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How smart contracts can implement the policy objective of ‘report once’

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Focus Session

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Contents

Introduction – objectives of the presentation

The presentation discusses a demonstrator built for the European Commision’s DG FISMA and show how smart contracts can implement 'digital doppelgängers' of OTC derivatives contracts that are traded to help achieve the policy objective of ‘report once’.

EC DG FISMA

The Directorate-General for *Financial Stability, Financial Services and Capital Markets Union* is the Commission department responsible for EU policy on banking and finance.

OTC derivatives

Derivatives are financial instruments whose value depends on (‘derives from’) the values of other, more basic, underlying variables e.g. a stock of a company, or an index such as S&P. Over-the-counter (OTC) derivatives are customized, bilateral agreements that transfer the risk from one party to the other (such as swaps and forwards).

Smart contracts as ‘digital doppelgängers’

Smart contracts are executable pieces of software residing on an electronic distributed ledger. In the presented demonstrator, a private Ethereum ledger was used. The smart contracts are a representation of OTC derivatives

Overview of the project

Objectives of the project

Explore possibilities to address the problems of cost of regulatory burdens for banks and financial institutions and inadequate monitoring of risk attached to financial contracts.

Study investigated the feasibility of Distributed Ledger Technologies (DLTs) as the new way of financial institutions to meet their reporting obligations as laid down in EU financial sector legislation.

Novelties

- resulting demonstrator uses smart contracts to meet the policy objective "report once" in financial reporting (EMIR, MIFIR, COREP) in the EU
- Use of ACTUS semantics

Overview of the regulations

EMIR (European Market Infrastructure Regulation) provides that some classes of OTC derivative transactions have to be cleared through Central Counterparties (CCPs), and that risk mitigation techniques have be be applied for other OTC transactions

MiFIR extends the clearing obligation by CCPs to regulated markets for exchange-traded derivatives

COREP, issued by EBA, specifies Guidelines for Common Reporting:

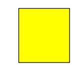
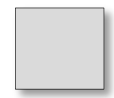
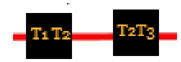
- for Capital Requirements Directive (CRD) reporting
- covers credit risk, market risk, operational risk, own funds and capital adequacy ratio
- when trading each counterparty conducts its own reporting to its own supervisor

Overview of the demonstrator

- The demonstrator shows
  - How digital representations of *Over The Counter (OTC)* derivatives such as bonds or swaps can be implemented as smart contracts on a blockchain. The life-cycle of the derivatives during trading follows the real assets' life-cycle in semi real-time.
  - How blockchain-based reports can assemble and calculate the information required for compliance reporting (COREP, EMIR, MIFIR) towards supervisory bodies
- Today, this reporting information is typically dispersed and difficult to obtain and correctly aggregate. However, in the demonstrator, as all the is present on-chain, these reports contain all required information ('report once')
- The demonstrator is a vehicle to demonstrate Distributed Ledger Technology (DLT) concepts, it is not an implementation of a target solution

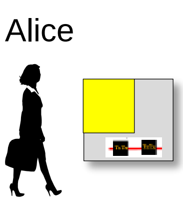
Distributed ledgers in one minute

Vocabulary

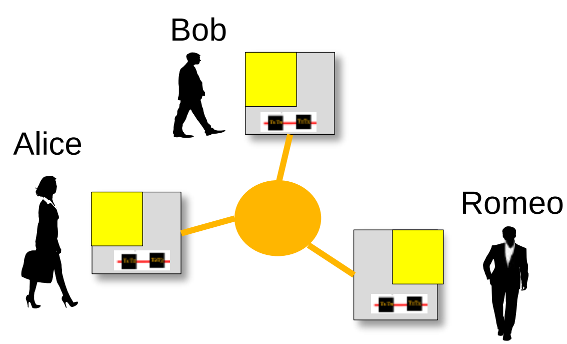
- Users (Alice, Bob, Romeo, ...) 
- Applications (cryptocurrency wallet, digital doppelgänger, ...) 
- Nodes (alternatively called 'blockchain nodes') 
- Blockchain (concatenation of blocks) 

- 'Consensus' (all nodes agree on which blocks are part of the blockchain)

Single node:



Set of nodes:

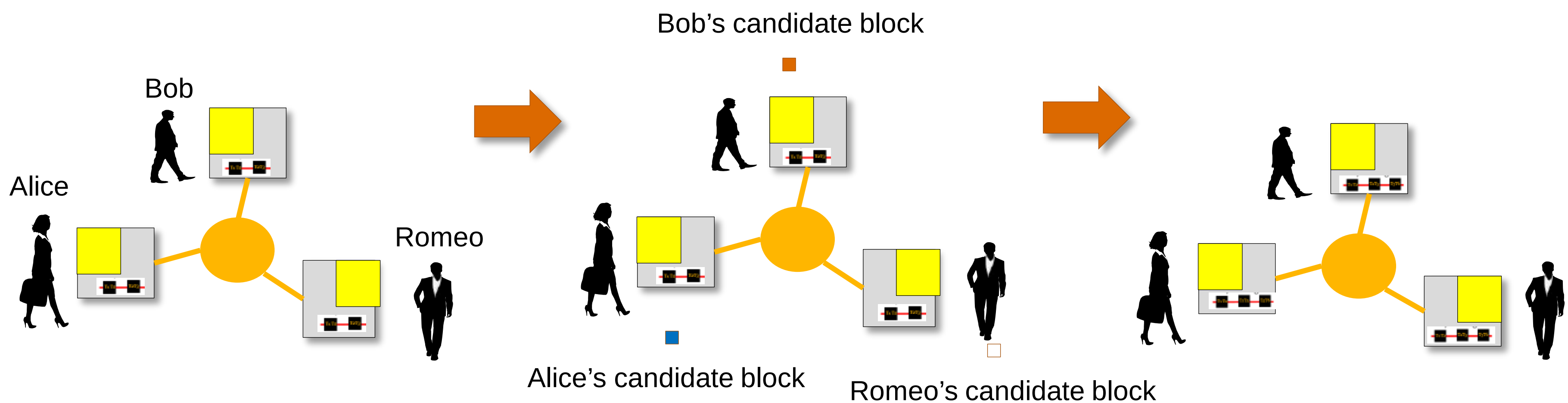


All nodes have an identical copy of the blockchain
What is stored in the blockchain is considered immutable

Distributed ledgers in one minute

Users perform transactions through the application
Every node broadcasts its transaction outputs
Every node can create its candidate block

Blockchain is extended everywhere by selected candidate block



Which candidate block gets selected?
In most blockchain implementations, nodes try to solve a cryptopuzzle (mathematically hard problem based on hashing), and the first node that solves the puzzle has its candidate block accepted by the other nodes
Once new block is part of the chain, it is considered as immutable, and the transactions as committed on a ledger

Consensus is important
Ensures that the next block in a blockchain is the one and only version of the truth,
Keeps powerful adversaries from derailing the system and successfully forking the chain
There are many different ways to obtain consensus

The smart contract demonstrator

Functionality of the demonstrator

Contracting parties (Alice, Bob, Eve)

- trade OTC derivatives through their usual channels
- have a user interface at their disposal to create *digital doppelgängers* on the distributed ledger

These *digital doppelgängers* are replicated to all nodes on the ledger according the consensus protocol

Every node, including the regulator (Romeo) has access to the same information in semi-real time

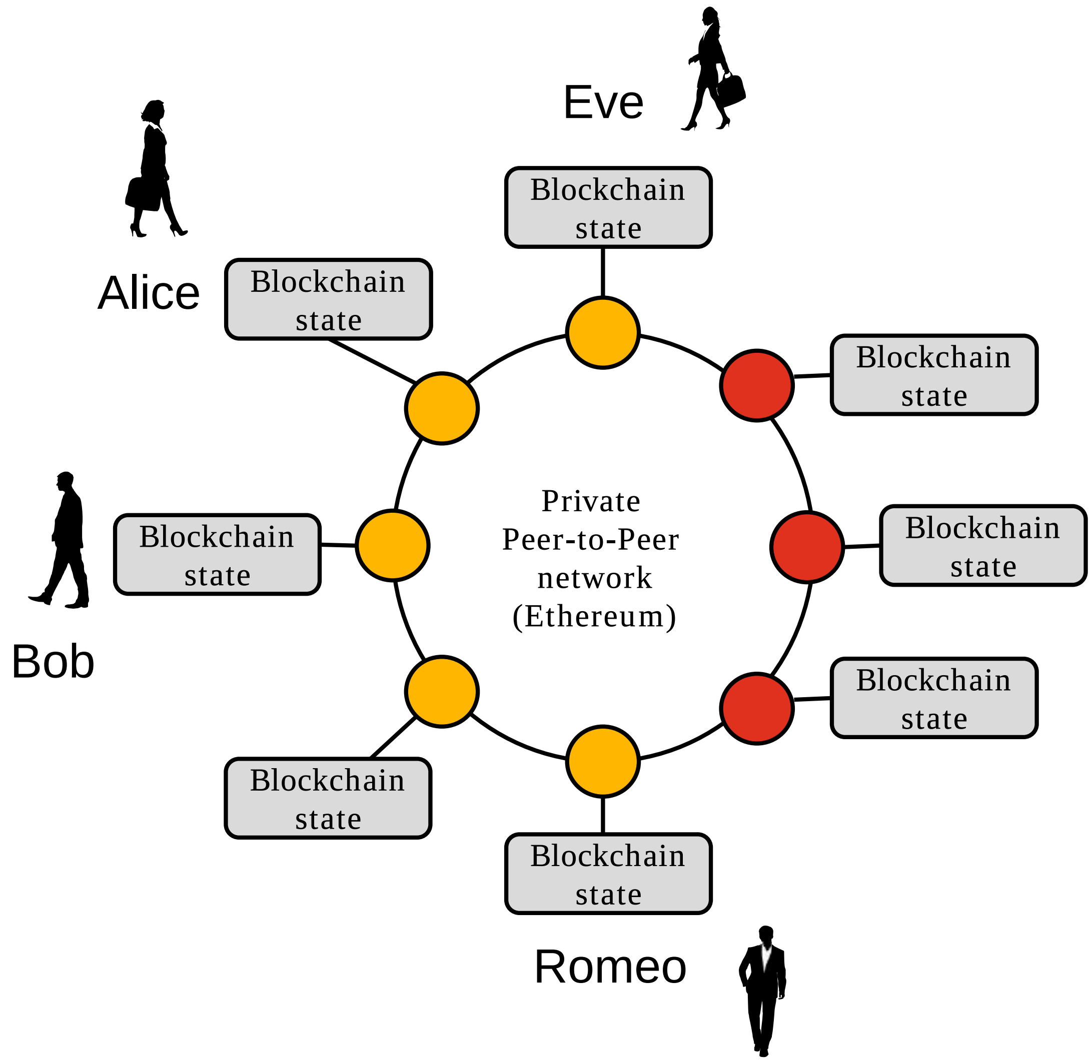
Every node can produce the compliance reports

Set-up of the demonstrator (conceptual)

Two types of nodes

Raspberry PI (Ethereum node, not mining)

Laptop (Ethereum node, mining)



Raspberry PI

Set-up of the demonstrator

Specific aspects:

Client requested to demonstrate cheap 25 € computers (Raspberry Pi's) could also run a node

However, these:

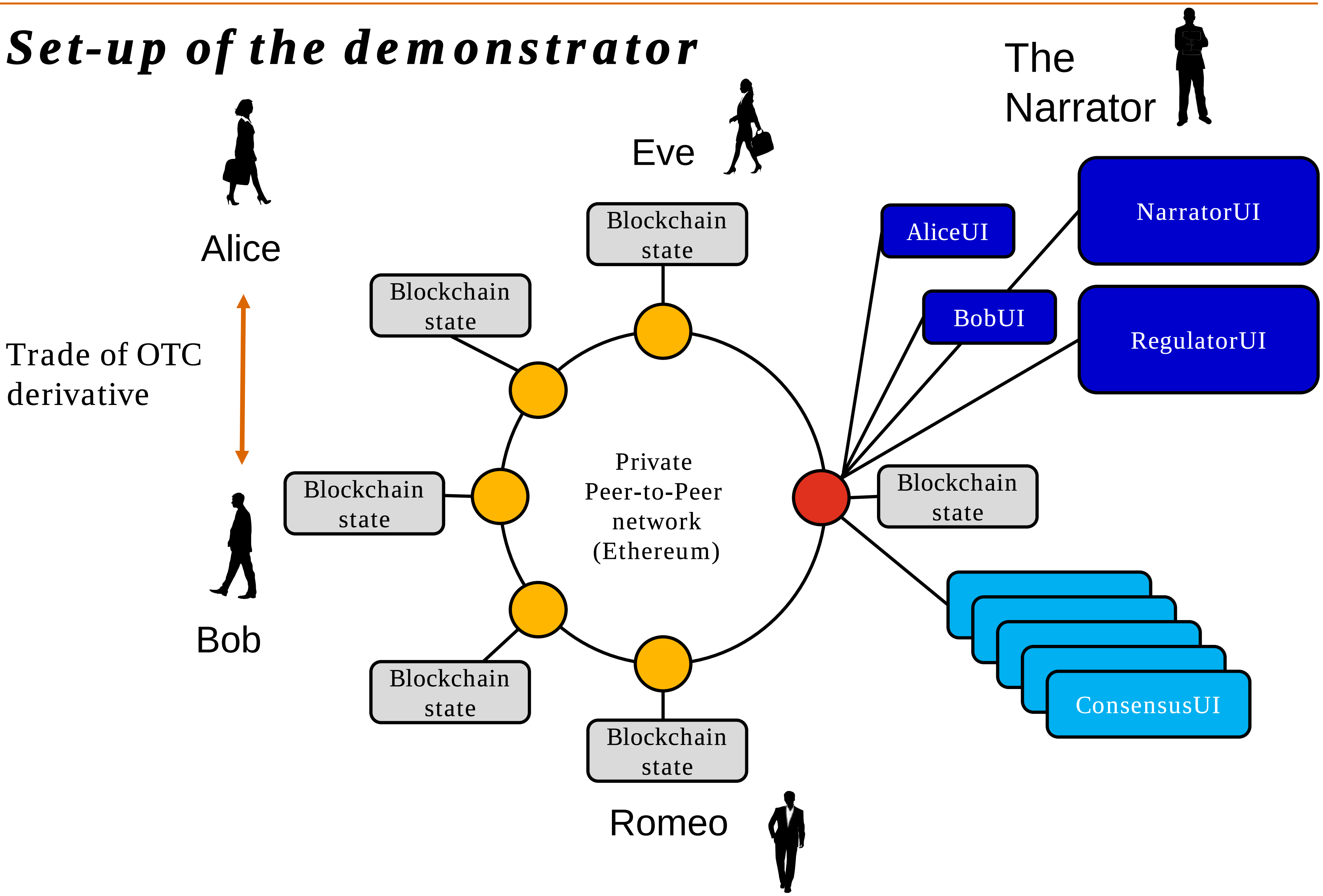
- Do not have a screen to run a user interface
- Do not have sufficient computing power to mine

As a consequence:

Standard off-the-shelve laptops were added to run the UI and do the mining

Furthermore, a dedicated user interface was developed to visualise the consensus

Set-up of the demonstrator



OTC Derivatives as smart contracts

A ‘Smart Contract’ is essentially a piece of software. It forms a contract capable of automatically enforcing itself, without a third party between individual participants. It is created and executed on the distributed ledger.

It contains the **contract logic**, the rules of what should happen at a certain point:

And it contains the **contract state**, in our case meaning interest rate, duration of the contract, nominal value, etc.

For this demonstrator we implemented two contracts:

- Bond (based on Actus PAM contract)
- Interest Rate Swap or IRS (based on Actus ‘Plain Vanilla‘ PVSWAP contract)

Bond

What	Implemented as
A bond is a **debt investment**	A Smart Contract type that can be created on the blockchain, each contract has its ContractID (CID)
in which an investor loans money to the issuer which borrows the funds,	RecordCreator (LEIRC) and Counterparty (LEICP), specifying a currency (CUR) and NotionalPrincipal (NT)
for a defined **period of time,**	MaturityDate (MD)
at **variable or fixed** interest rate,	e.g. National Nominal Interest Rate (IPNR)
paid at **specific dates,**	Cycle anchor date of interest payment (IPANX) and Cycle of interest payment (IPCL)
that **can be transferred** (sold) to another investor.	LEICP can be updated

Bond (extract only)

```
pragma solidity^0.4.9;
 contract PAM{
   enum currencies { EUR, USD, GBP, JPY }
   enum cycles {Y, H, Q, M, W, D}

   //Actus contract attributes
    string public CID; // ContractID
   string public LEIRC; // LegalEntityIDRecordCreator
   string public LEICP; // LegalEntityIDCounterparty
   uint128 public CDD; // ContractDealDate = unixtimestamp
   uint128 public IED; // InitialExchangeDate = unixtimestamp
   uint128 public MD; // MaturityDate = unixtimestamp
   uint128[2] NT; // NotionalPrincipal
   currencies public CUR; // Currency
   uint128[2] IPNR; // National Nominal Interest Rate
   string public IPDC; // Day Count Convention
   uint public IPANX; //cycle anchor date of interest payment = unixtim
   cycles public IPCL; // Cycle of interest payment
   uint128[2] IPCBA; // InterestCalculationBaseAmount
   uint256 public SD; // Status Date = unixtimestamp

//Actus state variables
   uint128[2] Nvl; // Nominal Value
   uint128[2] Nrt; // Nominal Rate
   uint public Led; // Last event Date = unixtimestamp

   //Operational variables
   bool public initialpaymentdone;
   int public interestpayments;
   bool public defaulted;
   bool public active;
   uint128 periodCounter; // the total number of periods that have passe

    .......
```

```
  .......

//Series of setter and getter functions
// Series of helper functions e.g. for conversions and handing of floats

function initialise(string _CID, string _LEIRC,
// idem for _LEICP, _IED, _MD, _NT, etc

 {periodCounter = 0;
      active = true;
      CID = _CID;
      LEIRC = _LEIRC;
      LEICP = _LEICP;
      IED = _IED; // initial payment day
      MD = _MD; // end date of the contract
      NT = _NT;
      CUR = currencies(_CUR);
      IPNR = _IPNR;
      IPDC = "30/360";
      IPANX = _IPANX;
      IPCL = cycles(_IPCL);
      IPCBA = _IPCBA;
      SD = now;

      Nvl = _NT;
      Nrt = _Nrt;
      Led = SD;
  }

  // advance the period with 1
  function nextPeriod() constant returns (bool){
                    Led = SD;
                    SD = now;
                    periodCounter += 1;
  }

  function setDefault(){
     defaulted = true;
  }
}
```

Swap

What	Implemented as
A swap is a transaction between two parties	A Smart Contract type that can be created on the blockchain, each contract has its ContractID (CID) Parties are the RecordCreator (LEIRC) and Counterparty (LEICP),
These two parties agree to exchange cash flows in the future	Agreeing on the value for the swap, coded in nominalValue Agreeing on fixed parameters, coded in: fixedRate (interest rate) and fixedPayout (value), Agreeging on variable parameters, coded in variableRate (interest rate) and variablePayout (value)
They agree about the specific dates when the cash flows are to be paid	There is a start date SD, and a maturity date MD There is a constant defined that specifies the periods per year, PPY = 4, and a counter maintaining the contract's period
that **can be transferred** (sold) to another investor.	LEICP can be updated

Swap (extract only)

```
pragma solidity^0.4.9;
 contract PAM{
   enum currencies { EUR, USD, GBP, JPY }
   enum cycles {Y, H, Q, M, W, D}

  //Actus contract attributes
   //Actus state variables
  //Operational variables

  // Getter, setter and helper functions ....

 function nextPeriod() returns (int128){

      periodCounter += 1;

      fixedPayout =    [(((nominalValue[0])*fixedRate)/100) / 4,nominalValue[1]];

      variablePayout = [(((nominalValue[0])*variableRate)/100)/4,nominalValue[1]];

      payoutValue = [(fixedPayout[0]/fixedPayout[1]) - (variablePayout[0] / variablePayout[1]),1];

  }

    .......
```

Set-up of the demonstrator

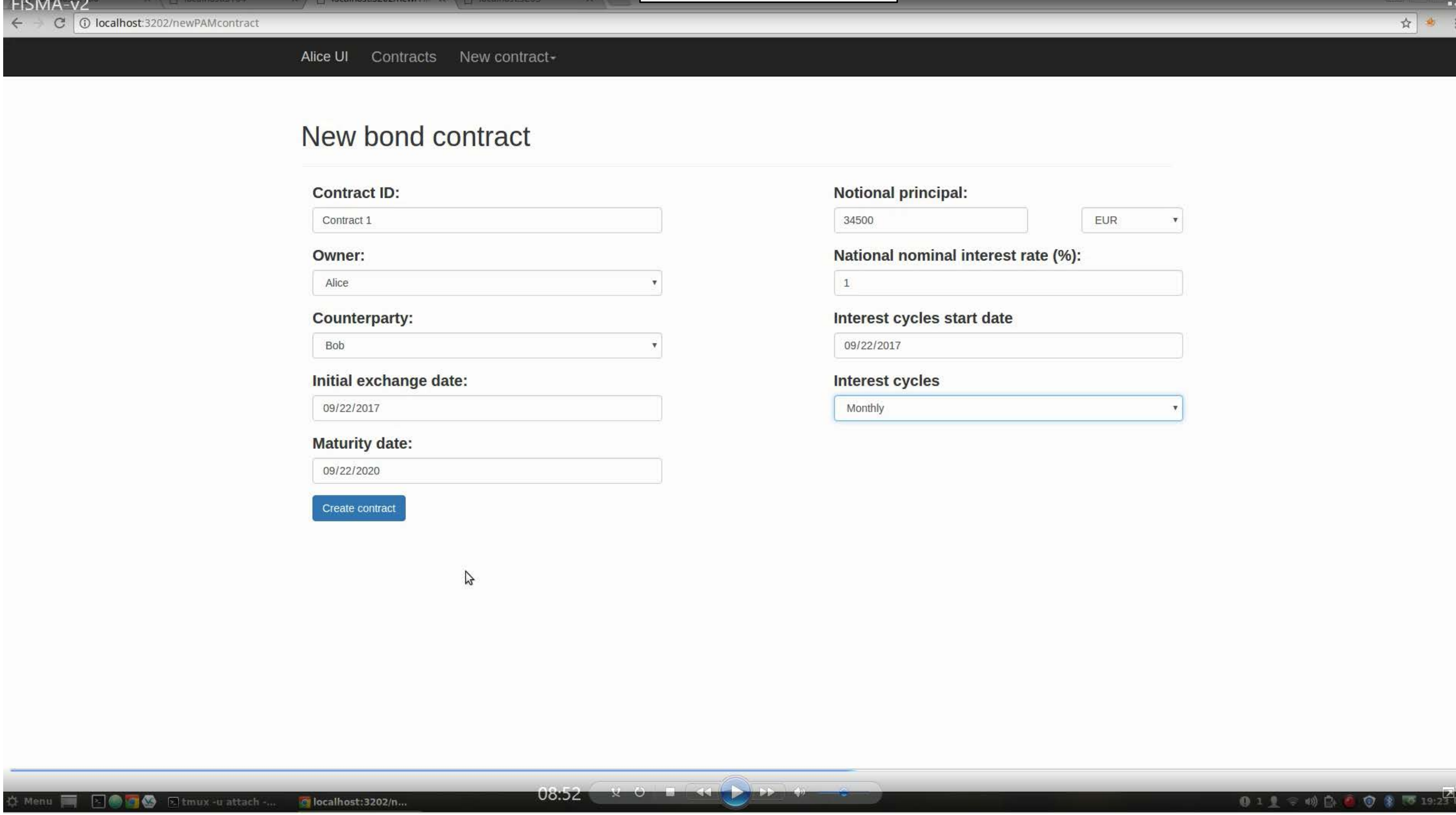
Actors:

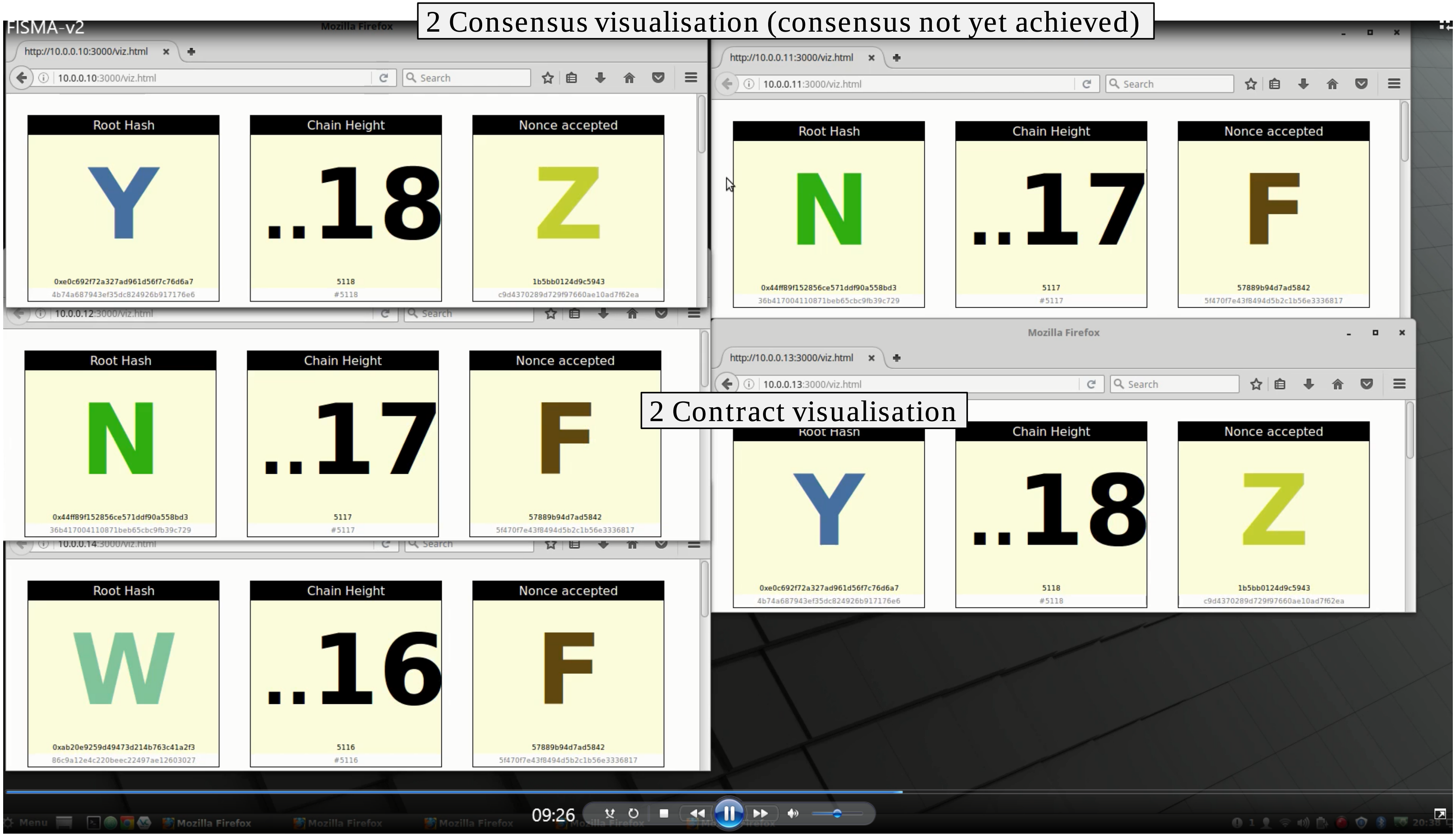
- **Alice**, **Bob** and **Eve** are contracting parties, using their respective *AliceUI* and *BobUI* (UI: UserInterface)
- **Romeo**, party with the reporting application, using the *RegulatorUI*
- **The Narrator**, tells the stories, uses the *NarratorUI*
  - Story 1: Bond, where Alice lends money to Bob and later merges with Eve to form AliceEve
  - Story 2: Interest Rate Swap, where Bob creates contract towards AliceEve and creates a new 'PlainVanillaSwap' (PVSWAP) contract with her
  - Story 3: AliceEve defaults on the PVSWAP contract
  - Showing the contents of the DLT, generating reports (EMIR, MIFIR, COREP) and demonstrating consensus takes place during the stories

Demonstrator Story 1: Bond

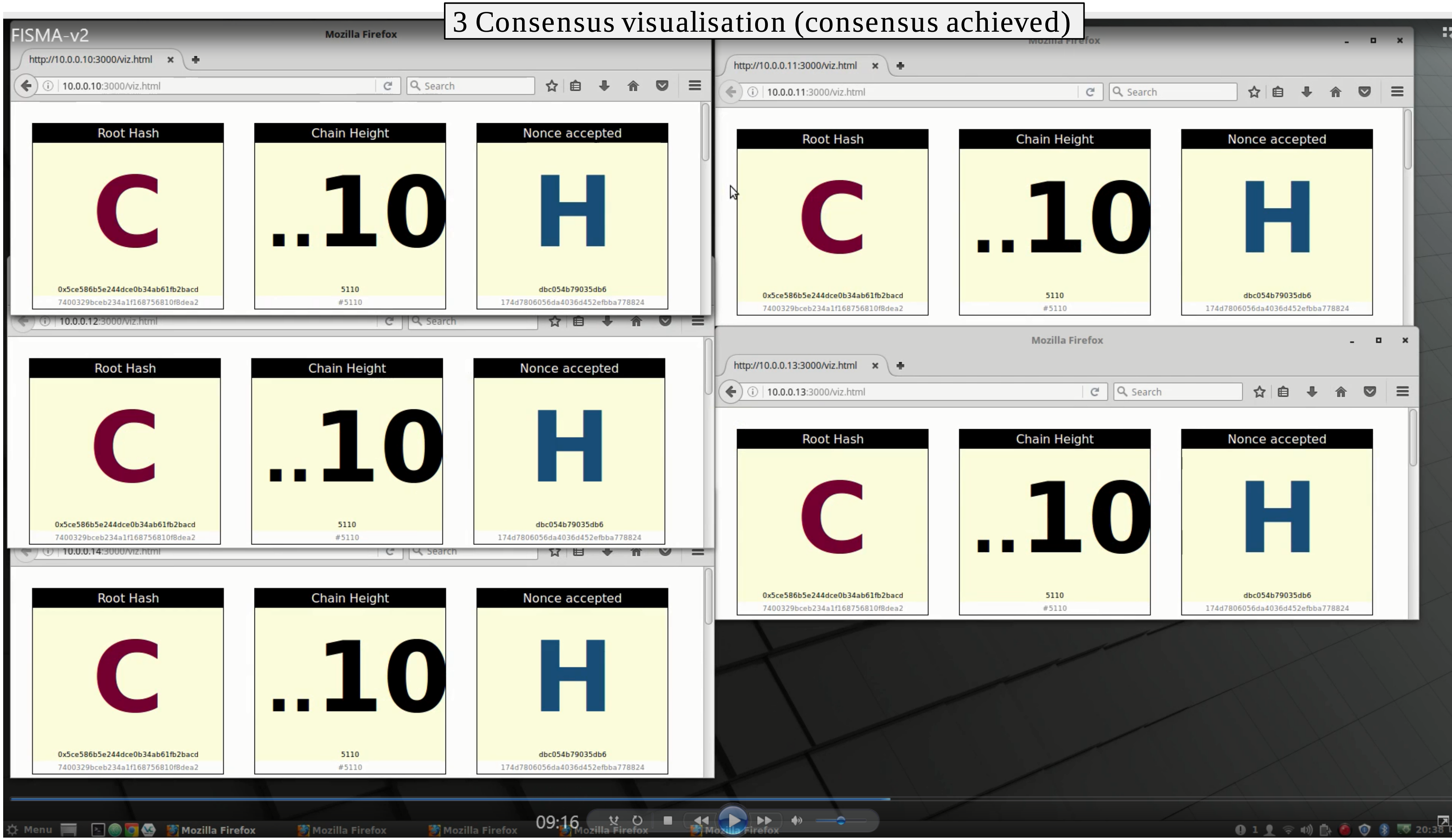
- In this story, Alice and Bob conclude a bond contract.
- On the blockchain a digital doppelgänger of this contract is created, and through consensus this appears in each node
- The Narrator simulates that time is advanced to the next quarter
- Romeo generates a regulatory report, a COREP report
  - All data available on-chain according ACTUS semantics
  - Hence all calculations can be performed in real-time
  - And report is available immediately

1 Contract creation

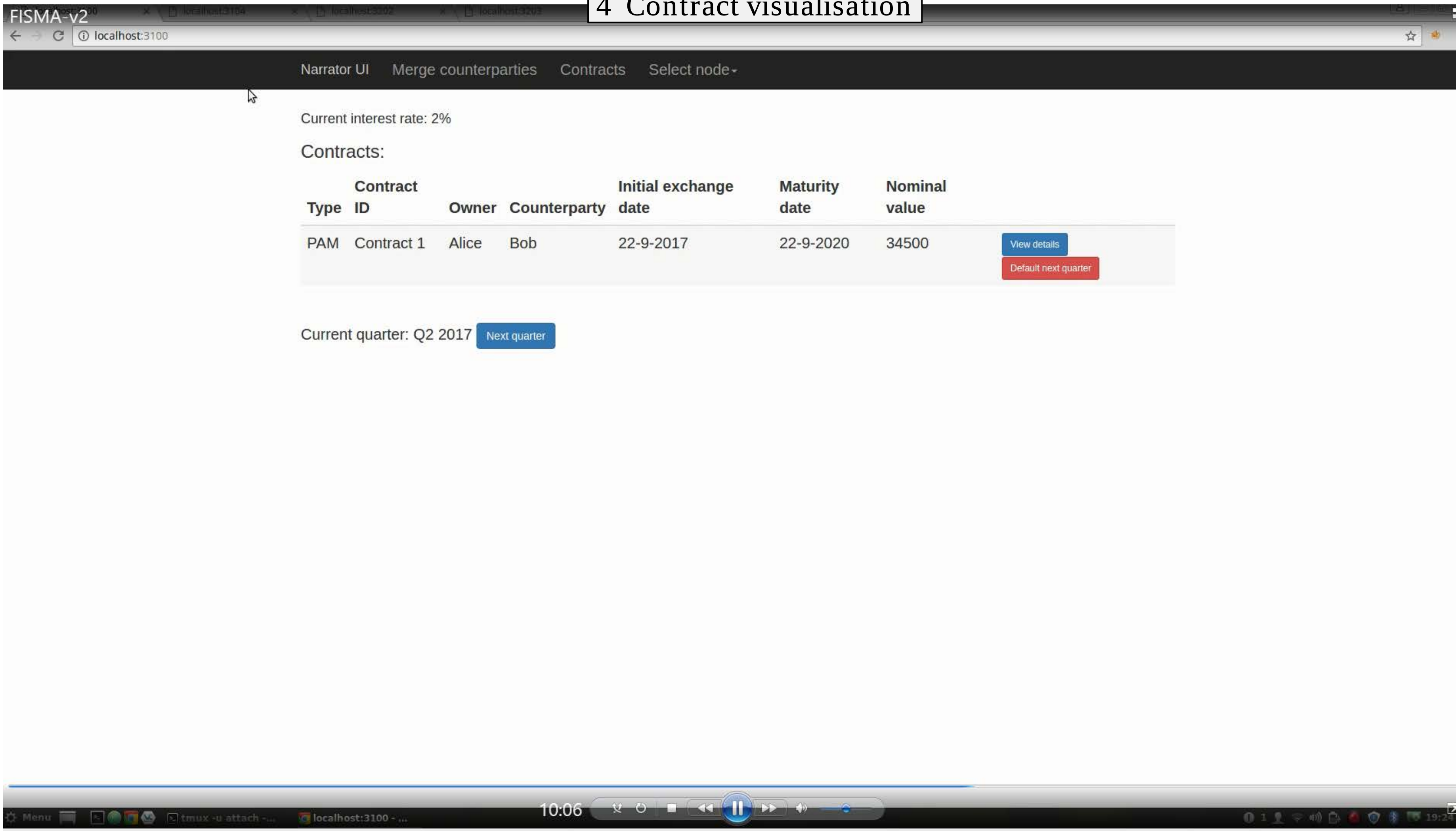



2 Consensus visualisation (consensus not yet achieved)
2 Contract visualisation
FISMA-v2
Mozilla Firefox
http://10.0.0.10:3000/viz.html
http://10.0.0.11:3000/viz.html
http://10.0.0.13:3000/viz.html
Root Hash
Chain Height
Nonce accepted
Y
..18
Z
N
..17
F
W
..16
09:26

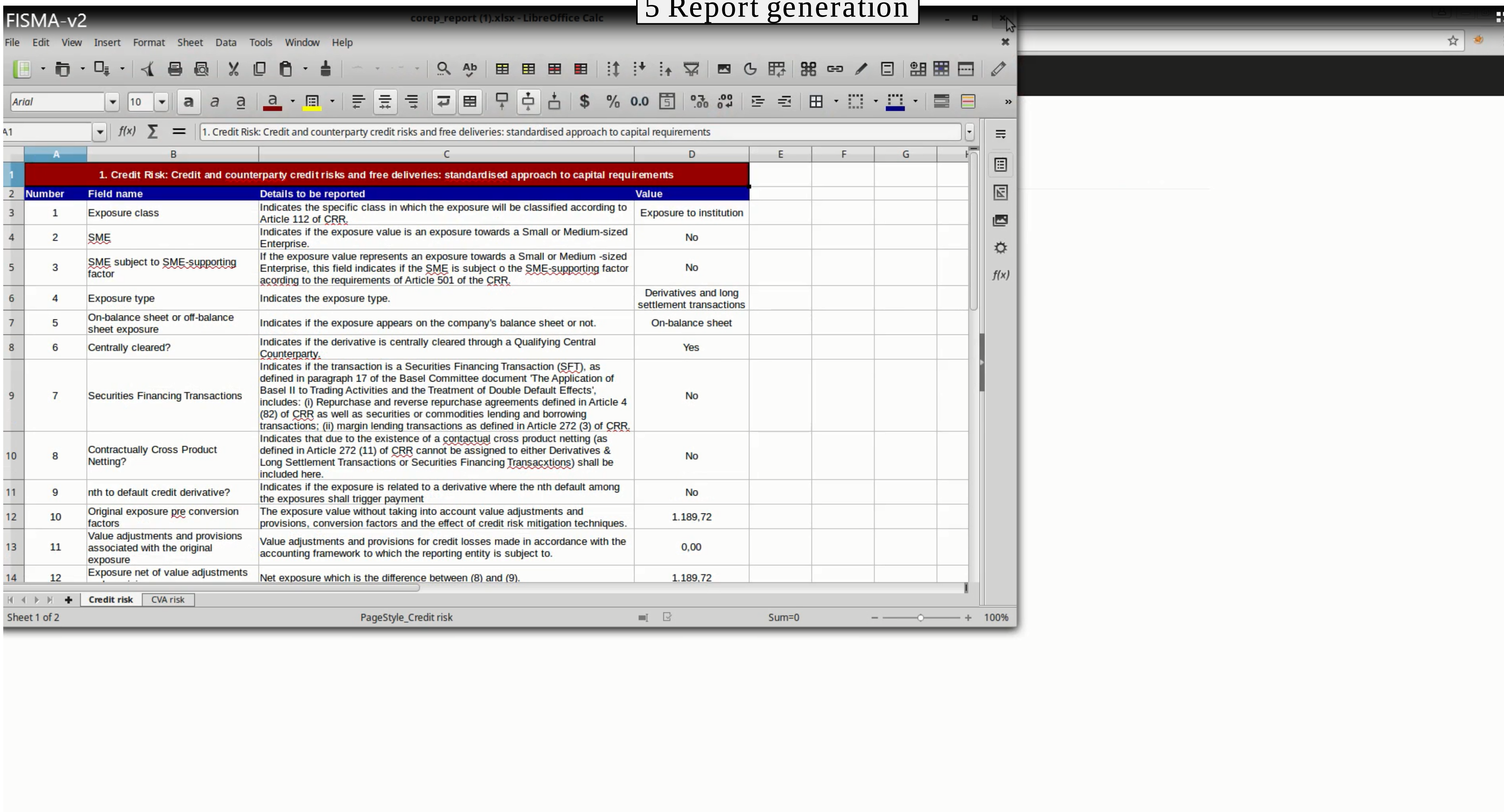
3 Consensus visualisation (consensus achieved)



4 Contract visualisation



5 Report generation



1. Credit Risk: Credit and counterparty credit risks and free deliveries: standardised approach to capital requirements			
Number	Field name	Details to be reported	Value
1	Exposure class	Indicates the specific class in which the exposure will be classified according to Article 112 of CRR.	Exposure to institution
2	SME	Indicates if the exposure value is an exposure towards a Small or Medium-sized Enterprise.	No
3	SME subject to SME-supporting factor	If the exposure value represents an exposure towards a Small or Medium -sized Enterprise, this field indicates if the SME is subject o the SME-supporting factor acording to the requirements of Article 501 of the CRR.	No
4	Exposure type	Indicates the exposure type.	Derivatives and long settlement transactions
5	On-balance sheet or off-balance sheet exposure	Indicates if the exposure appears on the company's balance sheet or not.	On-balance sheet
6	Centrally cleared?	Indicates if the derivative is centrally cleared through a Qualifying Central Counterparty.	Yes
7	Securities Financing Transactions	Indicates if the transaction is a Securities Financing Transaction (SFT), as defined in paragraph 17 of the Basel Committee document 'The Application of Basel II to Trading Activities and the Treatment of Double Default Effects', includes: (i) Repurchase and reverse repurchase agreements defined in Article 4 (82) of CRR as well as securities or commodities lending and borrowing transactions; (ii) margin lending transactions as defined in Article 272 (3) of CRR.	No
8	Contractually Cross Product Netting?	Indicates that due to the existence of a contactual cross product netting (as defined in Article 272 (11) of CRR cannot be assigned to either Derivatives & Long Settlement Transactions or Securities Financing Transacxtions) shall be included here.	No
9	nth to default credit derivative?	Indicates if the exposure is related to a derivative where the nth default among the exposures shall trigger payment	No
10	Original exposure pre conversion factors	The exposure value without taking into account value adjustments and provisions, conversion factors and the effect of credit risk mitigation techniques.	1.189,72
11	Value adjustments and provisions associated with the original exposure	Value adjustments and provisions for credit losses made in accordance with the accounting framework to which the reporting entity is subject to.	0,00
12	Exposure net of value adjustments	Net exposure which is the difference between (8) and (9).	1.189,72

Demonstrator constraints

In the current demonstrator implementation:

- In the current set-up of the demonstrator, for simplification reasons, contracting information is reflected in the DLT, and all participants have access to it (may not be desirable for a production system)
- The contracting which takes place between parties is supposed to take place outside the blockchain universe (via phone or via another application)
- Only these contracts are then created on the blockchain
- The identities of the parties is not cryptographically confirmed (production system would do this e.g. with electronic authentication)
- The identity and state of the parties (e.g. legal entity definition, identity attributes, defaulted or not) is not maintained on the blockchain
- The authenticity of the contract itself is not cryptographically confirmed (production system would do this e.g. with electronic signatures)
- Valuation is done within the reporting application, taking into account the data on the blockchain as well as external data (currently hardcoded)

Further references

Open access publication describing the demonstrator in detail at https://zenodo.org/record/884497#.W4zoTLhLeUn

A movie of the demonstrator in action is available at https://www.pwc.be/fismablockchain

ACTUS: http://actusfrf.org

Also:

http://www.pwc.be/blockchain

http://www.marcsel.eu