



Physical Blockchain: A blockchain use case for the physical internet

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Conclusions 1

- The current state of the art of the present system handles a Physical Blockchain based Mezcal crate cross-border trade from Mexico to Germany.
- The system is based on the Hyperledger Fabric, an architecture comprised of data models, smart contracts and access controls for blockchains participants.

Conclusions 2

- The full system consists of three blockchains:
 1. A mainchain of the Physical Internet cross-border logistics and payouts across participants
 2. A sidechain for auctions where goods, Incoterms, and additional transport and delivery specifications are described; and where the transfer of funds from the customer to the mainchain occurs
 3. A sidechain for chain of custody where information is produced and transfer to the mainchain in exchange of transfer of funds from the mainchain

- To do list:
 1. The first mainchain: will be extended to include in payouts penalties and rewards based on service level KPIs, such as: fill rates, order accuracy, lead time, etc.
 2. The second sidechain: will be upgraded to include in the auction algorithm non-physical goods/assets, and futures markets.
 3. The third sidechain: will be extended to include π _nodes, π _transport, and π _containers where orders are located, as well as the status of the cargo, such as in unloading/loading bays, crossdocking, (de/re)consolidation, sorting, storage, inspection, quarantine, transport, etc





Why a Physical Blockchain?

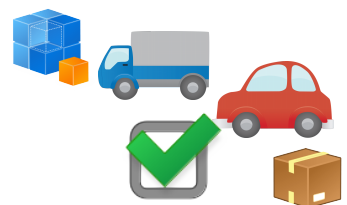
A piece of which world do we want?

- Do we need to stress the need for the importance of the PI?
 - Economies of scale, scope, speed, and space.
 - Standardized π -containers; π -nodes, π -transport/routes
 - Optimization, synchronization, automation
- Do we need to stress the technological possibilities of the Blockchain?
 - Blockchain 1.0: cryptocurrencies
 - Blockchain 2.0: Smart contracts and “black letter” rules.
 - Blockchain 3.0 & X.0: scalability; interchain operability; cloud & big data; on&off operability, security & governance; digitalization and IoT

Lets get our hands dirty

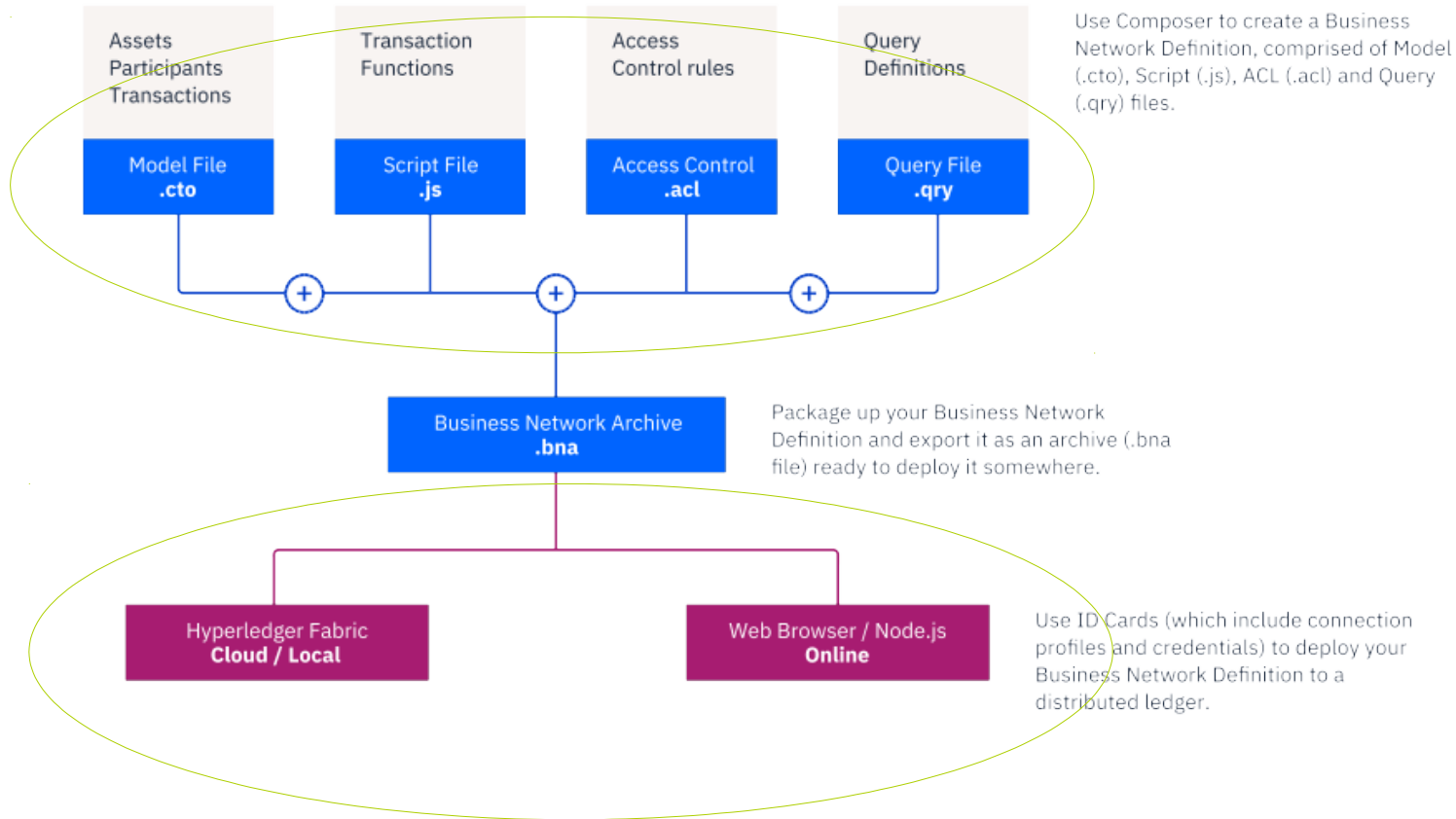
A classical physical internet

- Mexico supplies a Mezcal crate to Germany
 - Oaxaca, Mexico receives an purchase order from Germany
 -
 - The exporter places the Mezcal in π -packs and a π -box  
 -
 - The π -box is placed in a π -container and loaded in the LSP's π -transport
 -
 - The π -container passes through a regional π -node, and international π -node in Mexico for air transport to Germany 
 -
 - The π -container arrives to an international π -node in Germany and passes through a regional π -node, and a last mile delivery π -node in Hamburg. 



Lets get our hands dirty

A hyperledger fabric architecture to handle the physical internet



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Data model

Script file

Access Control List

```

1  /**
2  * Data model for a blind Mezcral crate auction
3  */
4  namespace org.acme.mezcal.auction
5
6  asset Mezcral identified by vin {
7    o String vin
8    --> Member owner
9  }
10
11 enum ListingState {
12   o FOR_SALE
13   o RESERVE_NOT_MET
14   o SOLD
15 }
16
17 asset MezcralListing identified by listingId {
18   o String listingId
19   o Double reservePrice
20   o String description
21   o ListingState state
22   o Offer[] offers optional
23   --> Mezcral mezcral
24 }
25
26 abstract participant User identified by email {
27   o String email
28   o String firstName
29   o String lastName
30 }
31
32 participant Member extends User {
33   o Double balance
34 }
35
36 participant Auctioneer extends User {
37 }
38
39 transaction Offer {
40   o Double bidPrice
41   --> MezcralListing listing
42   --> Member member

```

```

15  /**
16   * Close the bidding for a Mezcral crate listing
17   * highest bid that is over the asking price
18   * @param {org.acme.mezcal.auction.CloseBidding} closeBidding
19   * @transaction
20   */
21  function closeBidding(closeBidding) {
22    var listing = closeBidding.listing;
23    if (listing.state !== 'FOR_SALE') {
24      throw new Error('Listing is not FOR_SALE')
25    }
26    // by default we mark the listing as FOR_SALE
27    listing.state = 'RESERVE NOT MET';
28    var highestOffer = null;
29    var buyer = null;
30    var seller = null;
31    if (listing.offers && listing.offers.length > 0) {
32      // sort the bids by bidPrice
33      listing.offers.sort(function(a, b) {
34        return (b.bidPrice - a.bidPrice);
35      });
36      highestOffer = listing.offers[0];
37      if (highestOffer.bidPrice >= listing.reservePrice) {
38        // mark the listing as SOLD
39        listing.state = 'SOLD';
40        buyer = highestOffer.member;
41        seller = listing.mezcal.owner;
42        // update the balance of the seller
43        console.log('#### seller balance before: ', seller.balance);
44        seller.balance += highestOffer.bidPrice;
45        console.log('#### seller balance after: ', seller.balance);
46        // update the balance of the buyer
47        console.log('#### buyer balance before: ', buyer.balance);
48        buyer.balance -= highestOffer.bidPrice;
49        console.log('#### buyer balance after: ', buyer.balance);
50        // transfer the mezcral to the buyer
51        listing.mezcal.owner = buyer;
52        // clear the offers
53        listing.offers = null;
54      }
55    }
56    return getAssetRegistry('org.acme.mezcal.auction').
57      then(function(mezcalRegistry) {

```

```

1  /**
2  * Access Control List for the mezcral auction network.
3  */
4  rule Auctioneer {
5    description: "Allow the auctioneer full access"
6    participant: "org.acme.mezcal.auction.Auctioneer"
7    operation: ALL
8    resource: "org.acme.mezcal.auction.*"
9    action: ALLOW
10 }
11
12 rule Member {
13   description: "Allow the member read access"
14   participant: "org.acme.mezcal.auction.Member"
15   operation: READ
16   resource: "org.acme.mezcal.auction.*"
17   action: ALLOW
18 }
19
20 rule MezcralOwner {
21   description: "Allow the owner of a mezcral total access"
22   participant(m): "org.acme.mezcal.auction.Member"
23   operation: ALL
24   resource(v): "org.acme.mezcal.auction.Mezcral"
25   condition: (v.owner.getIdentifier() == m.getIdentifier())
26   action: ALLOW
27 }
28
29 rule MezcralListingOwner {
30   description: "Allow the owner of a mezcral total access to their mezcral"
31   participant(m): "org.acme.mezcal.auction.Member"
32   operation: ALL
33   resource(v): "org.acme.mezcal.auction.MezcralListing"
34   condition: (v.mezcal.owner.getIdentifier() == m.getIdentifier())
35   action: ALLOW
36 }
37
38 rule SystemACL {
39   description: "System ACL to permit all access"
40   participant: "org.hyperledger.composer.system.Participant"
41   operation: ALL
42   resource: "org.hyperledger.composer.system.*"
43   action: ALLOW

```

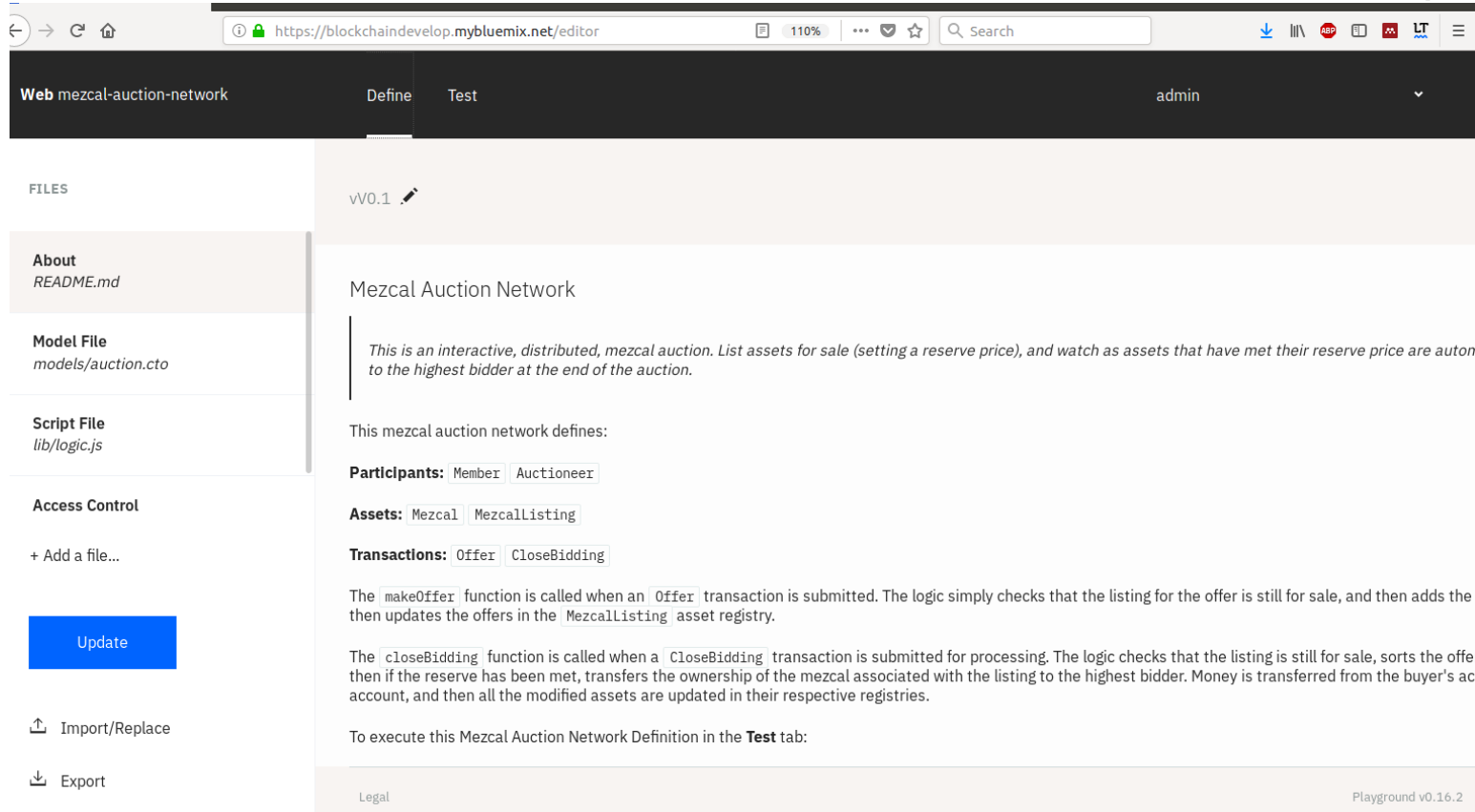
Lets get our hands dirty

A hyperledger fabric architecture to handle the physical internet

Network definition

Execution

IDs and Timestamps



The screenshot shows a web browser at `https://blockchaindevelop.mybluemix.net/editor` displaying the Hyperledger Playground editor. The interface is divided into several sections:

- Header:** Shows the network name "Web mezcal-auction-network", tabs for "Define" and "Test", and a user profile "admin".
- Files Panel (Left):** Lists files including "About README.md", "Model File models/auction.cto", and "Script File lib/logic.js". There is an "Update" button and "Import/Replace" and "Export" options at the bottom.
- Main Editor (Right):**
 - Version: v0.1
 - Title: Mezcal Auction Network
 - Description: *This is an interactive, distributed, mezcal auction. List assets for sale (setting a reserve price), and watch as assets that have met their reserve price are autor to the highest bidder at the end of the auction.*
 - Definition: "This mezcal auction network defines:"
 - Participants: Member, Auctioneer
 - Assets: Mezcal, Mezcallisting
 - Transactions: Offer, CloseBidding
 - Logic:
 - `makeOffer`: Called when an `Offer` transaction is submitted. Checks if the listing is for sale and adds the offer to the `Mezcallisting` registry.
 - `closeBidding`: Called when a `CloseBidding` transaction is submitted. Checks if the listing is for sale, sorts the offer, and transfers ownership to the highest bidder if the reserve is met.
 - Execution Note: "To execute this Mezcal Auction Network Definition in the **Test** tab:"
- Footer:** "Legal" on the left and "Playground v0.16.2" on the right.

Lets get our hands dirty

A hyperledger fabric architecture to handle the physical internet







Network definition

Execution

IDs and Timestamps

Web mezc-al-auction-network Define Test admin

Participant registry for org.acme.mezcal.auction.Member + Create New Participant

Participant Type	ID	Data	Actions
Member	fdallari@liuc.it	<pre>{ "\$class": "org.acme.mezcal.auction.Member", "balance": 5000, "email": "fdallari@liuc.it", "firstName": "Fabrizio", "lastName": "Dallari" }</pre>	 
MezcListing	rod@bestmans.ngo	<pre>{ "\$class": "org.acme.mezcal.auction.Member", "balance": 1000, "email": "rod@bestmans.ngo", "firstName": "Rod", "lastName": "Frankois" }</pre>	 
	sergio@mezpirits.mx	<pre>{ "\$class": "org.acme.mezcal.auction.Member", "balance": 5500, "email": "sergio@mezpirits.mx", "firstName": "Sergio", "lastName": "Barbarito" }</pre>	 

[Submit Transaction](#)

Lets get our hands dirty

A hyperledger fabric architecture to handle the physical internet

Network definition

Execution

IDs and Timestamps

Web mezcac-auction-network Define Test admin

110% Search

PARTICIPANTS

Auctioneer

Member

ASSETS

Mezcal

MezcalListing

TRANSACTIONS

All Transactions

Submit Transaction

Date, Time	Entry Type	Participant	
2018-04-18, 23:25:34	UpdateBusinessNetwork	admin (NetworkAdmin)	view record
2018-04-18, 23:22:52	UpdateBusinessNetwork	admin (NetworkAdmin)	view record
2018-04-18, 23:04:27	CloseBidding	admin (NetworkAdmin)	view record
2018-04-18, 23:03:43	Offer	admin (NetworkAdmin)	view record
2018-04-18, 23:01:46	Offer	admin (NetworkAdmin)	view record
2018-04-18, 23:00:10	AddAsset	admin (NetworkAdmin)	view record
2018-04-18, 22:57:51	AddAsset	admin (NetworkAdmin)	view record

Lets get our hands dirty

3 Blockchains

Mezcal crate auction

Export & Payouts

Block(chain) of custody



Lets get our hands dirty

3 Blockchains

Mezcal crate auction

Export & Pavouts

Block(chain) of custody

Crate a Smart Contract Rod-Sergio-Maya

```

    "id": "rod-sergio-maya",
    "type": "Mezcal_crate",
    "contract": "rod-sergio-maya",
    "status": "open",
    "location": "Mexico",
    "weight": 10,
    "volume": 10,
    "temperature": 20,
    "humidity": 50,
    "created": "2018-04-20T12:17:25Z",
    "updated": "2018-04-20T12:17:25Z",
    "contract": "rod-sergio-maya"
  
```

Crate a Shipment for Maya

```

    "id": "maya-shipment",
    "type": "Mezcal_crate",
    "contract": "rod-sergio-maya",
    "status": "open",
    "location": "Mexico",
    "weight": 10,
    "volume": 10,
    "temperature": 20,
    "humidity": 50,
    "created": "2018-04-20T12:17:25Z",
    "updated": "2018-04-20T12:17:25Z",
    "contract": "rod-sergio-maya"
  
```

Submit a Temperature Reading

Asset registry for org.acme.shipping.mezcal.Shipment

ID	Data
SHEP_001	<pre> "id": "rod-sergio-maya", "type": "Mezcal_crate", "contract": "rod-sergio-maya", "status": "open", "location": "Mexico", "weight": 10, "volume": 10, "temperature": 20, "humidity": 50, "created": "2018-04-20T12:17:25Z", "updated": "2018-04-20T12:17:25Z", "contract": "rod-sergio-maya" </pre>

Submit a Shipment Received

```

    "id": "maya-shipment",
    "type": "Mezcal_crate",
    "contract": "rod-sergio-maya",
    "status": "open",
    "location": "Mexico",
    "weight": 10,
    "volume": 10,
    "temperature": 20,
    "humidity": 50,
    "created": "2018-04-20T12:17:25Z",
    "updated": "2018-04-20T12:17:25Z",
    "contract": "rod-sergio-maya"
  
```

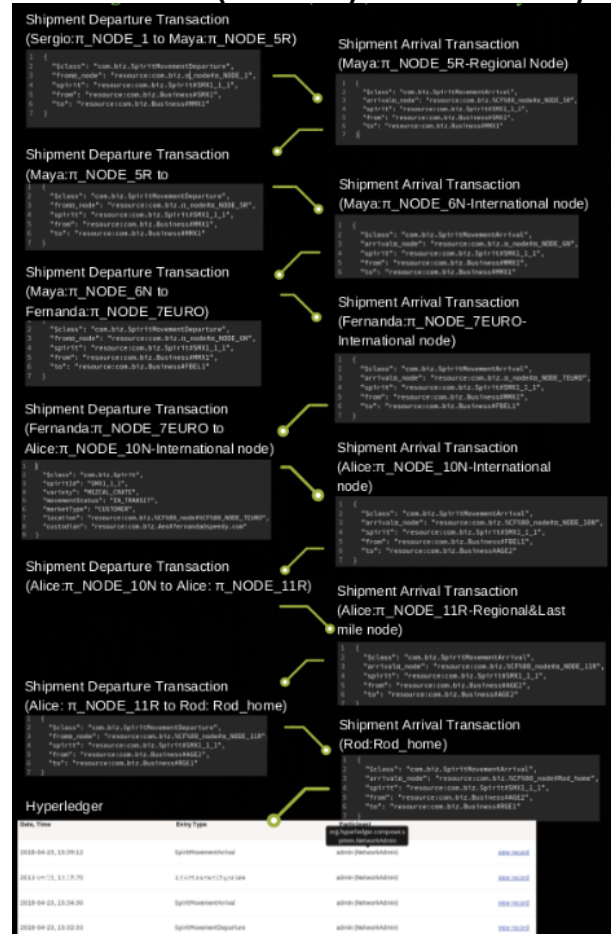
Source: Own elaboration

Lets get our hands dirty

3 Blockchains

Mezcal crate auction Export & Payouts

Block(chain) of custody



Final remarks

Physical Blockchain capability Requirements

- Decentralised Autonomous Organizations (DAOs) and smart devices
- Measurement and analytics
- Distributed marketplace
- Mainchain and sidechains integration
- Plugging-in non-blockchain systems
- Embedded optimisation algorithms in smart contracts
- Traditional, crypto, and virtual currencies and assets

Living labs?

- The full system consists of three blockchains:
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- To do list:
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Thank you! Suggestions! Lets talk!

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