ABCDE, an Agile Method to Specify and Design Blockchain Applications

Michele Marchesi

Dept. of Mathematics & Computer Science

University of Cagliari

Blockchain

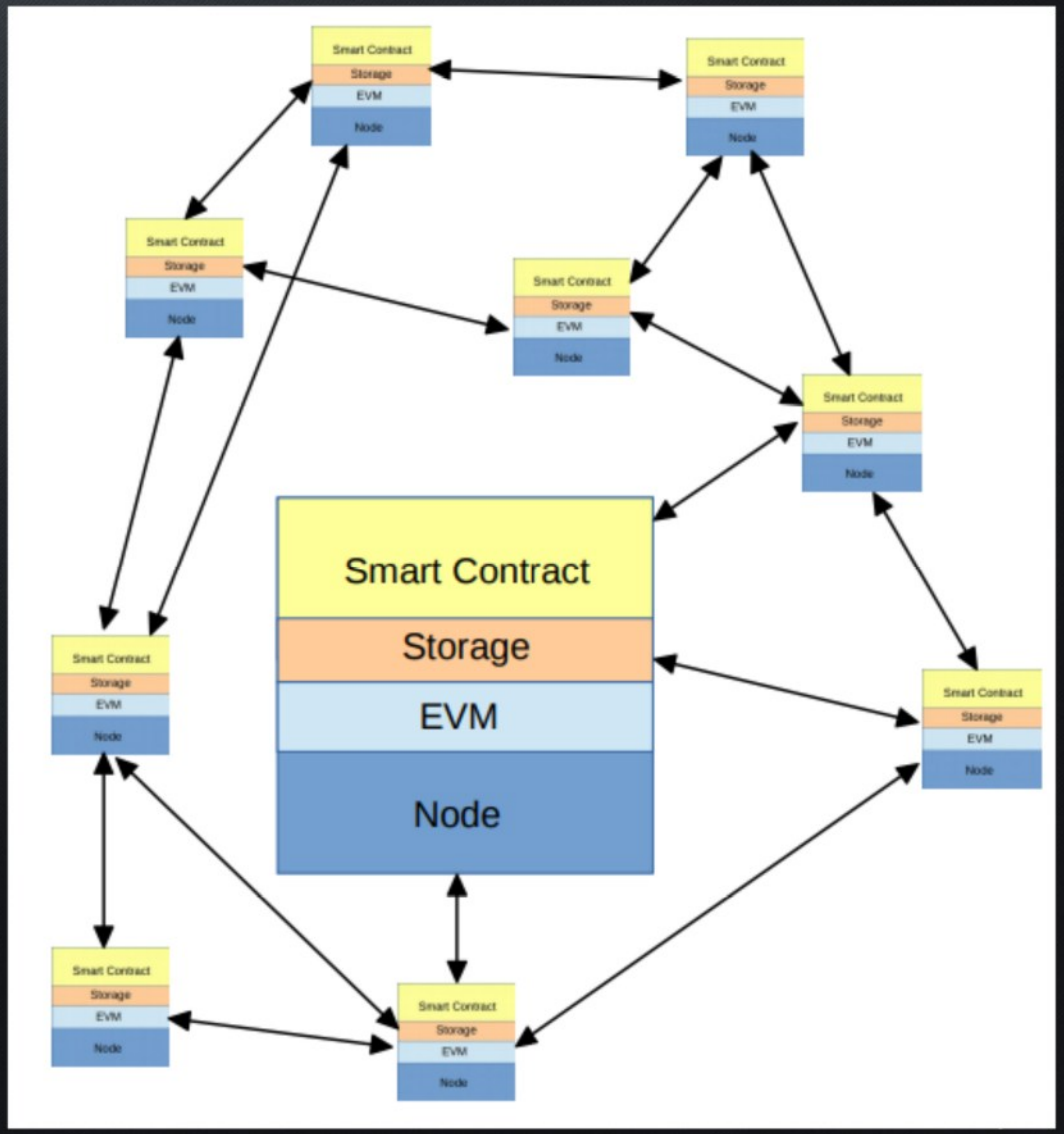
- The Blockchain is a technology whose first application was to run the Bitcoin cryptocurrency in a decentralized and secure way

- It is a distributed data structure characterized by:

  - data redundancy
  - check of transaction requirements before validation
  - recording of transactions in sequentially ordered blocks
  - ownership based on public-key cryptography
  - immutability
  - a transaction scripting language, associated to the transactions – the corresponding program is executed by all nodes

Smart Contracts (SC)

- The software associated to transactions and running on the Blockchain
- The SC run in every node
- **All executions must produce the same result**
- The calls and the storage modifications are recorded
- A SC cannot access any device or network
- The figure outlines the **Ethereum** approach for SC



Software Engineering for dApps

- In the past few years, there has been a strong increase of interest in cryptocurrencies, in Blockchain applications and in Smart Contracts
- This led to a huge inflow of money and of startup ideas
- Many projects were born and quickly developed software
- The scenario is that of **a rush to be the first on the market**, fearing of missing out
- This **unruled and hurried** software development does not assure neither software quality, nor that the basic concepts of software engineering are taken into account

Goals

- We propose **ABCDE – Agile BlockChain Dapp Engineering,** a software development process to:
  - Gather the requirements
  - Analyze, Design
  - Develop, Test
  - Deploy **Blockchain applications**
- The process is based on **Agile practices**
- It makes also use of **more formal notations**, modified to represent specific concepts found in Blockchain development

The case for Agile

- Agile methods are suited to develop systems whose requirements are not completely understood, or tend to change. These characteristics are present in dApps:
  - dApps are typically very innovative applications;
  - often, there is a run to write a dApp to be the first who launches it on the market.
- Most dApp teams are small, self-organizing, with experts in the system requirements highly available to the team.
- Agile is iterative and incremental with short iterations, and is suited to deliver quickly and to deliver often – which is very appreciated in the context of dApp development.

The case for traditional SE

- dApps have very strict security requirements, and a more formal approach with respect to some aspects of the development could be useful.
- Some key factors in SC design are:
  - **Data**: permanent data are very expensive, so they must be well designed and kept to a minimum.
  - **Interactions**: they are key to system proper behavior, and the source of all attacks.
  - **Security**: in a public blockchain, if there is a possible exploit, it will be exploited!

ABCDE — Main Steps

- Steps 1-3: Gather requirements (**without assuming the use of a blockchain**)
- Step 4: Divide the system in **two subsystems**:
  - Step 5: the **blockchain** system (SC)
  - Step 6: the **external** system (server, client, GUI)
- Step 7: **Test** the two subsystems
- Step 8: Integrate and deploy

Steps 1 and 2

1. **Define** in one or two sentences **the goal of the system**. For instance: *To create a simple crowfunding system, managing various projects that can be financed using Ethers*

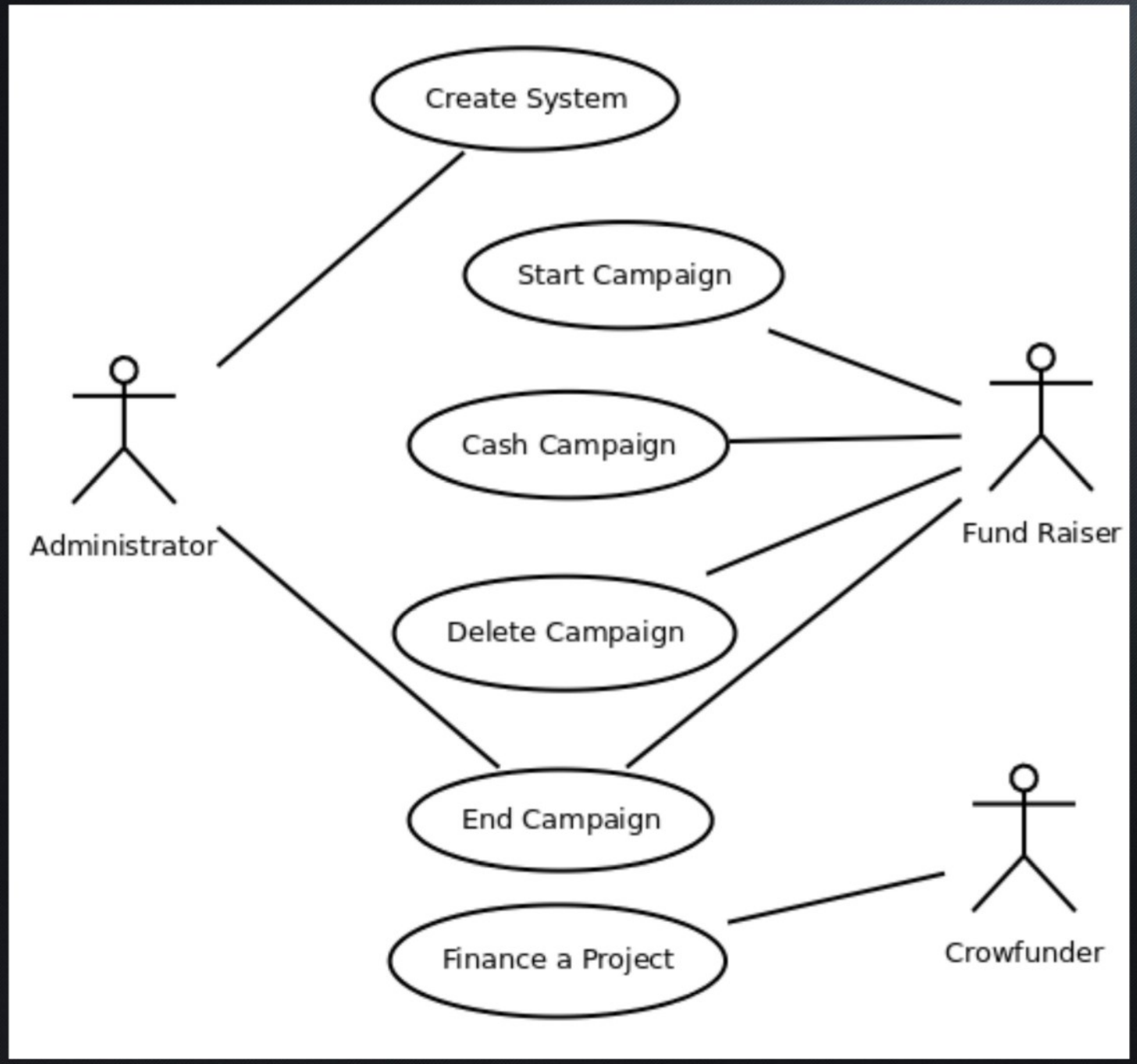
2. **Identify the actors** (human and external systems/devices). For instance:
   1. ***System Administrator***: *s/he accepts the projects and their property; takes action in the case of problems*
   2. ***Fund Raiser***: *they give the crowfunding project data, including the address receiving the money*
   3. ***Crowfunder***: *they finance projects sending Ethers*

Step 3 – User Stories

- Write the system requirements in term of **user stories** or features:
  - ***Create System***: The Administrator creates the contract, that register his address
  - ***Start Campaign***: A Fund Raiser activates a CF project, giving its data: soft and hard cap, end date, address where to send money to
  - ***Cash Campaign***: The Fund Raiser, if the time of the CF has expired, or if the hard cap has been reached, cashes out the Ethers given to the project

Step 3 – User Stories (cont.d)

- ***Delete Campaign***: The Fund Raiser cancels the project; the Ethers are given back to Crowfunders
- ***End Campaign***: The Administrator, or the Fund Raiser, if the time of the CF has expired and the soft cap has not been reached, ends the project; the Ethers are given back to Crowfunders
- ***Finance a Project***: a Crowfunders sends Ethers to a project

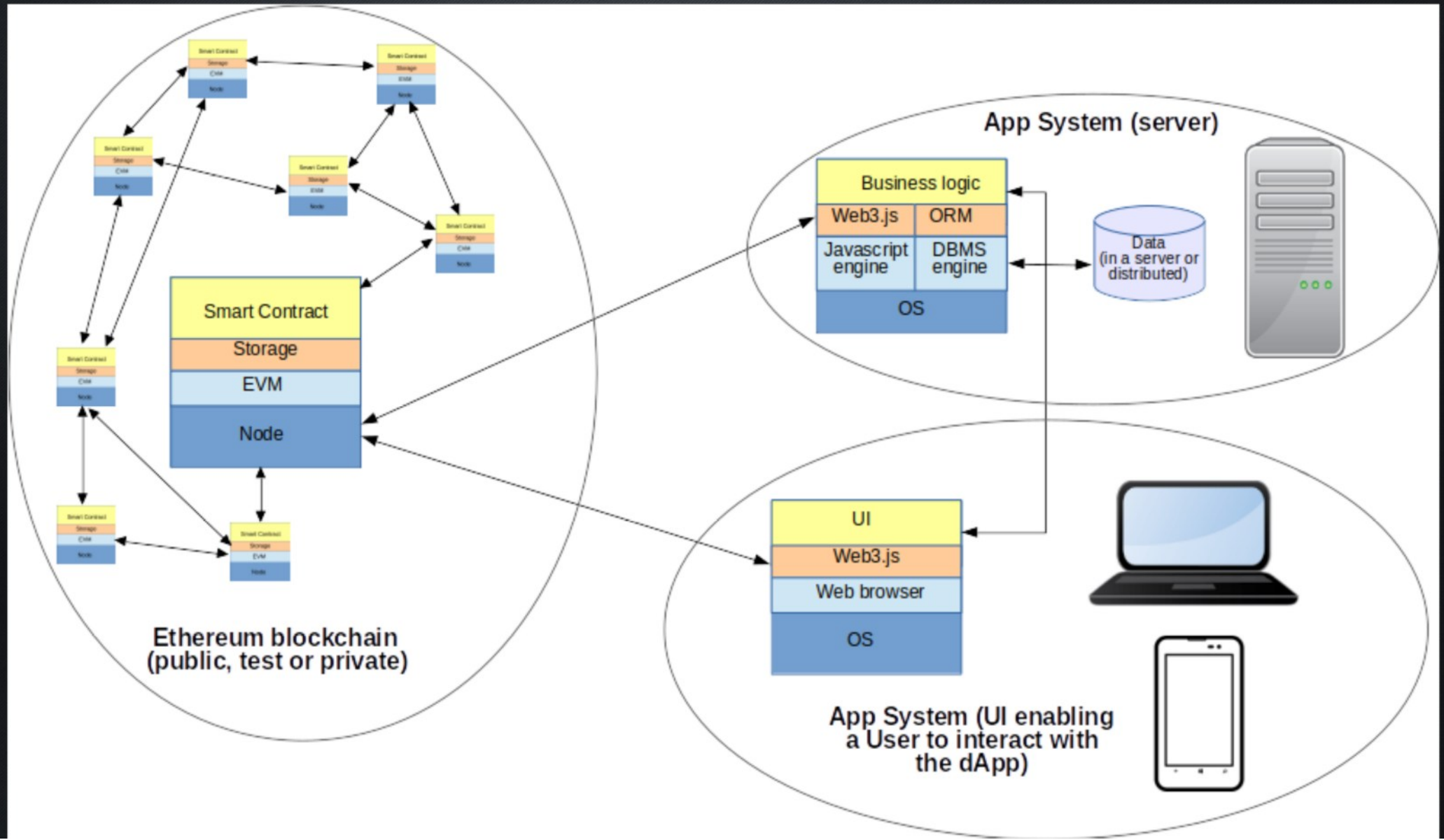


UML Use Case Diagram (with User Stories in place of Use Cases)

Step 4 - Divide into SC system and external system

- Divide the system in two separate systems:
  - The Blockchain system, composed by the SCs
  - The external system that interacts with the first, sending transactions to the Blockchain and receiving the results
- The SC system interacts with the outside **exclusively through blockchain transactions**.
  - It has actors, recognized by the respective address
  - It can use libraries and external contracts
  - It can generate transactions to other contracts, or can send Ethers
- The client / server system is the one described in the previous steps
  - **But it adds the interface to the SCs**

A Typical dApp Architecture



Step 5 - Design of the SC subsystem

- **Redefine** the actors and the user stories
- Define the **decomposition** in SCs (one or more)
- For each SC, define the structure, the flow of messages and Ether transfers, the state diagram (if needed), the data structure, the external interface (ABI), the events, the modifiers...
- Define the tests and the **security assessment practices**

Specific stereotypes of UML class diagram describing SCs

Stereotype	Position	Description
<<contract>>	Class symbol – upper compartment	Denotes a SC
<<library contract>>	Same as above	A contract taken from some (standard) library
<<struct>>	Same as above	A struct, holding data but no operation, defined and used in the data structure of a contract
<<enum>>	Same as above	A struct holding just a list of possible values
<<interface>>	Same as above	A contract holding only function declarations
<<modifier>>	Class symbol – lower compartment	A particular kind of function, defined in Solidity
<<array>>	Role of an association	The 1:n relationship is implemented using an array
<<mapping>>	Same as above	The 1:n relationship is implemented using a mapping
<<mapping[uint]>>	Same as above	The 1:n relationship is implemented using a mapping from integer to the value

Specific stereotypes of UML sequence diagram describing interactions

Stereotype	Description
<<person>>	A human role, sending messages using a wallet or other application
<<system>>	An external system, able to send messages to the blockchain
<<device>>	A device, typically IoT, able to send messages
<<contract>>	A SC, part of the system or external to it
<<oracle>>	A particular kind if SC, whose data are written by a trusted third party, and allows to access information about the external world
<<account>>	An Ethereum account, just holding Ethers. It can only receive Ethers or send Ethers to another account or SC if the owner activates the transfer

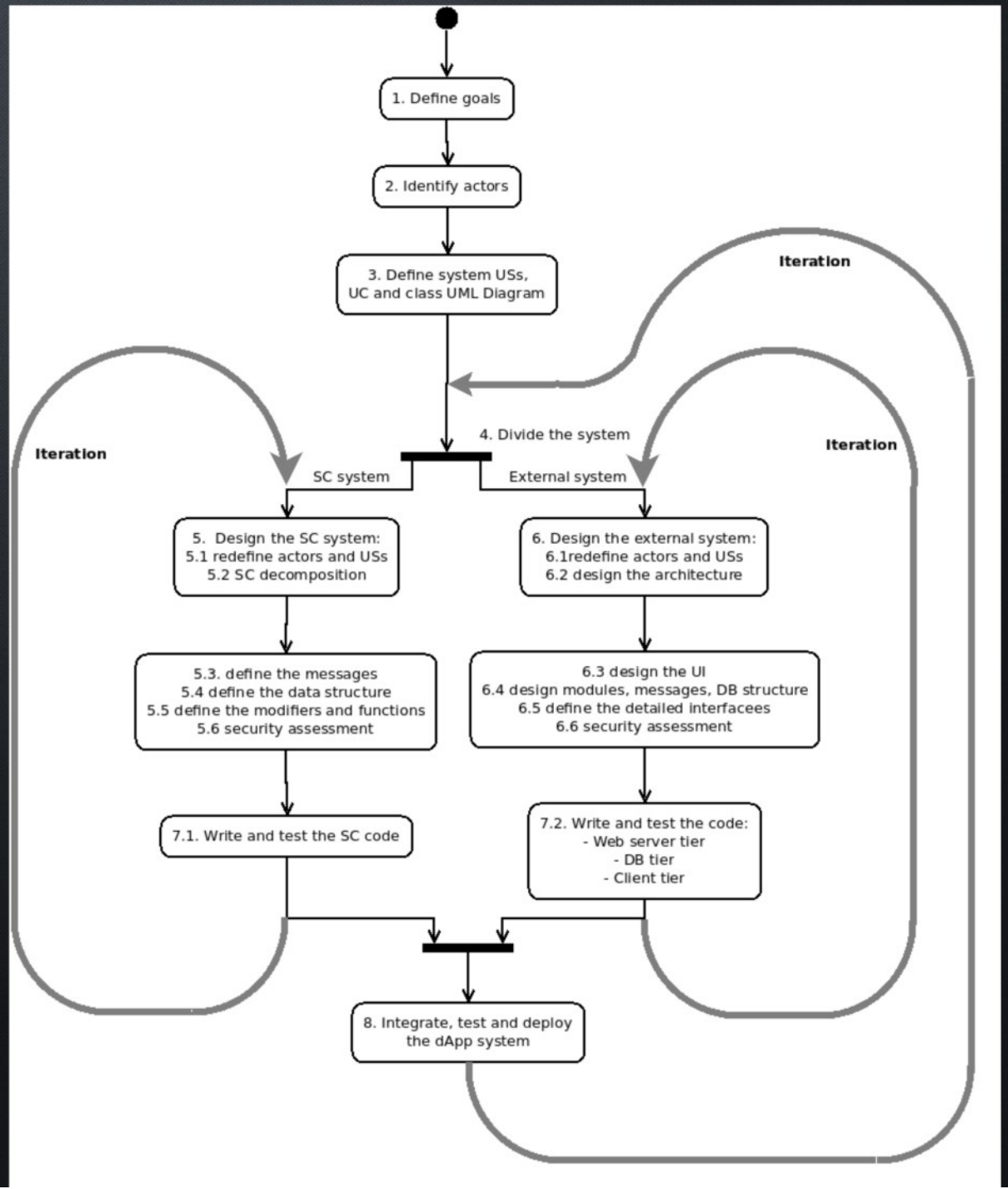
Step 6 – Design of the external subsystem

- Redefine the actors and the user stories, adding the new (passive) actors represented by the SCs
- Decide the architecture of the system
- Define the decomposition in modules, and their interfaces
- Define the User Interface of the relevant modules
- Perform a detailed design of the subsystem
- Perform a security assessment

ABCDE – Steps 7 and 8

7. Code and test the systems; in parallel and **using iterations**:
   - Write and test the SCs, starting from their data structure and functions;
   - Implement the USs of external subsystem with an agile approach (Scrum, maybe Kanban);
8. Integrate, test and deploy the overall system, every 3-4 iterations.

ABCDE – Overall View



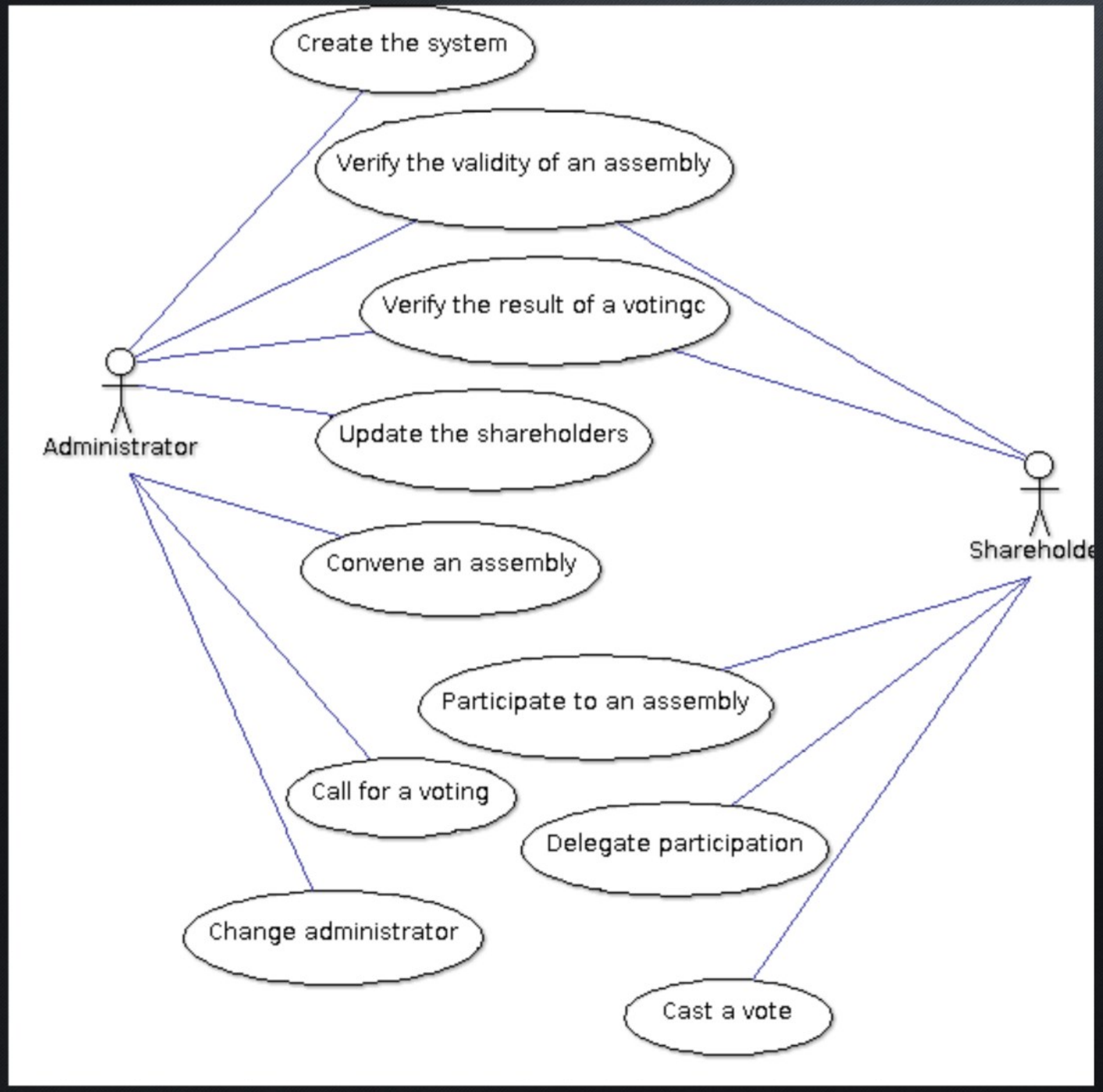
A Case Study: Corporate voting management

1. GOAL OF THE SYSTEM:

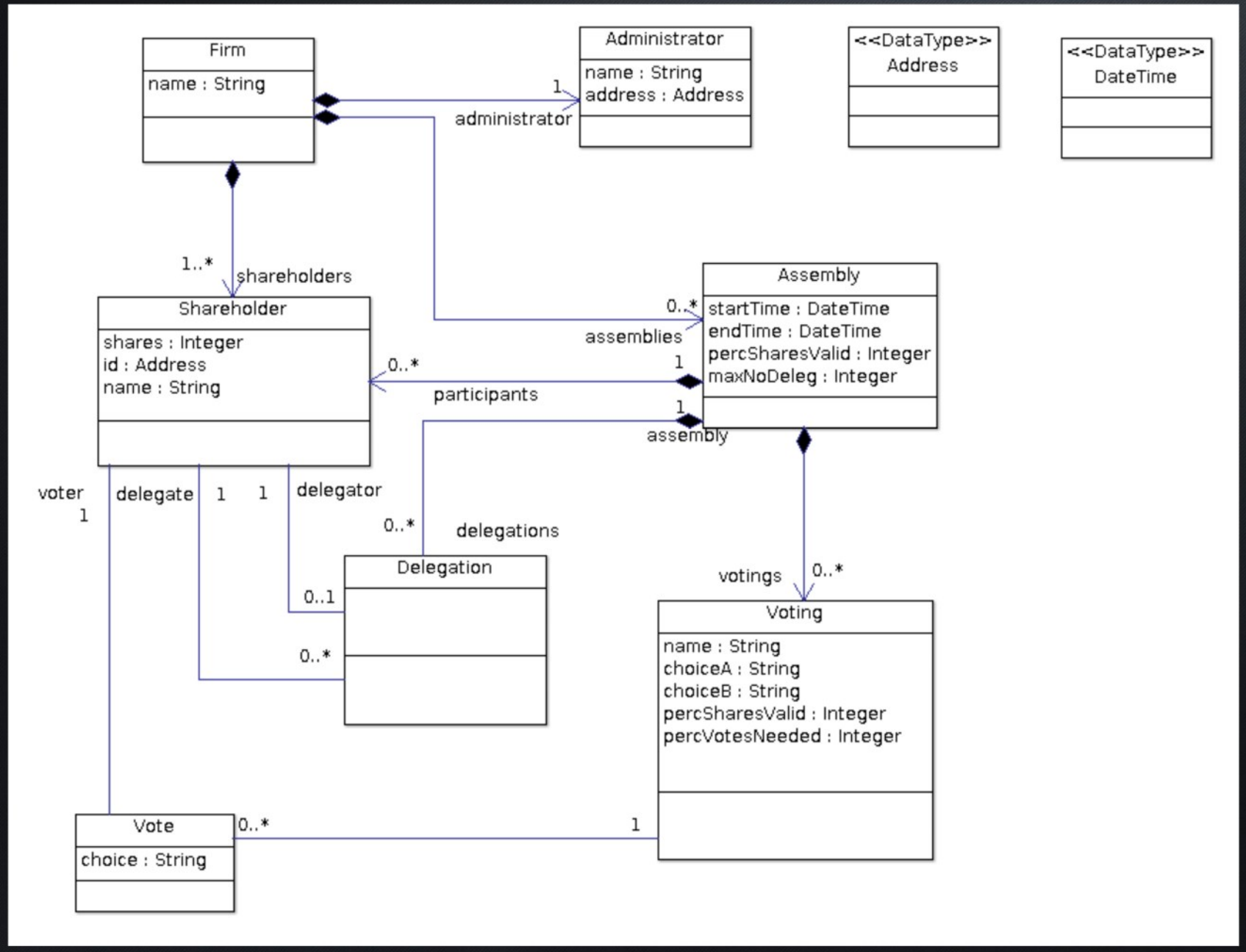
- To manage in a simplified way voting in corporate assemblies

2. IDENTIFY ACTORS:

- **Corporate administrator**: manages the system, manages the shareholders and their shares, convenes assemblies, calls for votings
- **Shareholder**: participates to assemblies, casts his votes, delegates participation to assemblies



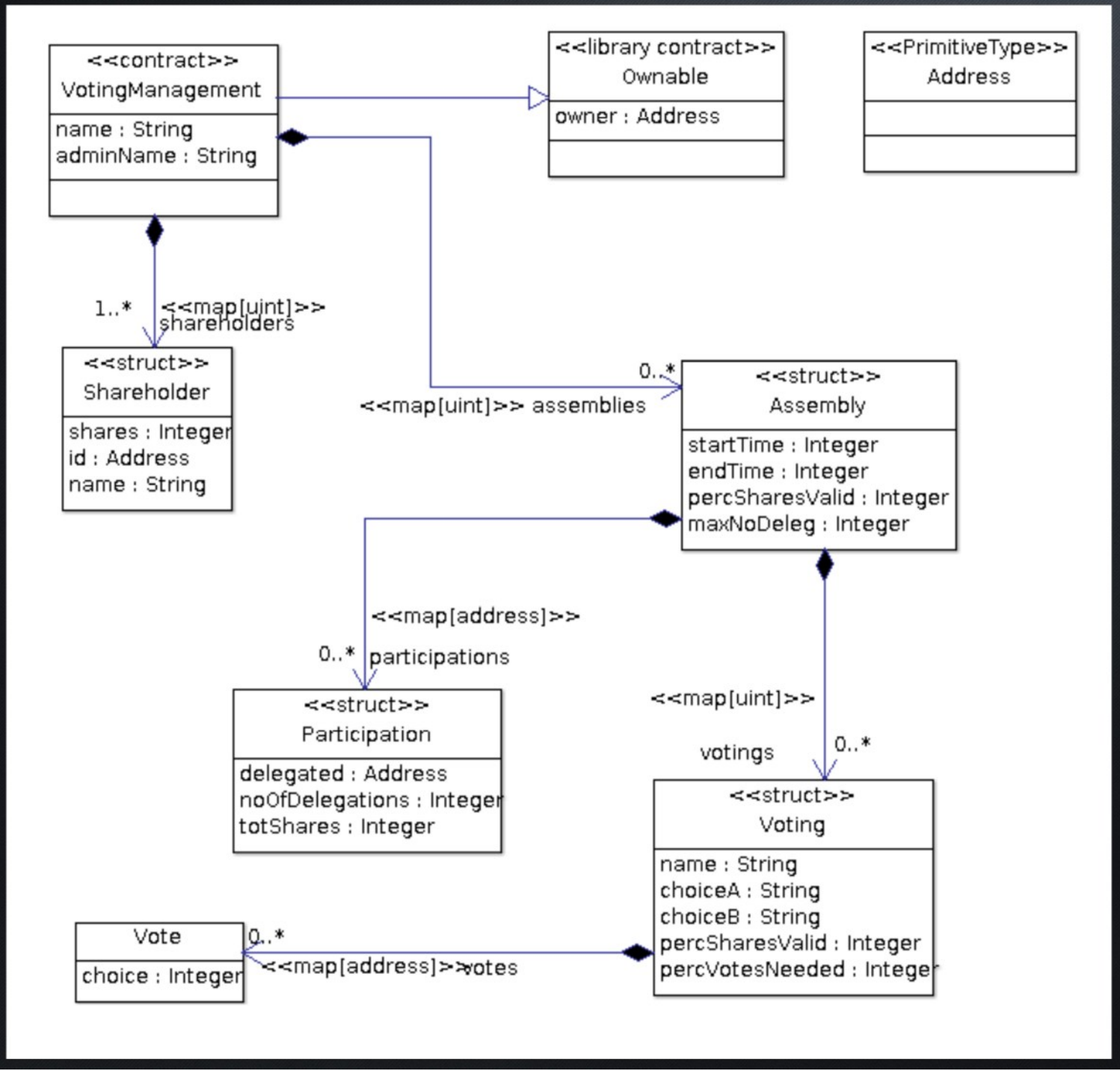
Step 3. User Stories



Step 3. The data structure representing this system, shown using a UML class diagram

Step 4. Divide the system

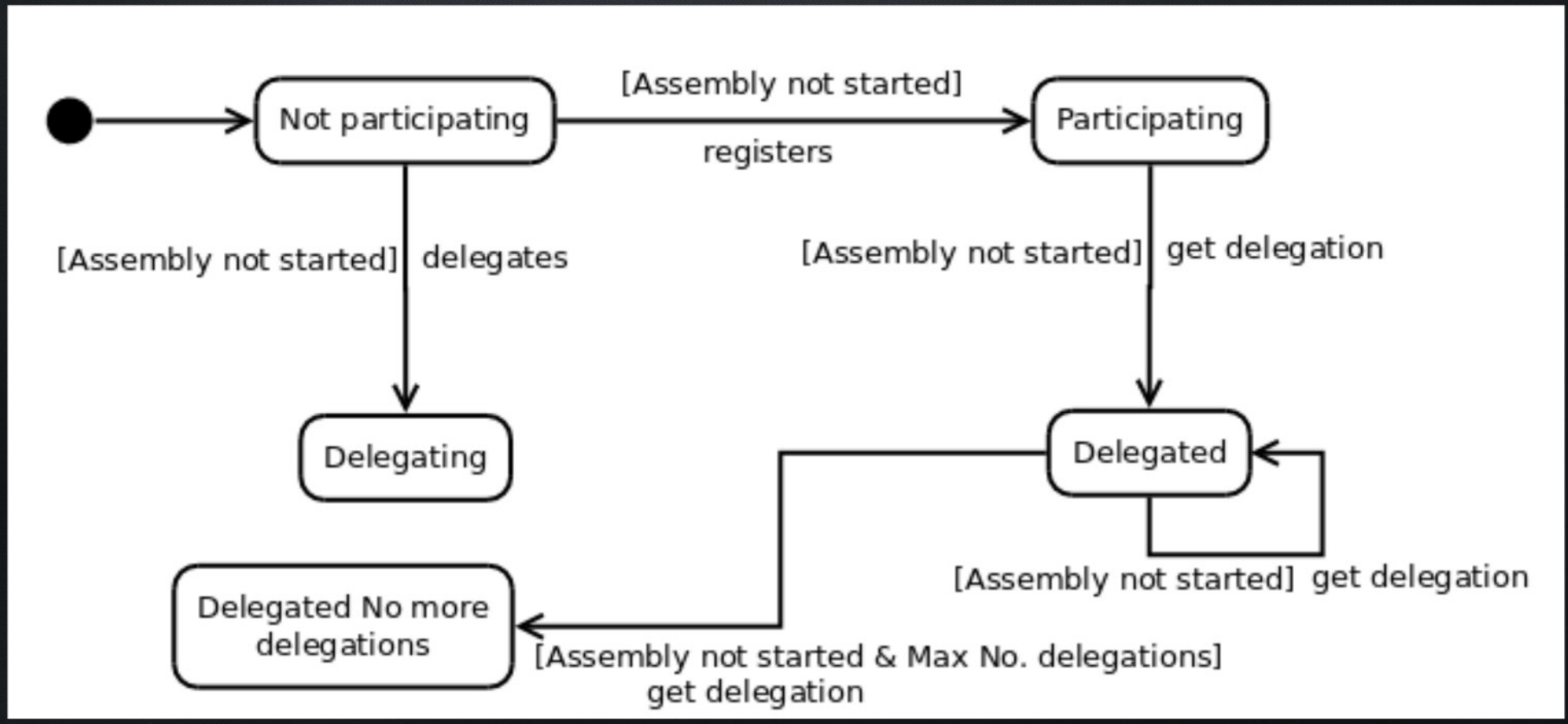
- In this case the subdivision is trivial, because all US make use of Smart Contracts.
- The DApp subsystem US are the same. Each includes the Blockchain as further Actor.
- The Blockchain subsystem US are the same. The identifiers of the Actors are their unique adresses:
  - **Corporate administrator**: her/his address is at first the address that creates the contract, and then possibily a further address set by the *Change administrator* US
  - **Shareholder**: their addresses are specified and managed by the Administrator.



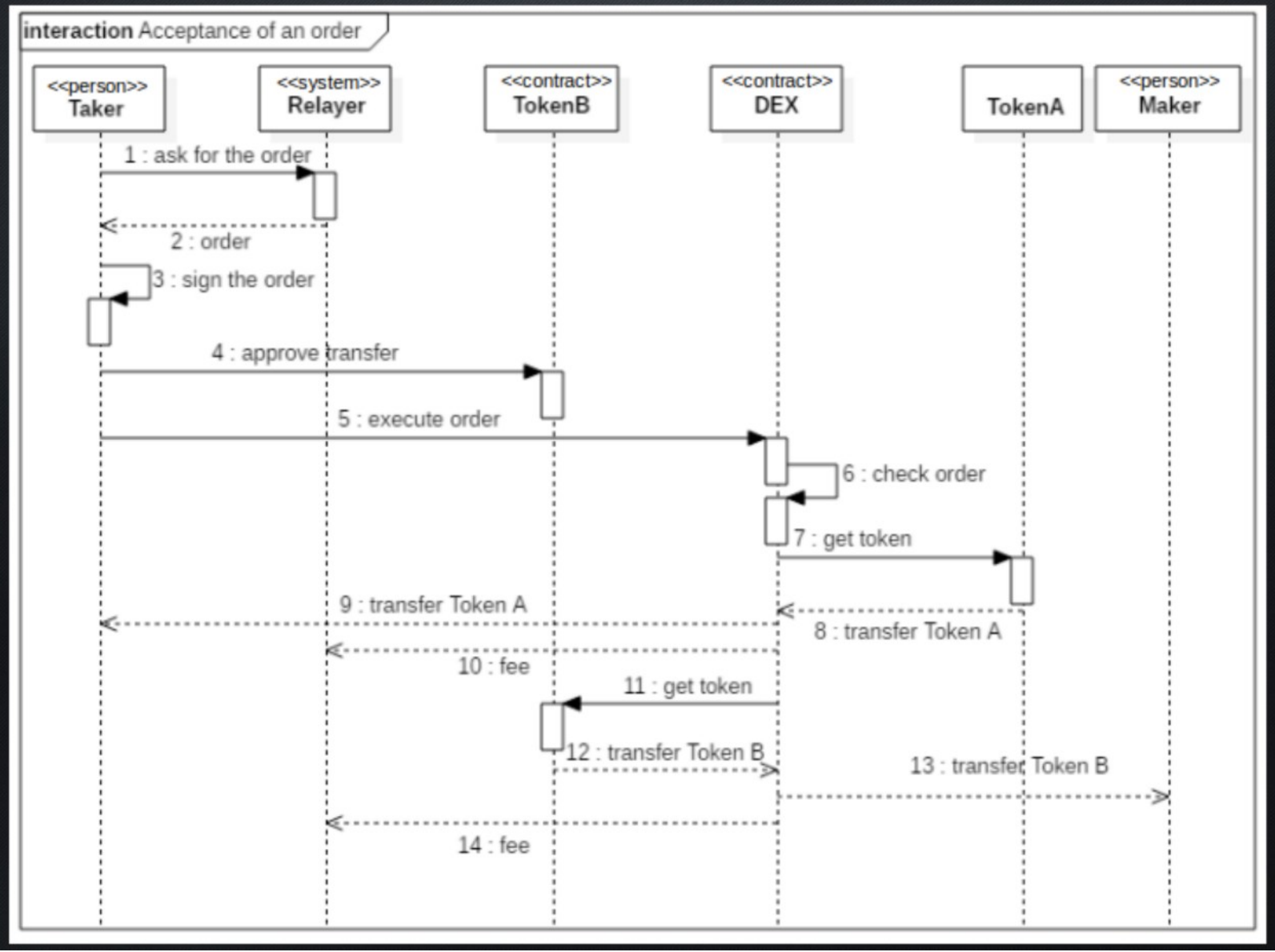
Step 5. Design of the SC Data structure of the SC shown using a modified UML class diagram

UML State diagram of a Shareholder

- showing the possible ways of her/his participation to an assembly:



An example of sequence diagram (of another system: a DEX)



Step 6. Design of the external subsystem (ESS)

- Actors of the ESS:
  - Administrator
  - Shareholder
  - SC subsystem
- Architecture:
  - A responsive application for managing the system
  - An app for the shareholders (voting and delegating)
- The app GUIs are designed
- The apps are developed using the Ethereum API web3.js library and a dev environment of choice

Steps 7 and 8: coding, testing, deploying the system

- Here we give some details of SC security assessment
- We apply a checklist to SC design and code, to assess their security against known attacks:
  - Minimize external calls and check for reentrancy
  - Follow the "checks-effects-interactions" pattern
  - Check the proper use of assert(), require(), revert()
  - Check if there are ways to make the SC permanently stuck due to gas consumption above the limit
  - Have some way to update the contract in the case some bugs will be discovered
  - . . .

Conclusions

- Despite the huge effort presently ongoing in developing DApps, software engineering practices are still poorly applied
- A **sound software engineering approach** might greatly help in overcoming many of the issues plaguing blockchain development:
  - Security issues
  - Software quality and maintenance issues
- The **ABCDE method** is the first SE method specifically introduced for DApps
- It is presently being successfully used in our spinoff company, FlossLab srl, and in other companies developing DApps

Thank you for listening!

If you are interested in ABCDE, pleas contact me:

- Michele Marchesi
- Email: marchesi@unica.it