



## **Implementing Blockchain Technology in NMAC System**

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# Introduction



- **Motivation**

- Emerging technologies have focused on blockchain technologies.
- Review of possible applications in the nuclear industries.

- **Objectives**

- Ensure transparency transactions in control of nuclear and radioactive material movements.

- **Contribution**

-  The implementation of the NMAC-blockchain as proof of concepts.

# Introduction



## State of the Art

- Cryptocurrencies
- Energy distribution from smart grids
- Finances and property rights
- The French Atomic Energy Commission (CEA) is developing a blockchain solution to control the products manufactured by the food industry
- Rosatom (Russia) invest in R&D on blockchain to safeguard military assets

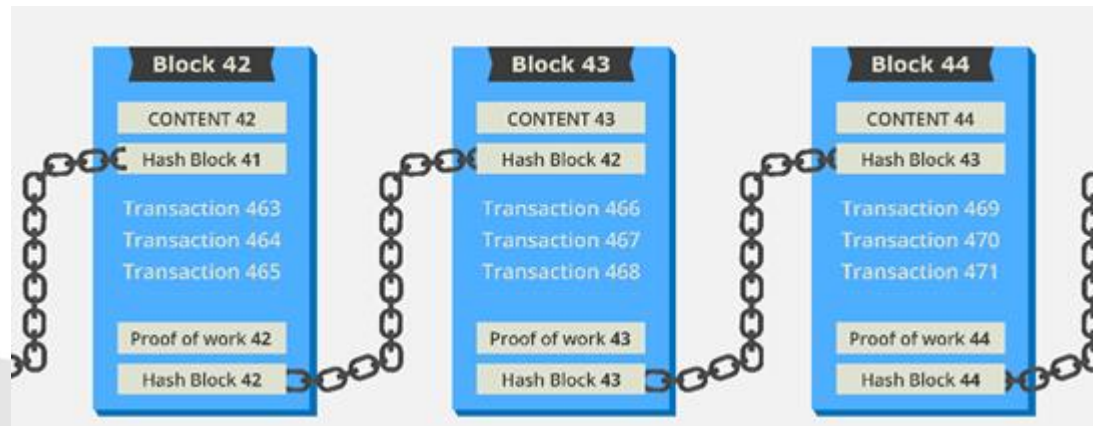


# Blockchain



- **Blockchain characteristics**

- Blockchain constructs a chronological chain of blocks, hence the name "block-chain".
- Each block is an immutable information unit.
- Blockchain consists of timestamping of transactions, Peer-to-Peer networks, cryptography, and shared computational power.
- Components: data model, transaction language, consensus algorithm.
- Smart Contracts: automatic execution code.



# Use case: NMAC Blockchain

## Scenario

“A new set of fuel rods arrives to the facility. A custodian named John Muller receives the set of material.

He must login in a web page that allows him to specify the type of source transaction. In this case, the transaction is record new sources.

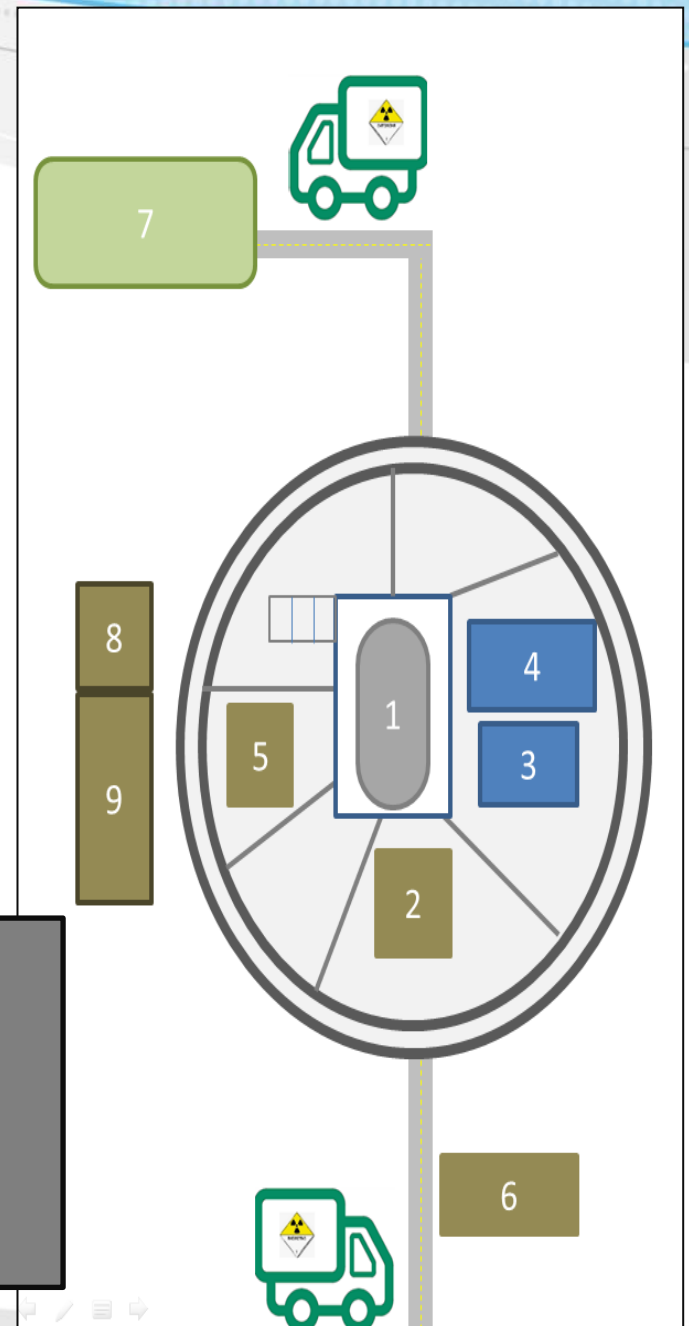
These transactions are registered in the nmac-blockchain with a timestamp specification.

Then, at the moment when the fuel rod replacement occurs, Muller has to write this new transaction in the nmac-blockchain.”

### Movements:

- ✓ Shipment
- ✓ Receipt
- ✓ Transfer
- ✓ Relocation

1. Nuclear Reactor Core
2. Storage Enclosure
3. Maneuvering Pool
4. Waste Disposal Pool
5. Laboratory 1
6. Reception
7. Waste Disposal Facility
8. Enclosure 1
9. Enclosure 2



# NMAC Blockchain: Design



## Participants

- **Regulator**: Monitoring source movements, audit the blockchain.
- **Nuclear Material Custodian**: Source/Nuclear Material Check in, Source/Nuclear Material Check out, Relocation of nuclear source, Adding source to the blockchain and Adding new location.



## Assets

- **Nuclear Material**

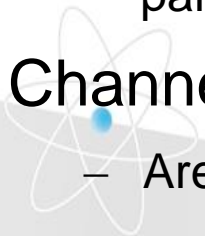


## Transactions

- 1) Add sources, 2) return a list of sources, 3) request information about a particular source, and 4) modify the source's custodian.

## Channels

- Are the communication buses between participants.

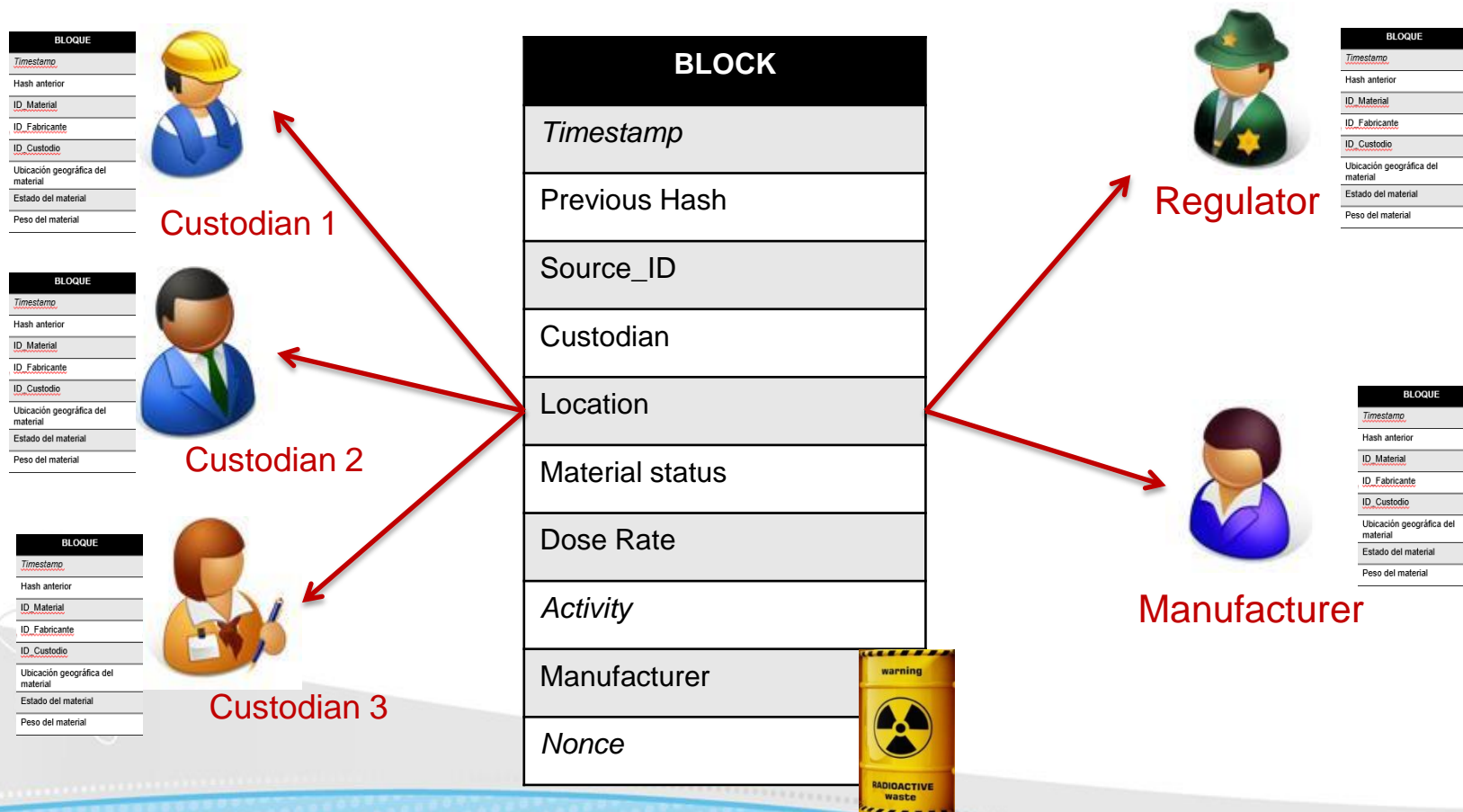




# NMAC Blockchain: Design



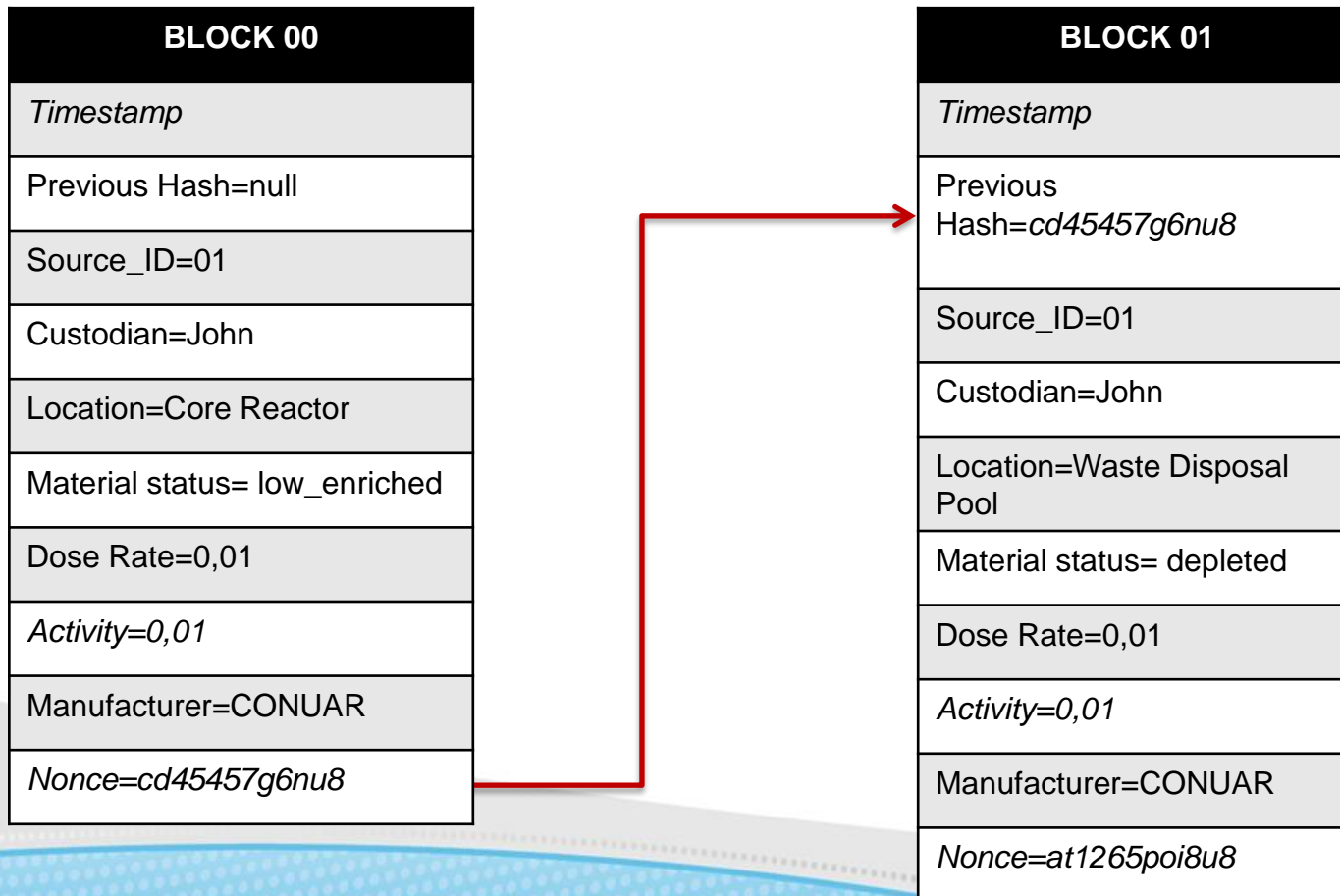
## A block structure in the nmac-blockchain



# NMAC Blockchain: Design

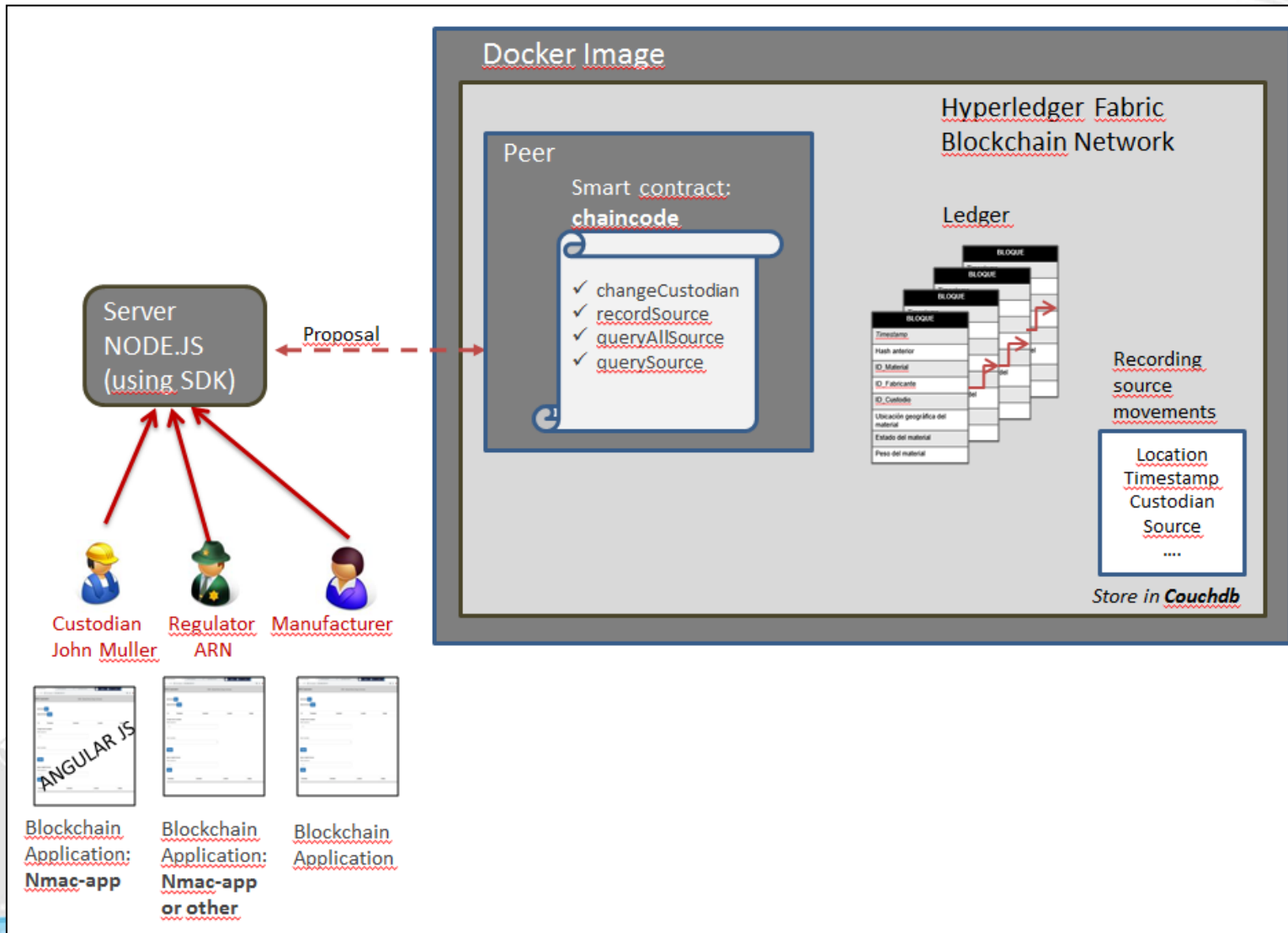


Representation of a previous hash.





# NMAC Blockchain Architecture



# NMAC Blockchain: Proof of Concepts



## Nmac-app

Browser window showing the NMAC Application interface. The address bar displays "192.168.60.229:8000". The page title is "NMAC Application" and the subtitle is "CNEA - National Atomic Energy Commission".

Buttons: "Add Source New" and "Query All Source Query".

ID	Timestamp	Custodian	Location	Isotope
1	1504054225	Miriam	SNM safe	U235
2	1504057825	Dave	Aries Lab	PuMT51
3	8754987634	Diego	Enclousure 2	U235
4	1496105425	Amalea	Source Safe	MOXe
5	1493512301			
6	1494117101			
7	1496104301			
8	1485066691			
9	1485153091			
10	1487745091			
11	5656565656			

Close-up of the "Change Source Custodian" form. A "Success!" message is displayed in a red-bordered box. The form includes a "Enter a source id:" field with the value "55" and a "Select custodian:" dropdown menu showing "John Muller".

ID	Timestamp	Custodian	Location	Isotope
55	1574432784714	Emily Tylor	Core Reactor	U235
6767	1574432253406	Susan Wilson	Waste Disposal Pool	U235

Change Source Custodian

Enter a source id:

55

Select custodian:

John Muller

ID	Timestamp	Custodian	Location	Isotope
55	1574432784714	John Muller	Core Reactor	U235
6767	1574432253406	Susan Wilson	Waste Disposal Pool	U235

Change Source Custodian

Enter a source id:



# NMAC Blockchain: Proof of Concepts



## Hyperledger Explorer

The screenshot shows the Hyperledger Explorer interface with the 'TRANSACTIONS' tab selected. The search filters are set to 'From: November 21, 2019 12:24 PM' and 'To: November 22, 2019 12:24 PM'. The table below shows a list of transactions:

Creator	Channel Name	Tx Id	Type	Chaincode	Timestamp
Org1MSP	mychannel	859857ba4f18c5dab13c6e40d1269abf319e16abc5dae2f616d62679aa29899e	ENDORSER_TRANSA...	nmac-app	2019-11-22T15:18:59...
Org1MSP	mychannel	f09d7f...	ENDORSER_TRANSA...	nmac-app	2019-11-22T14:22:19...
Org1MSP	mychannel	91dff3...	ENDORSER_TRANSA...	nmac-app	2019-11-22T14:20:24...
Org1MSP	mychannel	b9d08f...	ENDORSER_TRANSA...	nmac-app	2019-11-22T14:20:19...

```
changing custodian of source:  
Store path:/home/si/.hfc-key-store  
Successfully loaded user1 from persistence  
Assigning transaction_id: 859857ba4f18c5dab13c6e40d1269abf319e16abc5dae2f616d62679aa29899e  
Transaction proposal was good  
Successfully sent Proposal and received ProposalResponse: Status - 200, message - ""
```



# NMAC Blockchain: Proof of Concepts



## Hyperledger Explorer

Hyperledger Explorer Client Version: 0.3.9 Fabric Compatibility: v1.4

Block Number	Channel Name	Number of Tx	Data Hash	Block Hash	Previous Hash	Transactions
79	mychannel	1	dc3257 ...	b3ed33 ...	86df88 ...	<a href="#">859857 ...</a>
78	mychannel	1	d4ee21 ...	86df88 ...	aaecbd ...	<a href="#">8c2d23 ...</a>
77	mychannel	1	38e06f ...	aaecbd ...	1ba202 ...	<a href="#">1c987c ...</a>
76	mychannel	1	638e28 ...	1ba202 ...	979d3a ...	<a href="#">46a620 ...</a>
75	mychannel	1	38dd51 ...	979d3a ...	9b95ba ...	<a href="#">7f2981 ...</a>
74	mychannel	1	26adb9 ...	9b95ba ...	59602b ...	<a href="#">d98241 ...</a>
73	mychannel	1	de9bf6 ...	59602b ...	c710e6 ...	<a href="#">f09d7f ...</a>
72	mychannel	1	0aaf93 ...	c710e6 ...	43d4h7 ...	<a href="#">91dff3 ...</a>



# NMAC Blockchain: Proof of Concepts



## Hyperledger Explorer


Block Number	Channel Name	Number of Tx	Data Hash	Block Hash	Previous Hash	Transactions
79	mychannel	1	dc3257 ...	<a href="#">b3ed33 ...</a>	86df88 ...	<a href="#">859857 ...</a>



# NMAC Blockchain: Proof of Concepts



## Transaction Details

**Transaction ID:** 859857ba4f18c5dab13c6e40d1269abf319e16abc5dae2f616d62679aa29899e 

**Validation Code:** VALID

**Payload Proposal Hash:** d55fc01d511c2c98db0fb3fbe823d9a21960b99fb55ebbaa5c2ed92f105397b0

**Creator MSP:** Org1MSP

**Endoser:** {"Org1MSP"}

**Chaincode Name:** nmac-app

**Type:** ENDORSER\_TRANSACTION

**Time:** 2019-11-22T15:18:59.844Z

### Reads:

- ▼ root: [] 2 items
  - ▶ 0: {} 2 keys
  - ▶ 1: {} 2 keys

### Writes:

- ▼ root: [] 2 items
  - ▶ 0: {} 2 keys
  - ▶ 1: {} 2 keys



# Conclusions and Future Works

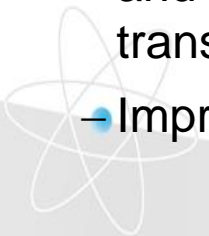


- **Conclusions**

- Nmac-blockchain could improve the current NMAC system.
- This technology bring transparency to nuclear material movements between facilities and different countries.
- Nmac-blockchain reduces costs and delays in the regulator's processes and enhances the security of the information assets helping avoid possible sabotages.

- **Futures works**

- We are going to implements more blockchain peers and evaluate the behaviour and performance of the nmac-blockchain with a large number of concurrent transactions.
- Improve the user experience.



# Implementing Blockchain Technology in NMAC system



## Questions?

Thanks for your attention.-



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