.example.com</code></div>
Peer(s)	<div>Peer Request URL <code>grpc://peer0.org1.example.com:7051</code></div> <div>Peer Event URL <code>grpc://peer0.org1.example.com:7053</code></div>
Key Value Store Directory	/home/composer/.composer-credentials

Advanced

Use this profile Export Connection Profile

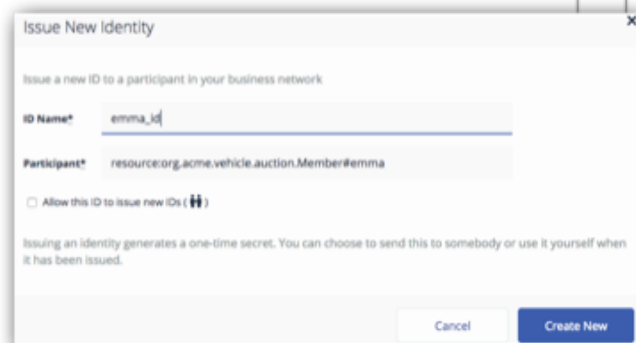
- Use **connection profiles** to describe Fabric connection parameters
 - One connection profile required per channel
 - Not necessary for web-based simulation
- Enrollment in Hyperledger Fabric network required (see later)
 - Issue Fabric identity from Composer participants

- Connection profiles currently used by Composer only
 - Plans to implement common connection profiles that can be used by both Fabric and Composer

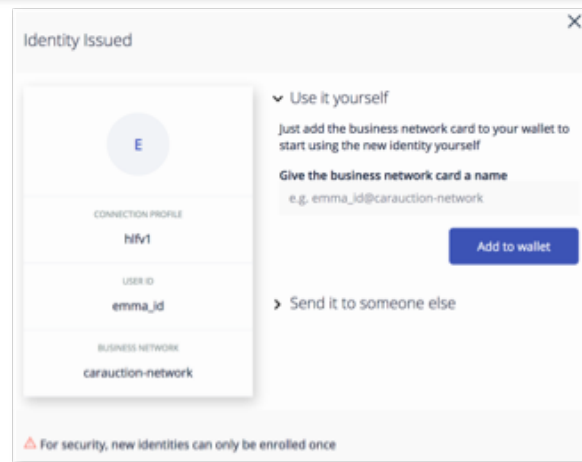
```
1 {
2   "type": "hifv1",
3   "orderers": [
4     { "url": "grpc://localhost:7050" }
5   ],
6   "ca": { "url": "http://localhost:7054",
7           "name": "ca.org1.example.com"
8   },
9   "peers": [
10    {
11      "requestURL": "grpc://localhost:7051",
12      "eventURL": "grpc://localhost:7053"
13    }
14  ],
15   "keyValStore": "${HOME}/.composer-credentials",
16   "channel": "composerchannel",
17   "mspID": "Org1MSP",
18   "timeout": "30s"
19 }
```


Participant Identity

- The **Network Service Consumer** issues network participants with an **identity** in order to connect to Hyperledger Fabric
 - Issued as a Hyperledger Fabric userid/secret
 - Automatically swapped for a certificate on first use
 - Packaged in a Business Network Card and supplied when the client application connects
- Composer Participant to Fabric Identity mapping is stored on the blockchain in an *identity registry*
- Usually, only **Business Service Consumers** have a Fabric identity
 - **End-users** log in to the business application using a separately managed identity; blockchain transactions invoked by proxy
- Manage identity from Playground, Javascript, REST or command line
 - For example: Test connection, issue identity, bind an identity to a participant, revoke an identity, list identities



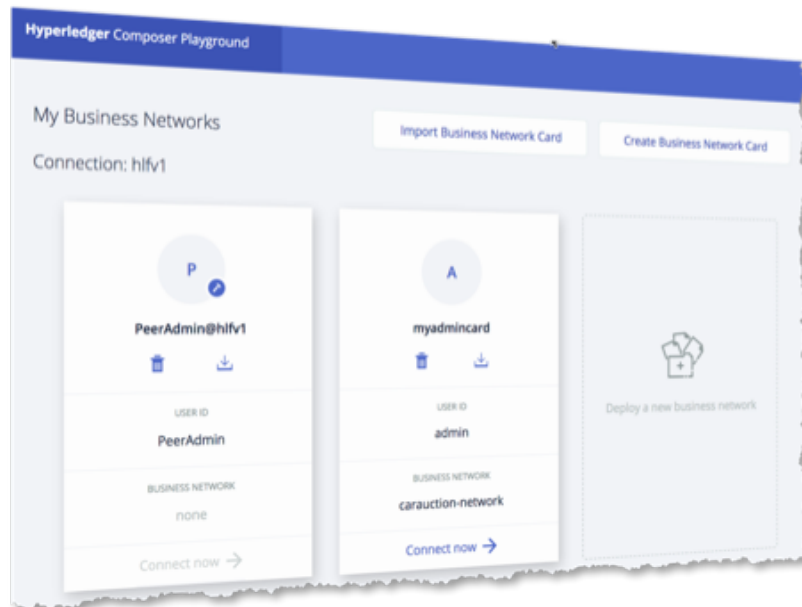
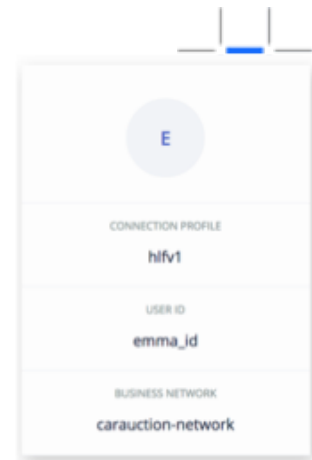
The 'Issue New Identity' dialog box is shown. It has a title bar with a close button. The main text says 'Issue a new ID to a participant in your business network'. There are two input fields: 'ID Name*' with the value 'emma_id' and 'Participant*' with the value 'resource:org.acme.vehicle.auction.Member#emma'. Below these is a checkbox labeled 'Allow this ID to issue new IDs (H)' which is unchecked. At the bottom, there is a note: 'Issuing an identity generates a one-time secret. You can choose to send this to somebody or use it yourself when it has been issued.' and two buttons: 'Cancel' and 'Create New'.



The 'Identity Issued' dialog box is shown. It has a title bar with a close button. On the left, there is a card titled 'CONNECTION PROFILE' with a blue circle containing 'E'. Below it, it says 'USER ID' and 'emma_id', and 'BUSINESS NETWORK' and 'carauction-network'. On the right, there is a section titled 'Use it yourself' with the text 'Just add the business network card to your wallet to start using the new identity yourself'. Below this is a field 'Give the business network card a name' with the value 'e.g. emma_id@carauction-network' and an 'Add to wallet' button. Below that is a section titled 'Send it to someone else'. At the bottom, there is a warning icon and text: 'For security, new identities can only be enrolled once'.

Business Network Cards

- Business Network Cards are a convenient packaging of *identity* and *connection profile*
 - Contains everything you need to connect to blockchain business network
 - Each card refers to a single participant and single business network
 - Analogous to an ATM card



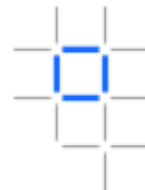
- Manage cards from both Playground and command-line
 - Create, delete, export, import, list
 - Create requires userid/secret or certificate/private key
- Use cards to connect to Fabric from Playground, command-line or from within your application

```
composer network deploy -a my.bna -c my.card
```

```
// Connect and log in to HLF
var businessNetwork = new BusinessNetworkConnection();
return businessNetwork.connect('cardName')
.then(function(businessNetworkDefinition){
    // Connected
});
```

Systems of Record Integration

- Domain specific APIs very attractive to mobile and web developers. Resources and operations are business-meaningful
- Composer exploits Loopback framework to create REST APIs: <https://loopback.io/>
- Extensive test facilities for REST methods using loopback
- Secured using JS Passport, giving >400 options for authentication
- Composer provides back-end integration with any loopback compatible product
 - e.g. IBM Integration Bus, API Connect, StrongLoop
 - Outbound and Inbound (where supported by middleware)



angular-app

Auctioneer : A participant named Auctioneer

Show/Hide | List Operations

CloseBidding : A transaction named CloseBidding

Show/Hide | List Operations

Member : A participant named Member

Show/Hide | List Operations

Offer : A transaction named Offer

Show/Hide | List Operations

Vehicle : An asset named Vehicle

Show/Hide | List Operations

GET /Vehicle

Find all instances of the model matched by filter from

POST /Vehicle

Create a new instance of the model and persist it in

GET /Vehicle/{id}

Find a model instance by {[id]} fro

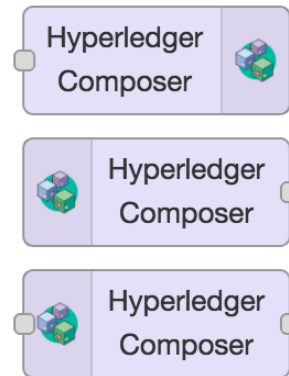
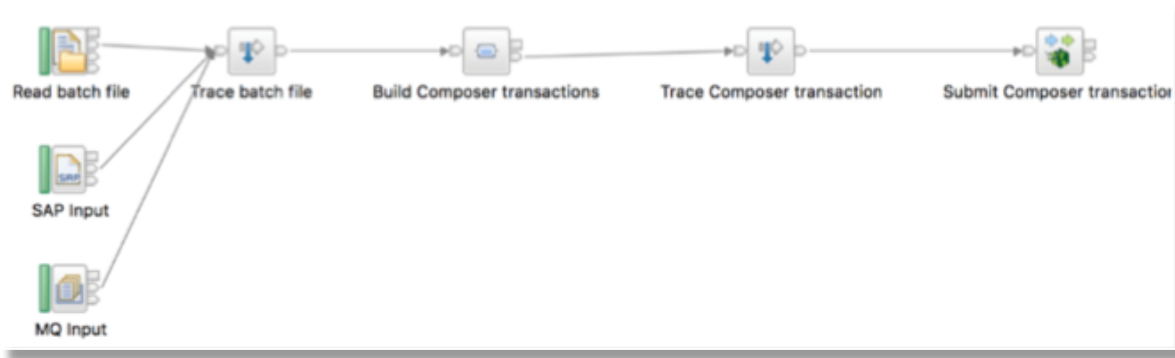
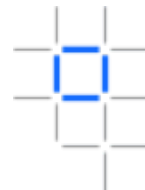
Request URL

http://0.0.0.0:3000/api/Vehicle

Response Body

```
{
  {
    "$class": "org.acme.vehicle.auction.Vehicle",
    "vin": "VEH:1234",
    "owner": "odowda@uk.ibm.com"
  }
}
```

Exploiting Loopback: Examples



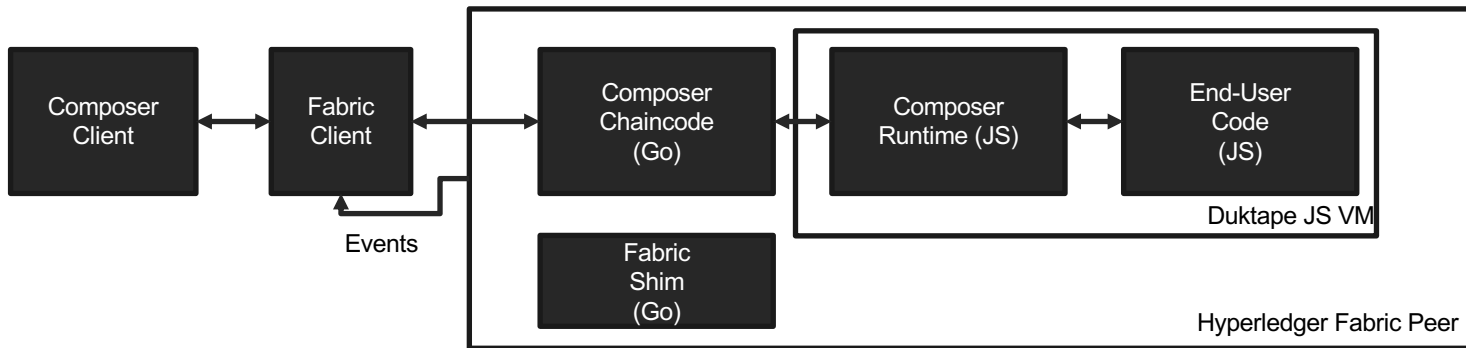
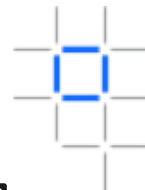
– IBM Integration Bus

- IIB V10 contains Loopback connector
- Example above takes input from file, SAP or MQ
- Data mapping from CSV, BAPI/IDOC or binary form to JSON model definition

– Node.RED

- Pre-built nodes available for Composer
- Connect to hardware devices, APIs and online services
- Install direct from Node.RED UI
 - Manage Palette -> Install -> node-red-contrib-composer

How Composer Maps to Fabric Chaincode



- Each Business Network is deployed to its own chaincode container
 - Container contains a static piece of Go chaincode that starts a Javascript virtual machine running transaction processors
- Browse these containers to view diagnostic information (docker logs)
- Embedded chaincode is not a Composer external interface

Hyperledger Composer Outlook

- Still early in product lifecycle
- Lots of improvements planned
 - See <https://github.com/hyperledger/composer/issues>
- An active development community
 - Open community calls every two weeks
 - Rocket Chat
 - Stack Overflow
- Get involved!



Hyperledger Rocket.Chat

You will need a [Linux Foundation ID](#) , or alternatively you can log in with Facebook, GitHub, Google, or OpenStack.

Let's chat

Stack Overflow

Ask questions in Stack Overflow with the tag [#hyperledger-composer](#).

Ask now

Contribute to the Project

GitHub

Check out the code, feel free to get involved.

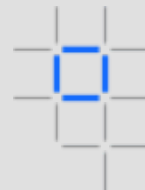
GitHub

Community Call

Join our weekly open community calls.

Learn how

Get started with Hyperledger Composer



- Define, Test and Deploy Business Networks
- Create domain APIs and sample applications
- Integrate existing systems and data

<https://hyperledger.github.io/composer/>

<http://composer-playground.mybluemix.net/>



Thank you

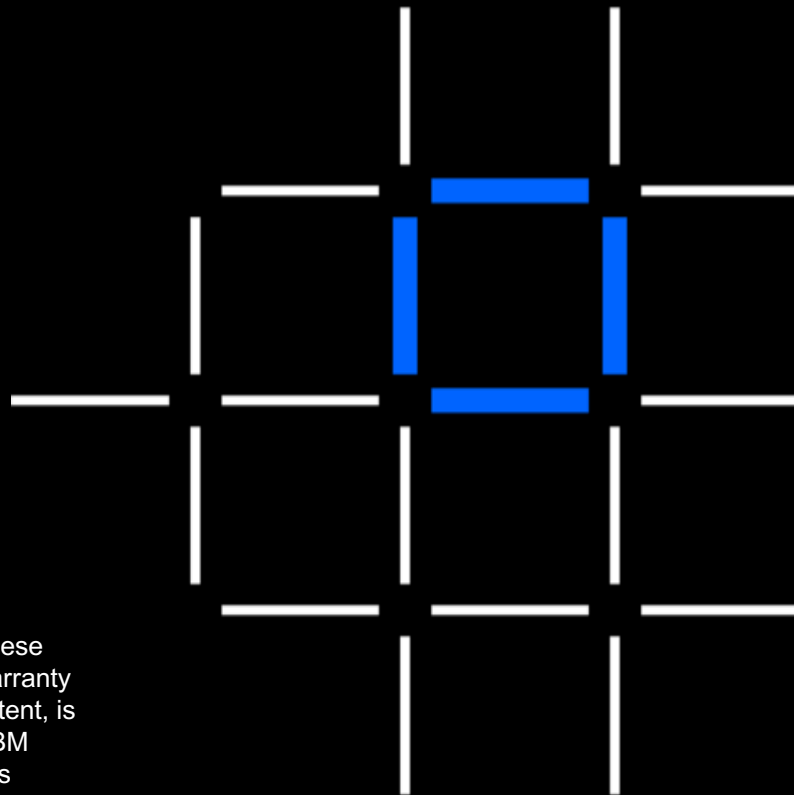
IBM Blockchain

www.ibm.com/blockchain

developer.ibm.com/blockchain

www.hyperledger.org

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