AY 2021/2022

POLITECNICO
MILANO 1863

RASD: Requirement Analysis and Specification Document

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1 Introduction

In modern India's economy agriculture plays a pivotal role. More than 58% of rural households depend on jobs in the agricultural sphere as the principal means of livelihood. Moreover, 80% of these households are smallholder farmers with less than 2 hectares of farmland, from which more than a fifth is below poverty.

World population keeps growing. It's estimated that there will be 9.7 billion people by 2050. Food demands are expected to grow anywhere between 59% to 98%.

Climate change effects are predicted to impact everything across the food and farm systems, from productivity to livelihoods, predicting a 4% to 26% loss of net income for farmers by the end of the century.

Covid-19 pandemic has greatly highlighted the vulnerabilities and fragility of our food supply chains, telling us that we need a more resilient food system and that we can't forget about marginalized communities or smallholder farmers. All these reasons call for a revamp of the entire mechanism that brings food from farms to our plates.

It's more important, now than ever, that we develop and adopt innovative methodologies and technologies that can help bolster countries against food supply challenges and shocks.

In this contest we propose our solution for the Telangana food system, the 11th largest state in India with a geographical area of 112 077 km2 and 35 193 978 residents.

1.1 Purpose

Our goal will be to design and develop a community-centric system that will support the agricultural community via a data-driven approach, bolstering both production and welfare of the farmer population.

Stakeholders of this project will be of three main categories:

- Farmers in the Telangana region. They will be aided in their work from the data that will be available to them. By accessing weather forecasts and critical information when necessary they will be able to both ease their work and get more in return.
- Agronomist involved in aiding farmers in the Telangana region. They will be aided in the organization of their daily visits and in responding to help requests, permitting more mirated and specific work on needing farmers.
- Policy makers in the Telangana region. By seeing specific performance data they will be able to check the results of the rule they applied, and through a direct connection to the farmers they will be able to quickly publish new advice and rules.

1.1.1 Phenomena

User login	World Shared
User registration	World Shared
Check username and password	Machine
Visualize weather forecasts	World Shared
Visualize personalized suggestions	World Shared
Insert data about production (and problems)	World Shared
Request for help and suggestions by agronomists and other farmers	World Shared
Get notification for help answers	Machine Shared
Respond to a request for suggestions and help	World Shared
Create discussion forums with other farmers	World Shared
Read a discussion forum	World Shared
Respond in a discussion forum	World Shared
Get notification from forum answers	Machine Shared
Receive requests of best practises	Machine Shared
Send best practises to policy makers	World Shared
Work on the crops	World
Get notification for new blog post	Machine Shared
Read blog post	World Shared
Receive incentive notification	Machine Shared
Choose responsibility area	World Shared
Receive help requests from farmers	Machine Shared
Respond with suggestions to farmers	World Shared
Visualize weather forecast in the area	World Shared
Visualize farmer performance data	World Shared
Visualize daily visit plan	World Shared
Modify daily visit plan (before the confirmation)	World Shared
Confirm the execution of the plan	World Shared
Specify deviations from the plan	World Shared
Visit farmers	World
Visualize farmers performance data	World Shared
Request best practices to the “resilient” farmers	World Shared
Receive best practices	Machine Shared
Publish best practice on a blog	World Shared
Decide and send special incentives	World Shared
Visualize crops performance data	World Shared

Table 1: Phenomena

1.1.2 Goals

- G1: Increase the overall welfare and production of the Telangana region. By facilitating the communication and the collaboration between farmers, policy makers, and agronomists the aim is to increase the wellbeing of farmers inhabiting the Telangana region.
- G2: Aid policy makers in the decisional process. Policy makers can see production data in order to decide the incentives for farmers, or whether the current policies are performing well or should be changed (in order to constantly improve Telangana’s production).
- G3: Aid the farmers in the management of their productions. Farmers will receive personalized suggestions and best practices, and they will also have the possibilities to ask for help to both other farmers (by lending/renting equipment or giving advice) or to agronomists.
- G4: Aid agronomist works to help farmers and check crops production. Creating and modifying a daily plan will help them organize their visits and maximize their help in a well-specified zone of expertise.

1.2 Definitions, Acronyms, Abbreviations

1.2.1 Definitions

- Farmer: a person who cultivates crops
- Resilient farmer: a farmer whose production is good despite meteorological adverse events.
- Agronomist: an expert in the science of soil management and crop production.
- Policy maker: a person in charge of formulating policies, related to the food system.
- Production: total crops-output generated. Could be related to a single farmer, a zone or the entire Telangana's state.
- Personalized suggestions: indication directly focused on a specific farmer, such as specific crops to plant or specific fertilizers to use based on location and type of production.
- Welfare: overall well-being of farmers which translates into the reduction of poverty and simplification of work (discussion with other farmers, suggestions, personalized data based on location).
- Best practices: cultivation procedure that has been shown by experience to produce optimal results (not only in terms of achieved final production but also in terms of resilience to adversities) and that should be proposed for widespread adoption.
- Responsibility area: zone of which an agronomist is in charge of, with the purpose of increasing its welfare and production.
- Visit: it refers to the agronomist going to a specific farm of his competence, and is identified by a date, a variable time-slot (deviations may occur) and a reason.
- Notification: alert that a certain event has occurred. Could be an email or an automated message sent to the smartphone when the app is not running.

1.3 Revision History

December 20, 2021: version 1.0 (first release)

1.4 Reference Documents

- Specification document: "RDD Assignment A.Y. 2021-2022"
- Course slides
- Alloy official documentation: https://alloytools.org/documentation.html
- Paper: "Jackson and Zave: the world and the machine"
- UML official specification https://www.omg.org/spec/UML/

1.5 Document Structure

- Chapter 1: Introduction. This section provides an overall description of the system scope and purpose, together with some information about this document.
- Chapter 2: Overall Description. This section offers a summary description about the overall organization of the system, and it also contains a description of all the features offered by the application, and of the actors who use it.
- Chapter 3: Specific Requirements. This section goes into detail about functional and nonfunctional requirements, also providing typical scenarios and use cases.
- Chapter 4: Formal Analysis using Alloy. This section includes a presentation of the main objectives driving the formal modeling activity, as well as a description of the model itself, what can be proved with it, and why what is proved is important given the problem at hand.

2 Overall Description

2.1 Product Perspective

2.1.1 User scenarios

- Sunita is a farmer. The season is right and she needs to reap the harvest but the past days were very wet. She needs to find the perfect weather to work, so she logs in the DREAM app and quickly checks the weather forecast section. She looks at the following weeks and finds that the following week the weather should be sunnier and the temperature right. So she decides that next week will be the perfect time to collect the crops.

- Sri it's a farmer. He is unsure which is the best weather for sowing rice. He logs in the DREAM app and goes to the ask help section to ask for help from the expert. He writes his help requests, sends it and then goes to work. In the meantime Anita, the agronomist responsible for the area, receives a notification from the message the farmer sent. She opens the app to read the request and write the correct answer, sending it to the farmer. As soon as the message is sent, the farmer receives a notification and opens the app, reading the agronomist's response. Now he knows when is the best weather to sow rice, without having lost too much time seeking for an answer or going to the agronomist.

- Anita is an agronomist. She needs to plan the visit to her assigned area for the following week. She opens the app and goes to the performance section to check which farmer seems to need more help. Having found this information, she goes into the daily plan section and starts inserting the names of the farmers she needs to visit. When she is finished, she sends the list to the system which returns to her that she is forgetting to visit Sunita, because she needs the second visit of the year. Anita changes the list accordingly and sends it to the system. This time the system checks that the list is valid so returns to Anita a daily plan for the next week, where farmers were grouped by vicinity, to ease Anita work. She is ready for the next week.

- Sanjay is a policy maker. He wants to check how the decisions his department is making are affecting the overall production. So he opens the DREAM app and goes to the performance section. He gathers from this section many useful insights and charts from which he can prepare a presentation for the next board meeting, where they can decide the best line of action.

- Gita is a policy maker and she is responsible for managing the best practices. They have decided to publish weekly suggestions, and she needs to prepare the next week's advice. She goes in the performance section to check the most performing farmers, then goes in the best practice request section and writes some questions to the ones that she thought was the most suitable. These farmers will then receive the questions and answer them during the week. When Gita has collected all the answers, she prepares the story and then publishes it in the best practice section, pushing it to the homepage of all DREAM farmers.

- Lakshmi needs help collecting the crops, he knows that the best time will be next week, but his harvester needs some fixing and will not be ready until the week after. So he opens the DREAM app and goes to the forum section. He finds the correct section and writes a post asking for help from another farmer, if someone is willing to rent him a harvester. Fortunately for him, Sri finds his post on the forum. Sri has already collected his crops and he is willing to rent his harvester. So he answers in the forum the request for help and then writes to Lakshmi a private message to make an agreement on the price for the rent. Lakshmi will receive a notification from the forum response and from the private message and he will respond accepting the help of Sri. His harvest is safe!

- A strange crop disease is spreading quickly in some farmers' land. Fortunately Sunita notes this and writes a request for help to Anita the agronomists. Anita knows the disease and suggests to Sunita a solution. Knowing the danger Anita decides to write to her administration to warn them about the danger. They understand and write a blog post to warn about this disease and inform about its prevention, and push it on the homepage of all DREAM farmers, rapidly informing all of them in time to save many harvests.

2.1.2 User Interface

The system should interface with users through devices which must be connected to the Internet.

Everyone that needs to use this service would connect to it through a Web Interface (from an existent domain, like www.dream.com) or through a mobile application that can be installed on smartphones (both IOS and Android).

2.1.3 Hardware Interface

The main hardware interface of the system consists in an internet connection from smartphone/pc/tablet in order to access the functionalities provided.

2.1.4 Software Interface

The mobile application must support Android and iOS. The web application works on any web server that supports Java.

The back-end stores its data in a RDBMS and can run on every platform that supports the JVM.

The back-end must over programmatic interfaces (APIs) for user inter- faces and external modules.

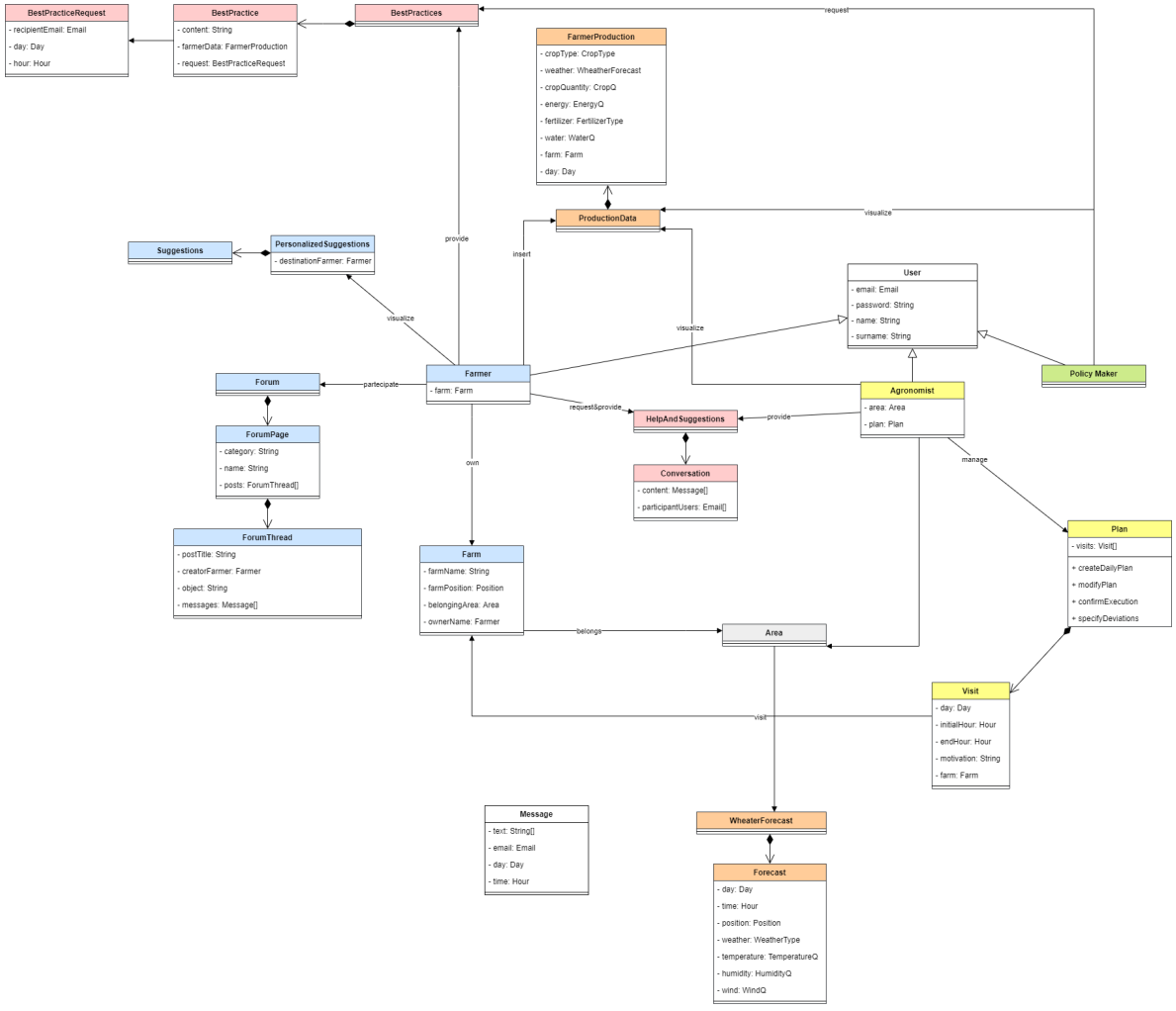


Figure 1: Class Diagram.

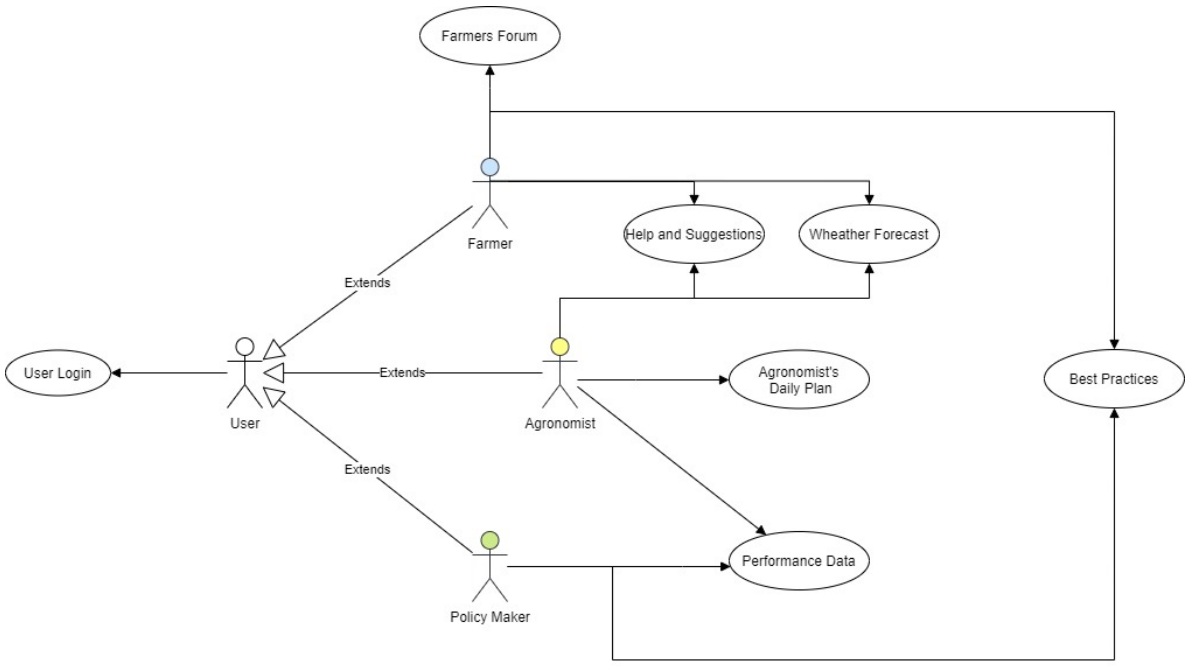


Figure 2: Use-Case Diagram.

2.2 Product Functions

- General user can:
  - Login
  - SignUp
- Farmers can:
  - Visualize relevant data
  - Insert data about production and problems in the system
  - Request for help and suggestions
  - Participate in a discussion forum
- Agronomists can:
  - Receive and answer to farmers requests for help
  - Visualize and update the daily plan
  - Confirm the execution of the daily plan
  - Specify the deviations from the daily plan
- Policy makers can:
  - See information about crops and farmers
  - Select well performing farmers and ask them best practice
  - Select bad performing farmers and send them suggestions

2.3 User characteristics

2.3.1 Farmer

It's a person engaged in agriculture, who is responsible for planting, cultivating, and managing plantations. In its work, it must take into account weather forecasts and personalized suggestions received by other farmers in order to make its production perform at its best. In addition to this, it should ask for suggestions if it has a problem, and help other farmers to resolve their own problems.

2.3.2 Agronomists

It's a person responsible for monitoring and visiting the farmers under his area of responsibility. Its job is to plan the visits to the farmers, by taking into account that every farmer must be visited at least twice a year. The primary role of agronomists are in research for the benefit of farms and food; they can provide technical advice for farmers such as in making crop calendars, prescribing fertilizers to avoid misuse, in order to optimize farm production.

2.3.3 Policy Makers

It's a person responsible for identifying those farmers who are performing well to take their best practices, and those farmers who are performing badly to help them. Its aim is to monitor the results of the work of the agronomists, in order to understand if the steering initiatives are producing good results.

2.4 Assumptions, dependencies and constraints

2.4.1 Assumptions

- D1: Users (farmers, agronomists, and policy makers) do not insert false information in the system.
- D2: Farmers reply as best as they can, giving the best advice, to requests for help and suggestions by other farmers (without providing unthruts).
- D3: Agronomists know the area they are responsible for.
- D4: Each area has at least one responsible agronomist.
- D5: Each farm is assigned to a specific area and has a unique identifier.
- D6: Users have access to a stable Internet connection (e.g. to visualize weather forecasts, to participate in a discussion, to send and receive help and suggestions).
- D7: The location of a farm is known by the application, and the responsible agronomist is able to reach the farm.

2.4.2 Hardware Constraints

The system has to run under the following worst-case conditions:

- App:
  - 3G connection, at 2 Mb/s
  - 100 MB of free space
  - 1 GB of RAM
- Web Application:
  - 2 Mb/s Internet connection
  - 800x600 resolution

3 Specific Requirements

3.1 Interface Requirements

3.1.1 User Interfaces (Farmer, Agronomist, Policy Maker)

In the figure we can see the login web page on the left and the login app screen on the right of the DREAM system. It is asked to the user to login or to create an account, and in case the user decides to register, different information can be added depending on the stakeholder it is registering.
Firstly the user will be asked to select from 3 types of account (policy maker, farmer, agronomist) and depending on the selection different information will be required (ex. the responsible area will be asked only for the creation of an agronomist's account). The system will then check the veracity of the inserted data and confirm the registration.

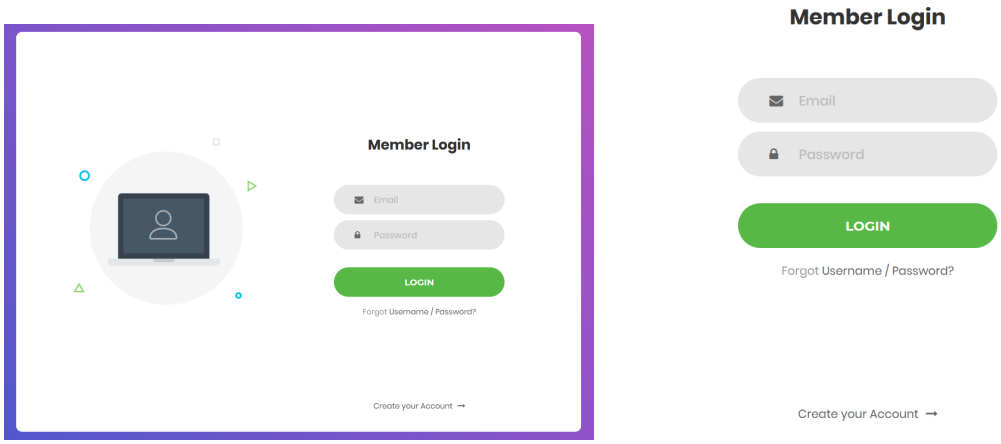


Figure 3: User Login.

- **Farmer interface**

Farmer interface is described in figures below (web and app view). The farmer can easily access all his functionalities in the menu (at the top of the page on the web, in the retractable menu in the app), but has also some relevant information on the home page. Here it is possible to read the weather forecast of the current day and have a quick lookup on some personalized suggestions (farmer can continue reading the shown suggestion or click on "Personalized suggestion" to go to all his suggestions).

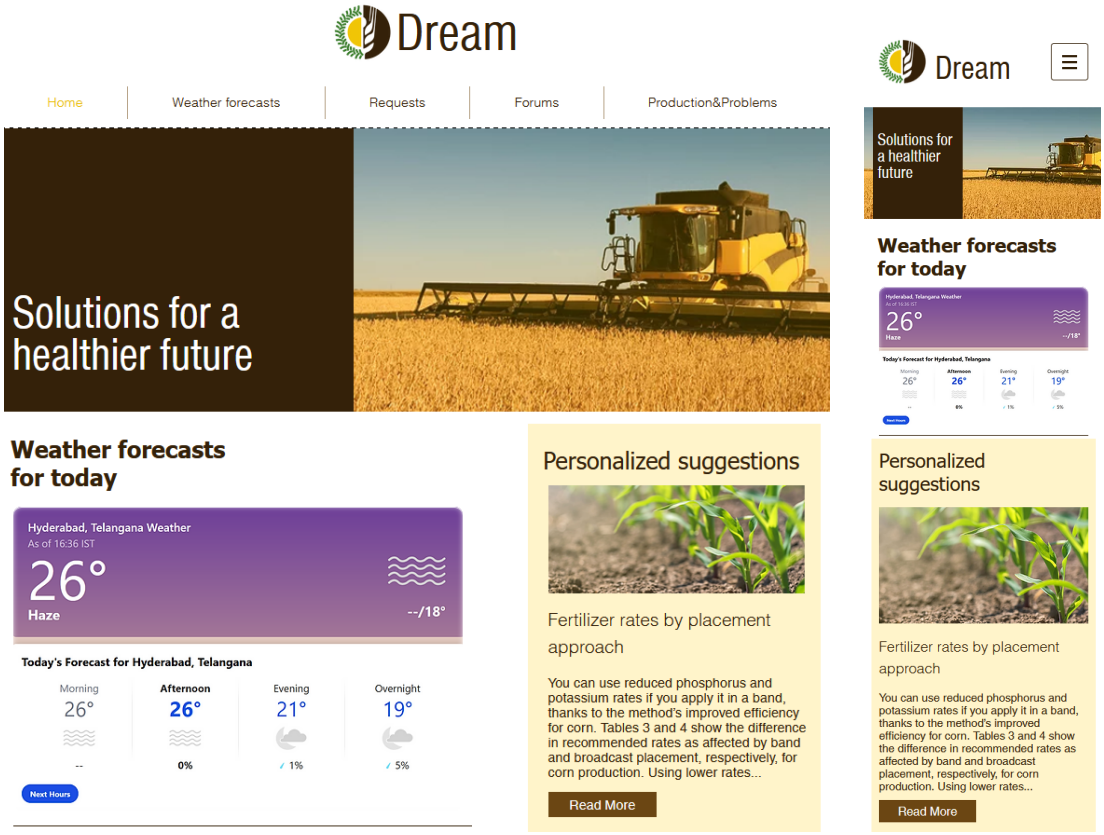


Figure 4: Farmer Home Page.

- **Agronomist interface**

Agronomist interface is described in figures below (web and app view). As the farmer, the agronomist can easily access all his functionalities in the menu (at the top of the page on the web, in the retractable menu in the app), but has also some relevant information on the home page. Here it is possible to read the weather forecast of the current day and have a quick lookup of today's plan.

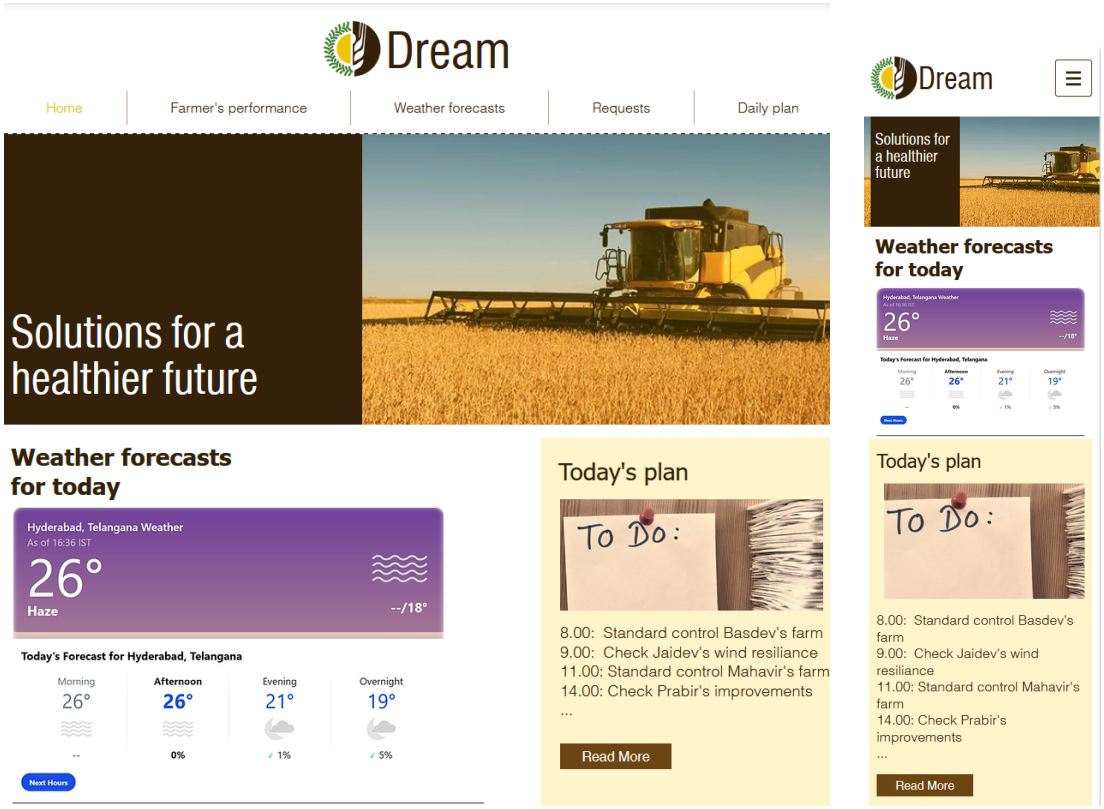


Figure 5: Agronomist Home Page.

- **Policy Maker interface**

Agronomist interface is described in figures below (web and app view). As the farmer, the agronomist can easily access all his functionalities in the menu (at the top of the page on the web, in the retractable menu in the app), but has also some relevant information on the home page. Here it is possible to read the weather forecast of the current day and have a quick lookup of today's plan.

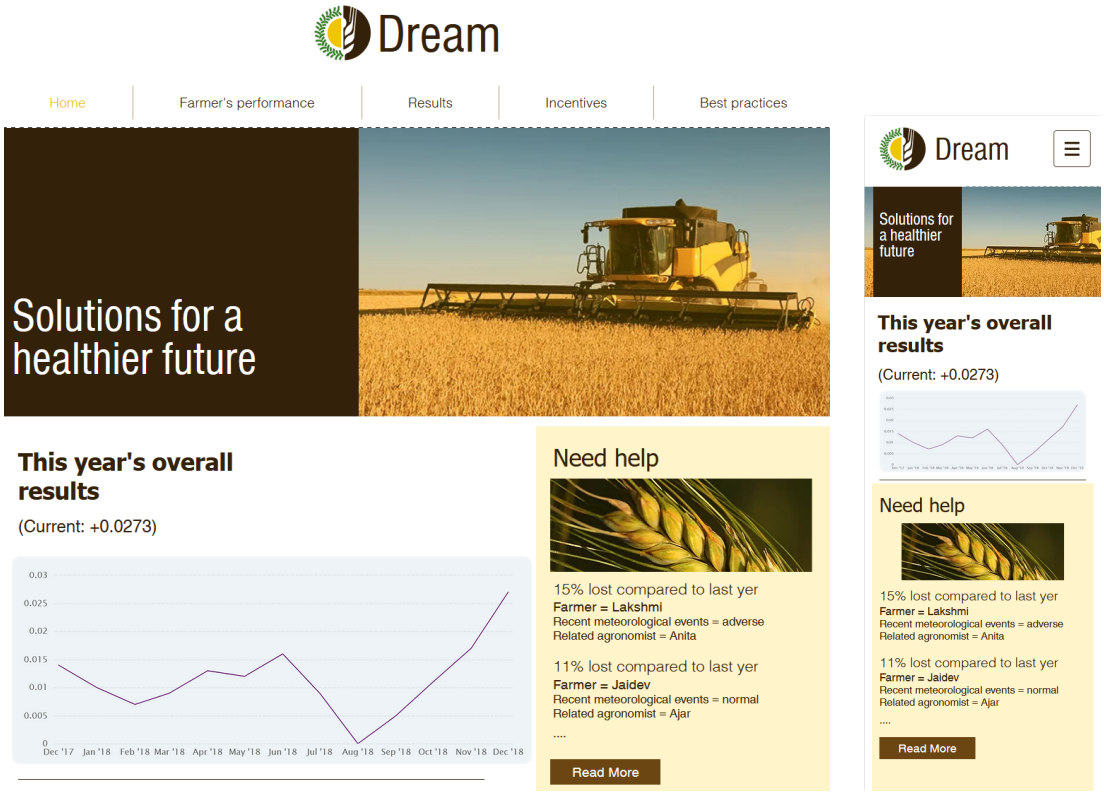


Figure 6: Policy Maker Home Page.

3.1.2 Hardware Interfaces

Dream application does not provide any hardware interface. However it is possible to connect to a government database in order to automatically check the veracity of the registration data of each user.

3.1.3 Software Interfaces

Dream requires Java to be installed on the system, more specifically at least Java version 8 (to include functional programming). Dream can also be connected with a MySQL, SQLite or PostgreSQL government database as presented in 3.1.2.

3.1.4 Communication Interfaces

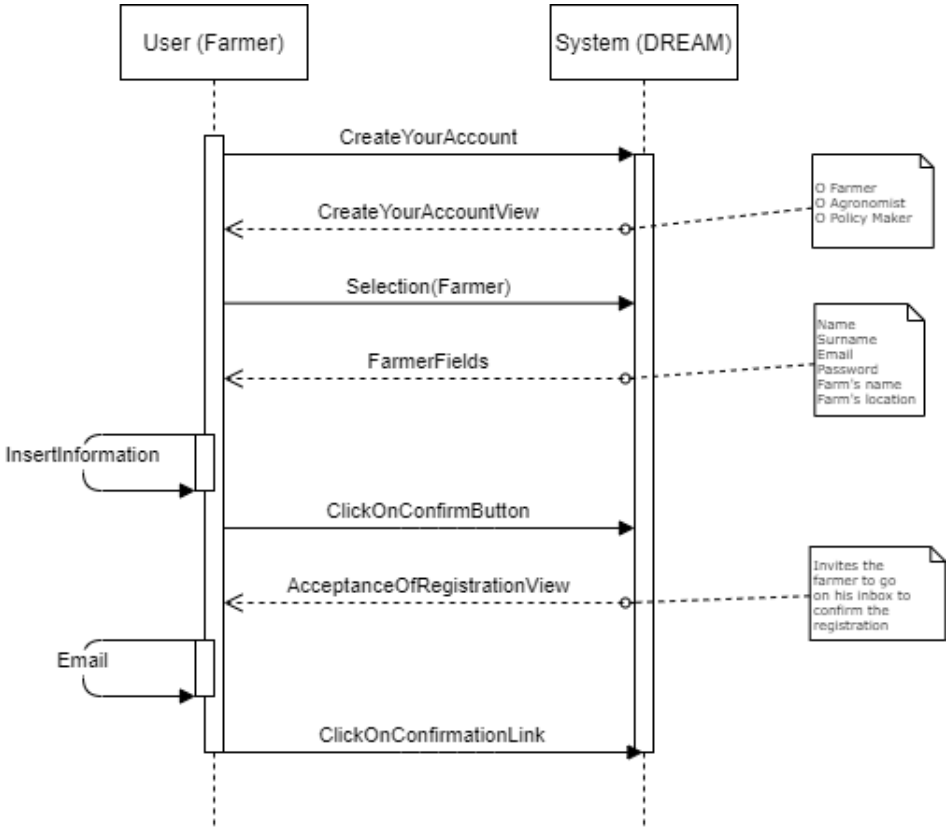
The clients communicate with the server via HTTPS requests.

3.2 Functional Requirements

3.2.1 Farmer Use Cases

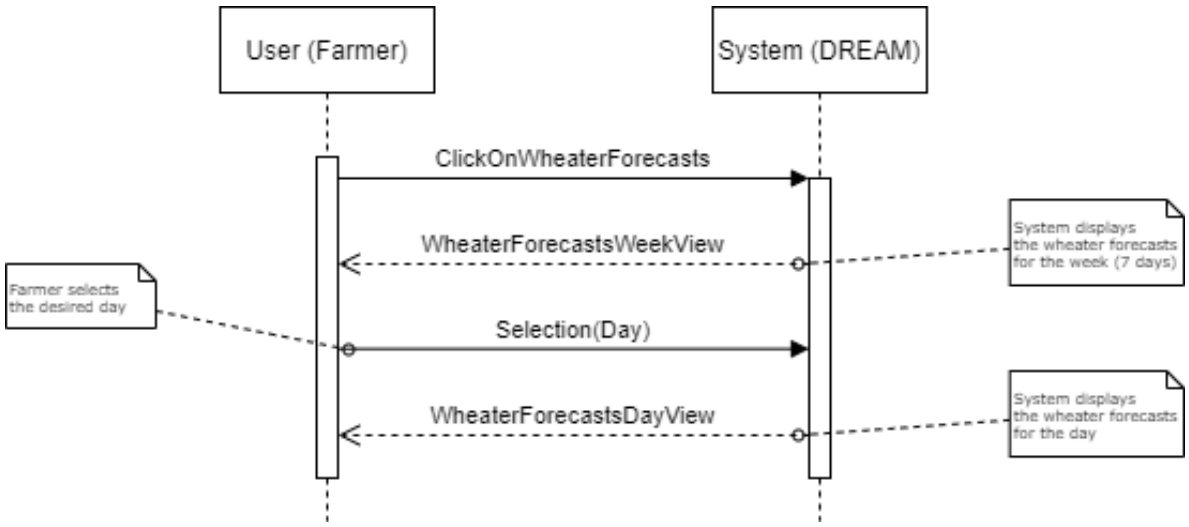
ID	1
Name	Farmer Sign Up
Actor	Farmer
Entry Conditions	Farmer has downloaded and opened the application on his smartphone (on the "Initial App Screen"), or has opened the web page on his personal computer (on the "Initial Web Page").
Input	• Email to use for the registration • Personal data (name, surname) • Farm data
Events Flow	• Farmer clicks on "Create your Account" • System displays a list of alternatives: – Farmer – Agronomist – Policy Maker • Farmer selects "Farmer" • System displays a list of fields that the farmer must compile: – Name – Surname – Email – Password – Farm's name – Farm's location • Farmer inserts the mandatory data and accepts the Terms of Services • Farmer clicks on "Confirm" button • System displays the acceptance of registration and invites farmer to go on his inbox in order to confirm the registration • Farmer opens his inbox, checks the emails and clicks on confirmation link
Exit Conditions	• Farmer registration has been successful: farmer's data are stored in the database of the system. • Farmer can now login with his credentials (email and password)

Output	• The email of the farmer is stored in the database of the application • The farmer receives the email of confirmation
Exceptions	• Farmer inserts an email which is already stored in the database. So, after the farmer inserts his data and clicks on confirm, the application displays an error page which tells that farmer is already registered to the service and invites him to login with that email. • Farmer inserts an invalid email. So, after the farmer clicks on the confirm button, the application displays the same page and an error message, which suggests to the farmer to check the email inserted or to change it. • Farmer inserts invalid data (e.g., farmer is not the owner of the specified farm, invalid farm's data), so, after the farmer clicks on confirm, the application displays an error page which tells that farmer has inserted invalid data and invites him to try again the registration.



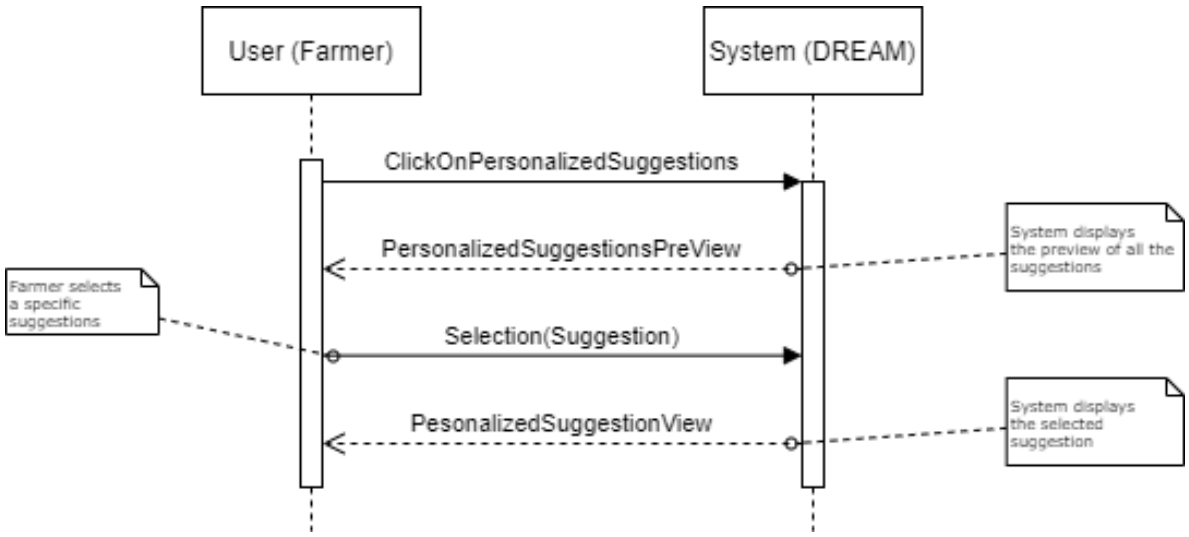
Sign Up Farmer

ID	2
Name	Farmer visualize “Weather Forecasts”
Actor	Farmer
Entry Conditions	• Farmer has logged in • Farmer is on his home page
Input	
Events Flow	• Farmer clicks on “Weather Forecasts” • System displays a page with the weather forecasts for the following seven days. For each day it shows four forecasts (morning, afternoon, evening, night). • Farmer selects a day • System displays the forecasts hour by hour of the selected day (wind, max and min temperature, sunrise time, ...).
Exit Conditions	System successfully displays the weather forecasts for the day selected by the farmer
Output	Farmer sees the weather forecasts for the desired day
Exceptions	Weather forecasts are unavailable due to a problem with the IT provider. System shows a page saying that weather forecasts are temporarily unavailable and to try again after a while. Then it shows the farmer’s home page.



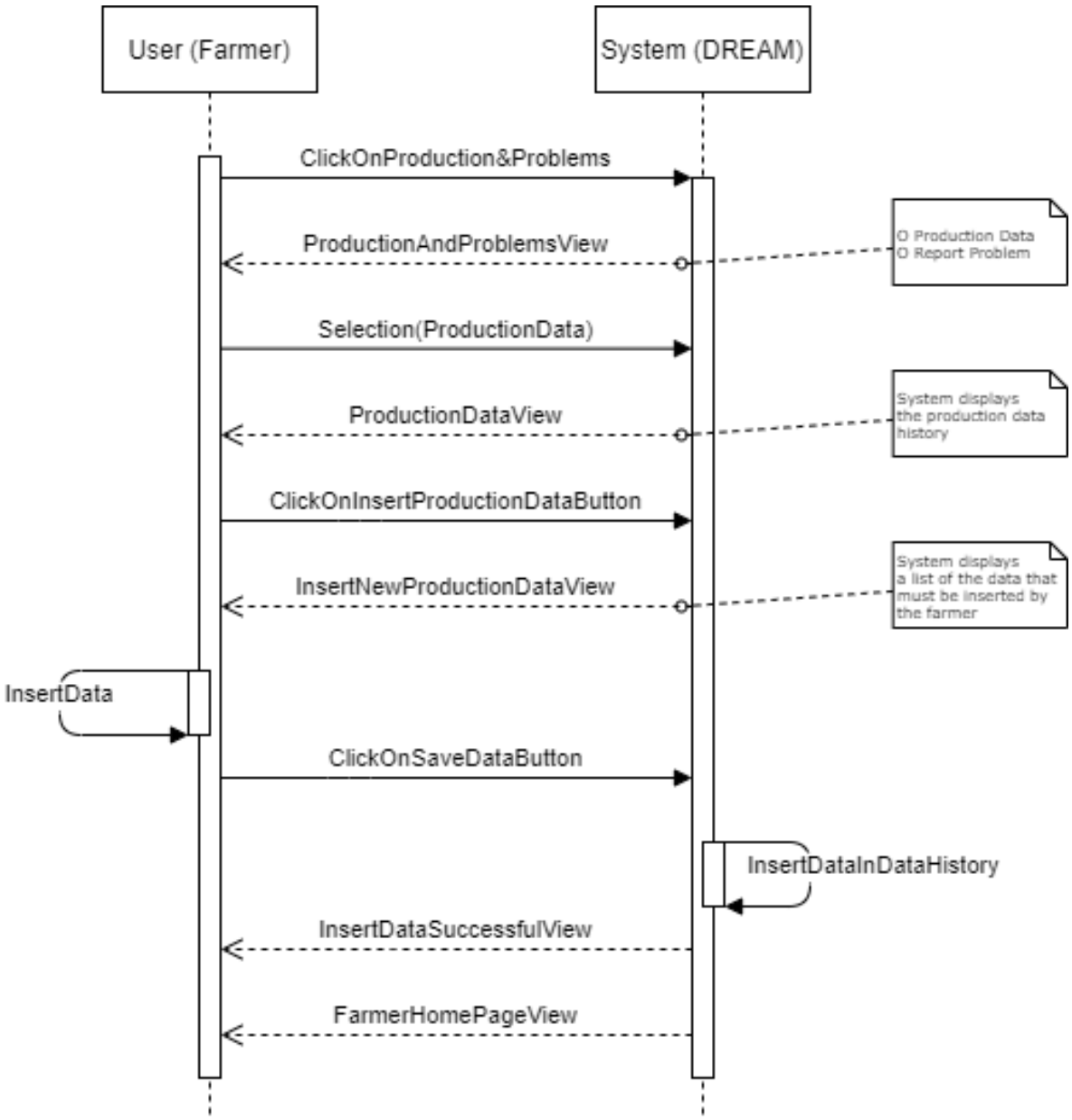
Farmer visualizes wheater forecast

ID	3
Name	Farmer visualize “Personalized Suggestions”
Actor	Farmer
Entry Conditions	• Farmer has logged in • Farmer is on his home page
Input	
Events Flow	• Farmer clicks on “Personalized Suggestions” – If farmer clicks on “Read More” on the preview of a suggestion on the Home Page jump directly to last point • - System displays a page with the preview of all his suggestions (which fertilizer to use, which crops to plant) • Farmer selects a suggestion • System displays the selected suggestion
Exit Conditions	System successfully displays the selected suggestion
Output	Farmer sees the selected suggestion
Exceptions	Chosen personalized suggestion has been removed while the farmer was reading its preview. When it is selected the system shows a message saying the suggestion is no more pertinent to him and displays its home page.



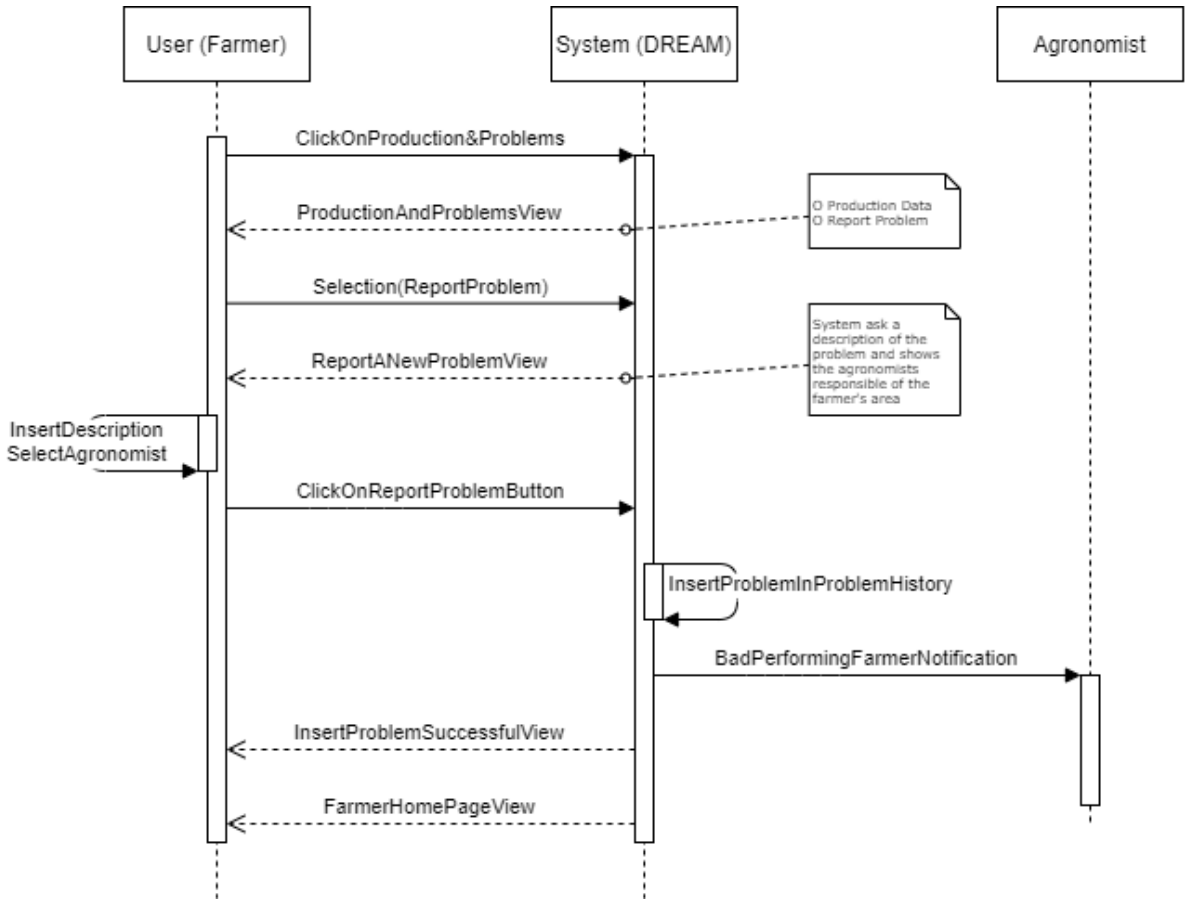
Farmer visualize “Personalized Suggestions”

ID	4
Name	Farmer insert “Production Data”
Actor	Farmer
Entry Conditions	• Farmer has logged in • Farmer is on his home page
Input	• Amount of corn produces • Amount of energy used per unit • Amount of fertilizer used per unit • Amount of water used per unit
Events Flow	• Farmer clicks on “ProductionAndProblems” • System asks if the farmer wants to access “Production Data” or wants to “Report a Problem” • Farmer selects “Production Data” • System displays a page with farmer’s production data’s history and the button “Insert Data” • Farmer selects the button (if selects an already present production data the system automatically opens the page of “Insert Data” with old datas copied in it, and if saved the old production will be automatically deleted) • System displays the page “Insert Production Data” • Farmer inserts the amount of corn produced and the amount of energy, water and fertilizer used per unit. • Farmer clicks “Save” button • System shows the message “Production has been inserted successfully” • System displays farmer’s home page
Exit Conditions	Production data has been successfully added to the system
Output	Farmer’s production data is stored in the database of the application
Exceptions	



Farmer insert "Production Data"

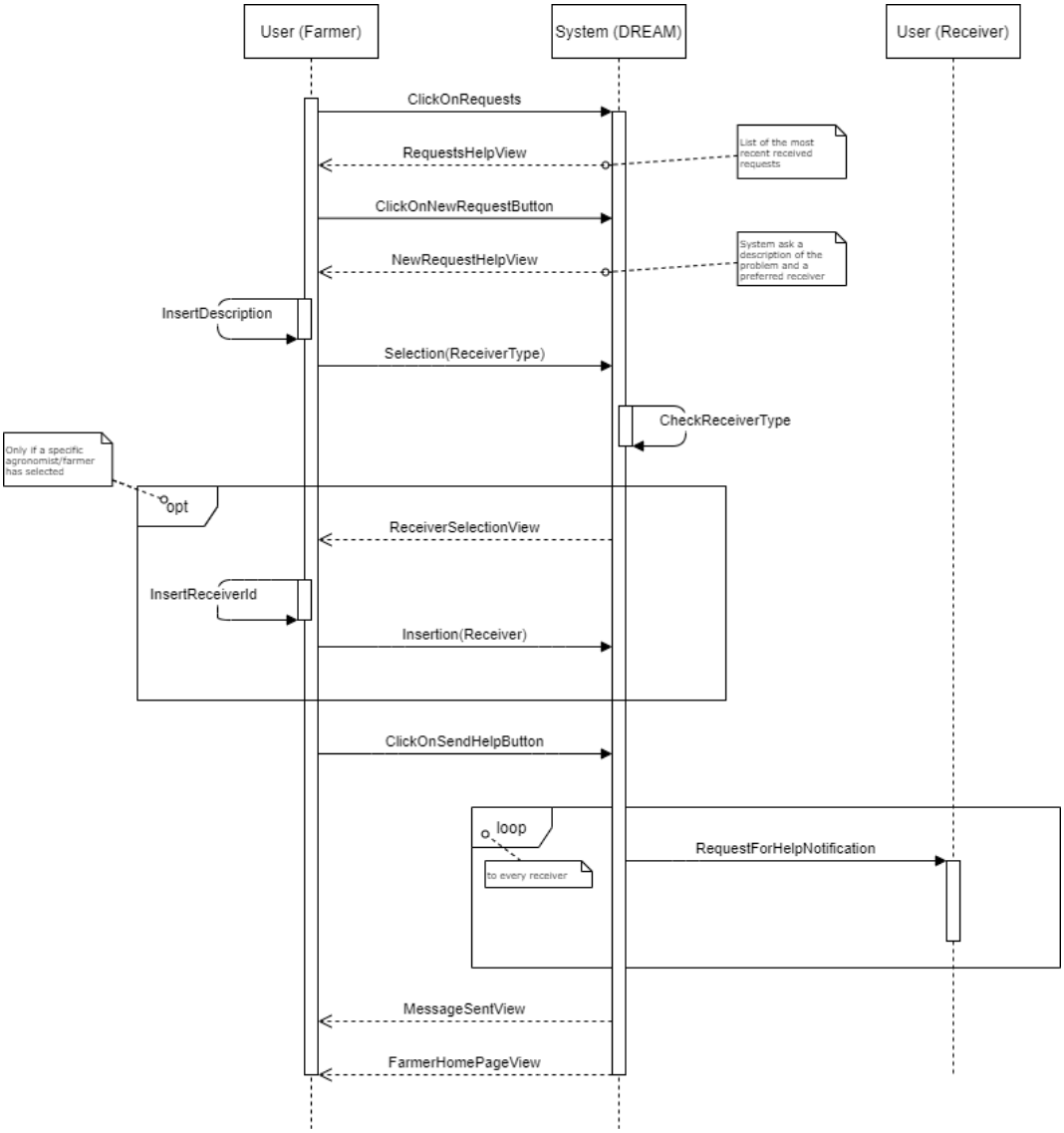
ID	5
Name	Farmer “Report a Problem”
Actor	Farmer
Entry Conditions	• Farmer has logged in • Farmer is on his home page
Input	Description of the problem
Events Flow	• Farmer clicks on “ProductionAndProblems” • System asks if the farmer wants to access “Production Data” or wants to “Report a Problem” • Farmer selects “Report a Problem” • System displays a page where it asks a brief description of the problem and shows the agronomists responsible of the farmer’s area • Farmer inserts the description of the problem and selects an agronomist • Farmer selects “Report” button • System sends a notification of “Bad Performing Farmer” to the selected agronomist • System shows the message “Problem has been reported successfully” • System displays farmer’s home page
Exit Conditions	Problem report has been successfully added to the system and the agronomist has been notified
Output	Problem report is stored in the database of the application and a notification has been sent to the agronomist
Exceptions	Farmer inserts a description of more than 400 words. Since it is no longer a brief description, when the farmer tries to save the report the system shows the message “Description must fit in 400 words” and the number of written words, and it remains on the same page (in order to let the user shorten the text)



Farmer "Report a Problem"

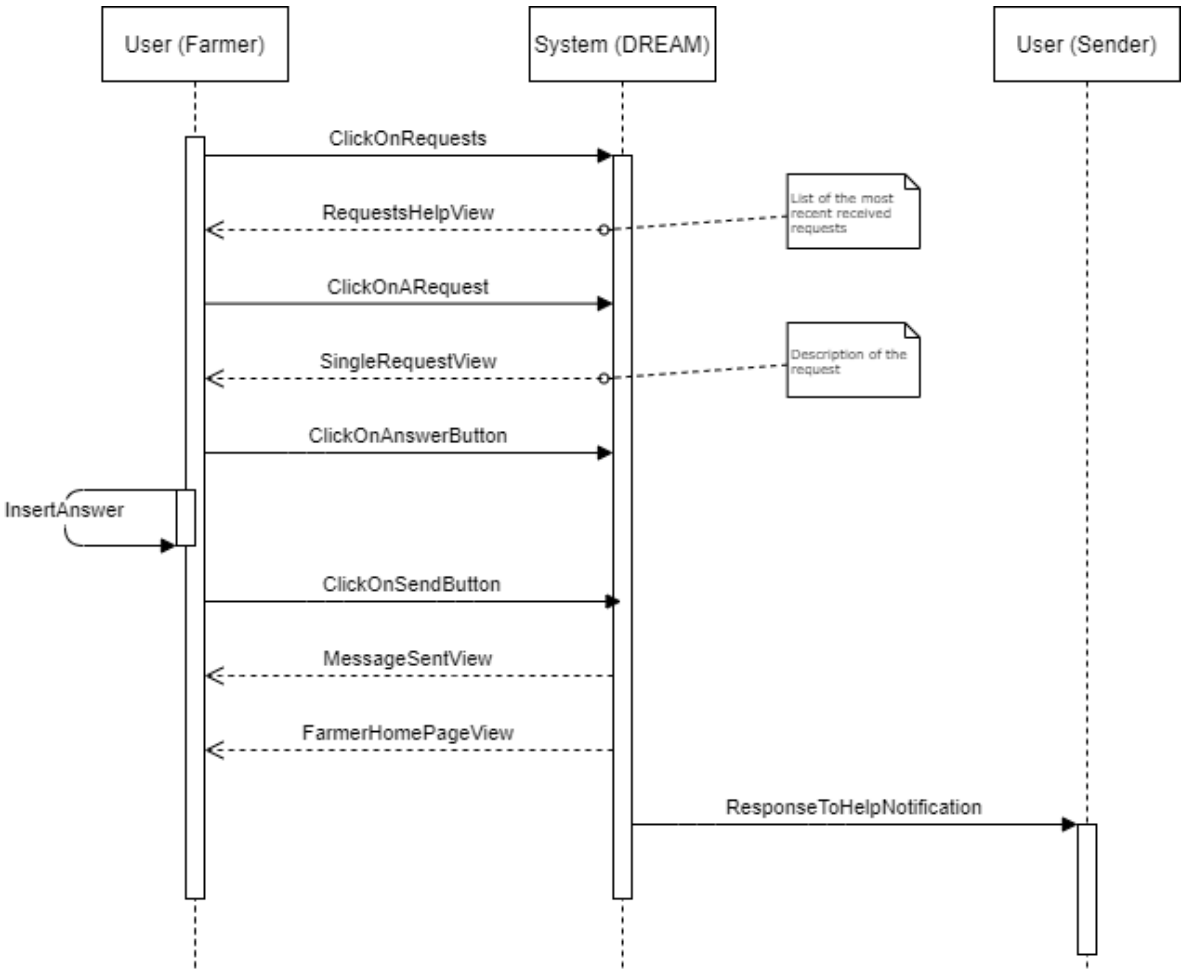
ID	6
Name	Farmer requests for “Help and Suggestions”
Actor	Farmer
Entry Conditions	• Farmer has logged in • Farmer is on his home page
Input	• Description of the request • Optional: Identifier of the addressee (specific agronomist/-farmer)
Events Flow	• Farmer clicks on “Requests” • System displays a page with a list of the most recent received requests and a button “Create New Request” • Farmer selects the button “Create New Request” • System displays a page with text field (to store the request) and a list of possible addressee (receiver of the request): – Specific Agronomist – Specific farmer – All farmers of my area – All agronomist of my area • Farmer insert the description of the request • Farmer selects the receiver – In case a specific agronomist/farmer has been selected, the system lets the farmer insert an identifier of the receiver • Farmer selects “Send” button • System sends a notification to receiver/s • System shows a message saying “Message sent” • System displays farmer’s home page
Exit Conditions	Request has been sent successfully
Output	• The request is stored in the database of the application • Receivers gets a notification

Exceptions	• Farmer inserts an invalid identifier of the receiver. The system shows the message "Invalid receiver" and displays the page of the request to let the farmer modify it. • Farmer inserts a message in the text field of over 400 characters. Systems shows an error message "A request can have at most 400 characters" and displays again the page with the text field (filled with old message) and the button.



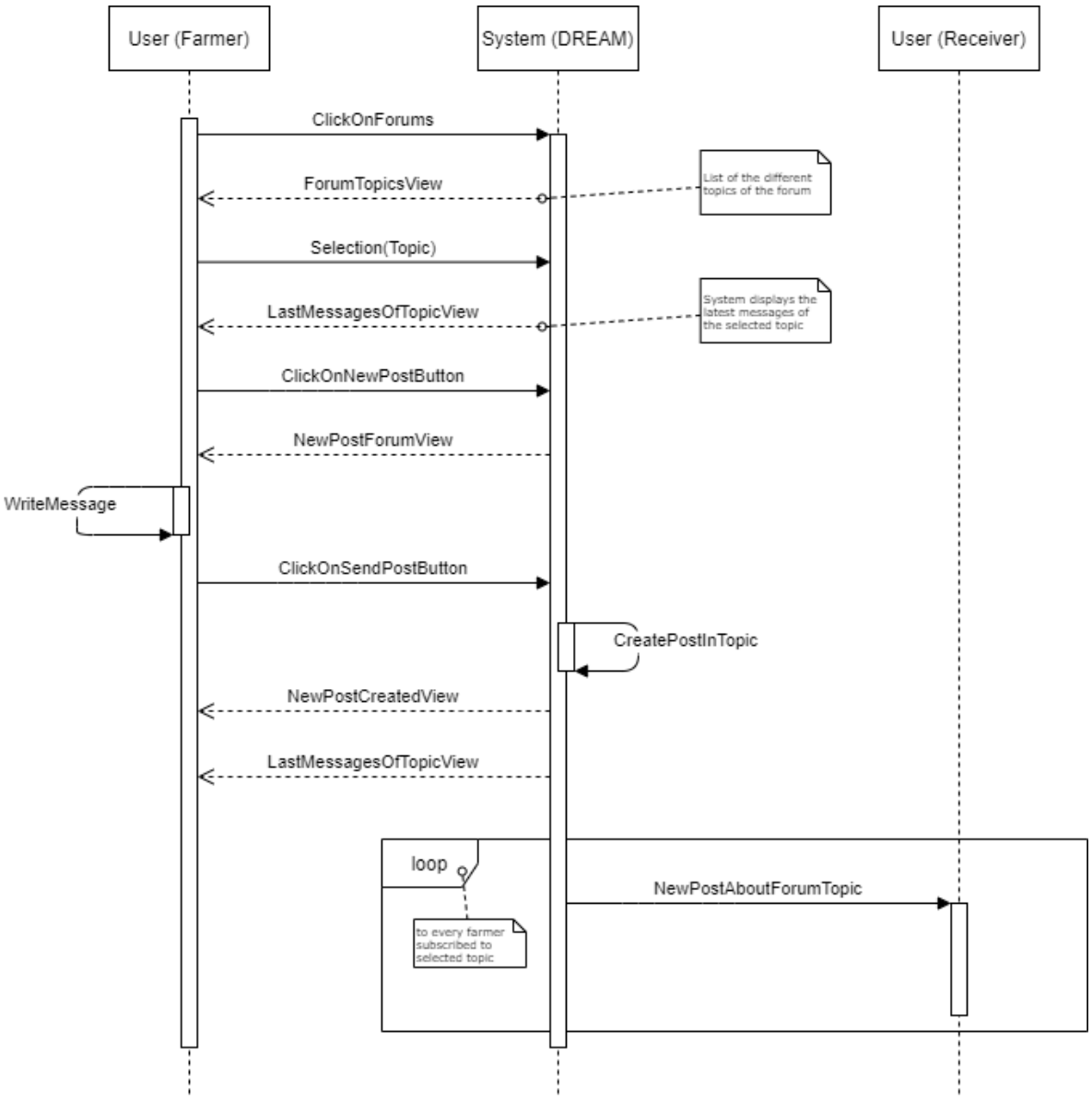
Farmer requests for Help and Suggestions

ID	7
Name	Farmer responds to a “Request for Help and Suggestions”
Actor	Farmer
Entry Conditions	• Farmer has logged in • Farmer has received a request for help
Input	Text of the response
Events Flow	• Farmer clicks on “Requests” – If farmer directly clicks on the notification of the request, jump directly to 4th point • System displays a page with a list of the most recent received requests and a button “Create New Request” • Farmer selects a request • System displays the request and an “Answer” button • Farmer reads the request and selects the “Answer” button • System displays a text field for the response and a “Send” button • Farmer inserts the text and clicks on the “Send” button • System shows a message saying “Message sent” • System displays farmer’s home page • System sends a notification to sender of the request
Exit Conditions	Response has been sent successfully
Output	• The response is stored in the database of the application • Receivers gets a notification
Exceptions	• Farmer selects the “Send” button with an empty message for the response. Systems shows an error message ”A response can’t be empty” and displays again the page with the text field and the button. • Farmer inserts a message in the text field of over 400 characters. Systems shows an error message “A response can have at most 400 characters” and displays again the page with the text field (filled with old message) and the button.



Farmer responds to a “Request for Help and Suggestions”

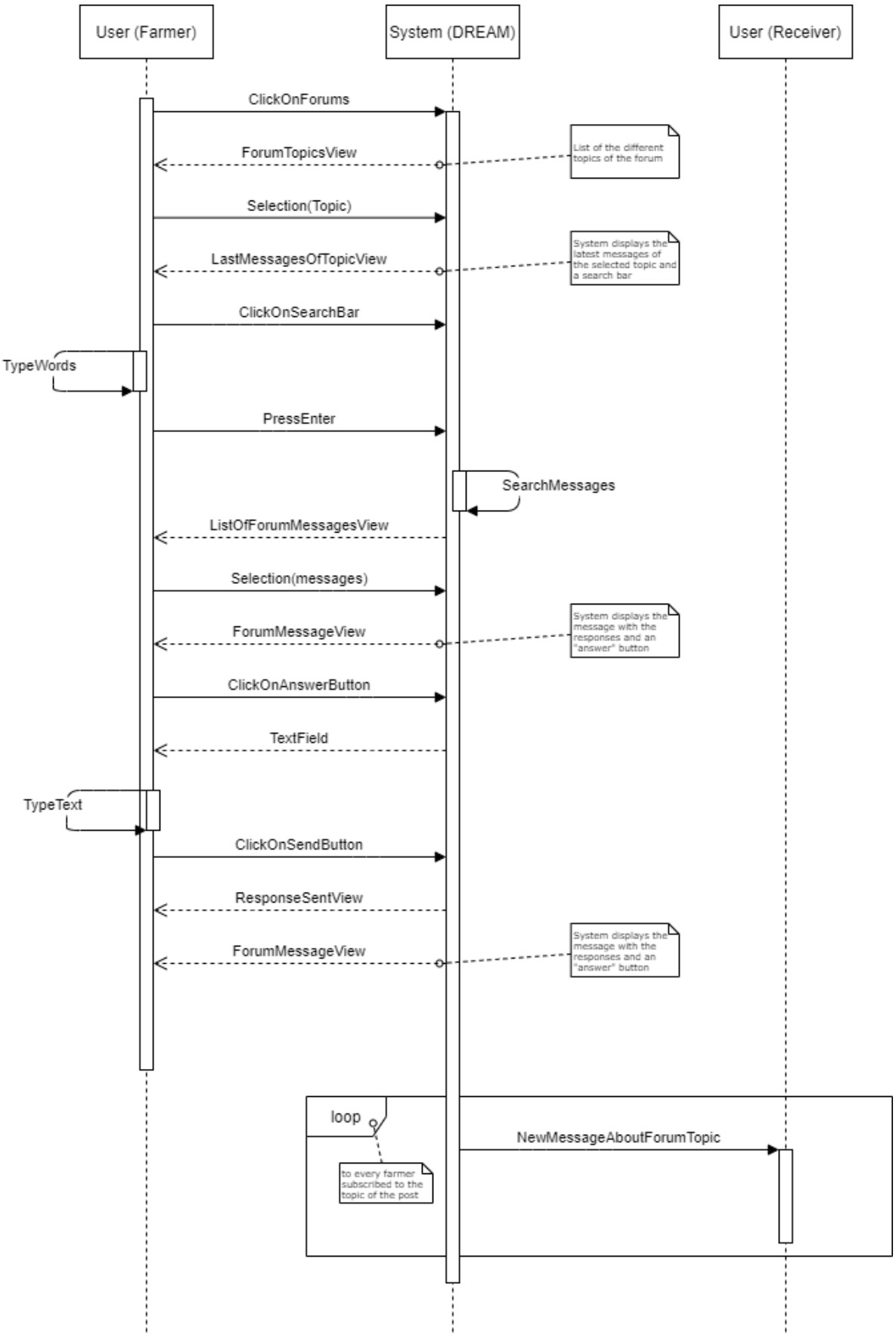
ID	8
Name	Farmer writes a new post on a discussion forum
Actor	Farmer
Entry Conditions	• Farmer has logged in • Farmer is on his home page
Input	Text of the response
Events Flow	• Farmer clicks on "Forums" • System displays a page with different topics • Farmer selects the topic related to his message • System displays: – The latest messages related to the selected topic – A search bar to permit the search of messages containing the written key words – The button "New Post" – The button "Subscribe" (or "Unsubscribe" if already subscribed) • Farmer selects "New Post" button • System displays a text field for the post and a "Send" button • Farmer writes the message and selects the "Send" button • System shows a message saying "New Post Created" • System displays forum's page of the same topic • System sends a notification to all the farmers subscribed to the topic of the post
Exit Conditions	Post has been successfully added
Output	• The post is stored in the database of the application • Farmer subscribed to the topic of the post gets a notification
Exceptions	• Farmer selects the "Send" button with an empty message for the post. Systems shows an error message "A post can't be empty" and displays again the page with the text field and the button. • Farmer inserts a message in the text field of over 300 characters. Systems shows an error message "A post can have at most 300 characters" and displays again the page with the text field (filled with old message) and the button.



Farmer writes a new post on a discussion forum

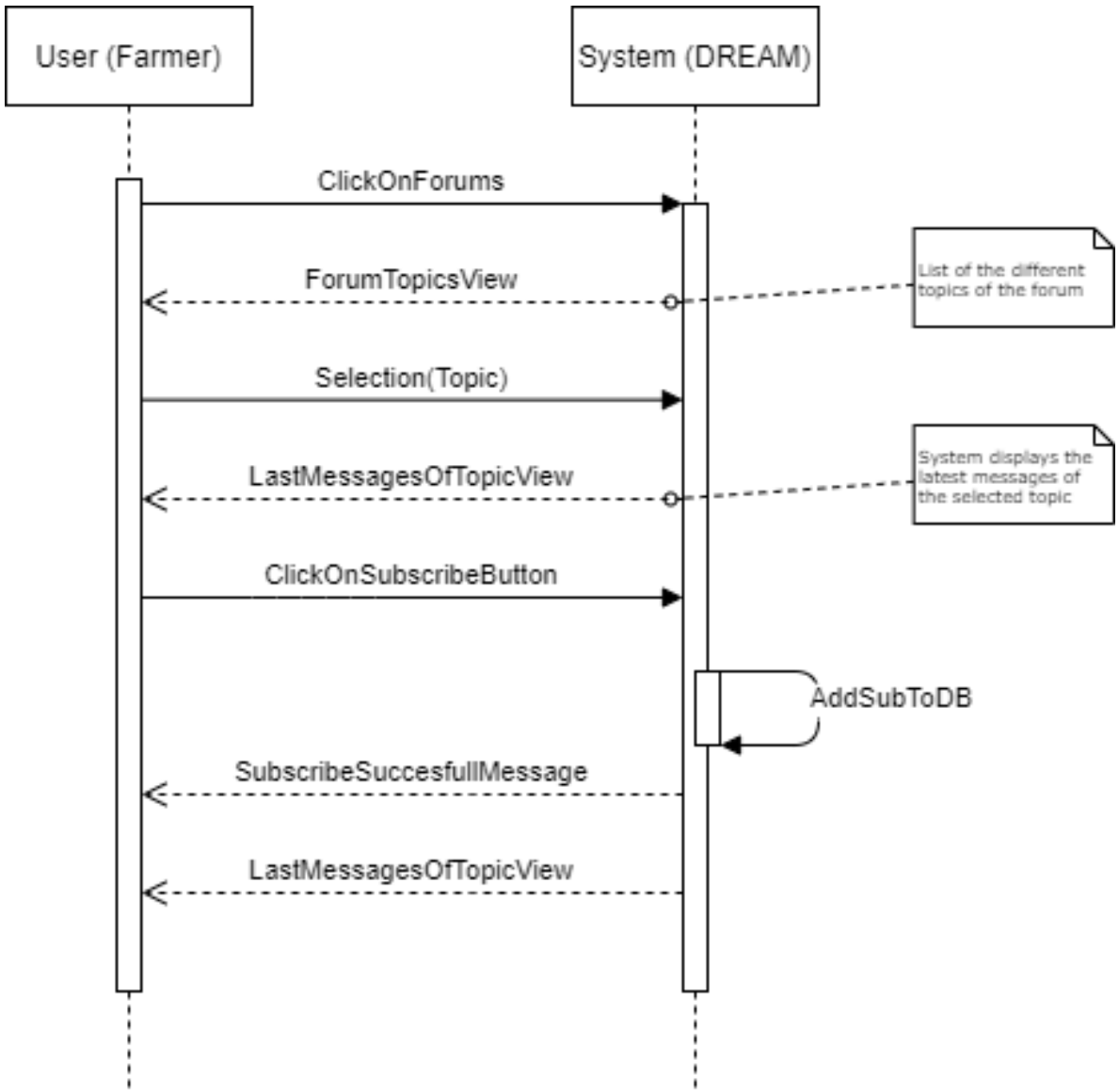
ID	9
Name	Farmer responds on a discussion forum
Actor	Farmer
Entry Conditions	• Farmer has logged in • Farmer is on his home page
Input	Message to be sent
Events Flow	• Farmer clicks on “Forums” • System displays a page with different topics • Farmer selects the topic • System displays: – The latest messages related to the selected topic – A search bar to permit the search of messages containing the written key words – The button “New Post” – The button “Subscribe” (or “Unsubscribe” if already subscribed) • Farmer selects the search bar and types some words to identify the message. Then press enter. • System shows a page containing the messages containing the selected words • Farmer selects a message • System shows the message with the most recent responses and an “Answer” button • Farmer selects the “Answer” button • System displays a text field for the response and a “Send” button • Farmer inserts the text and presses the “Send” button • System shows a message saying “Response sent” • System displays again the message selected before with the most recent responses and the “Answer” button • System sends a notification to all the farmers subscribed to the topic of the post (and to the creator of the post even if not subscribed to the topic)
Exit Conditions	Response has been sent successfully

Output	• The response is stored in the database of the application • Receivers gets a notification
Exceptions	• Farmer selects the “Send” button with an empty message for the response. Systems shows an error message ”A post can’t be empty” and displays again the page with the text field and the button. • Farmer inserts a message in the text field of over 300 characters. Systems shows an error message “A post can have at most 300 characters” and displays again the page with the text field (filled with old message) and the button.



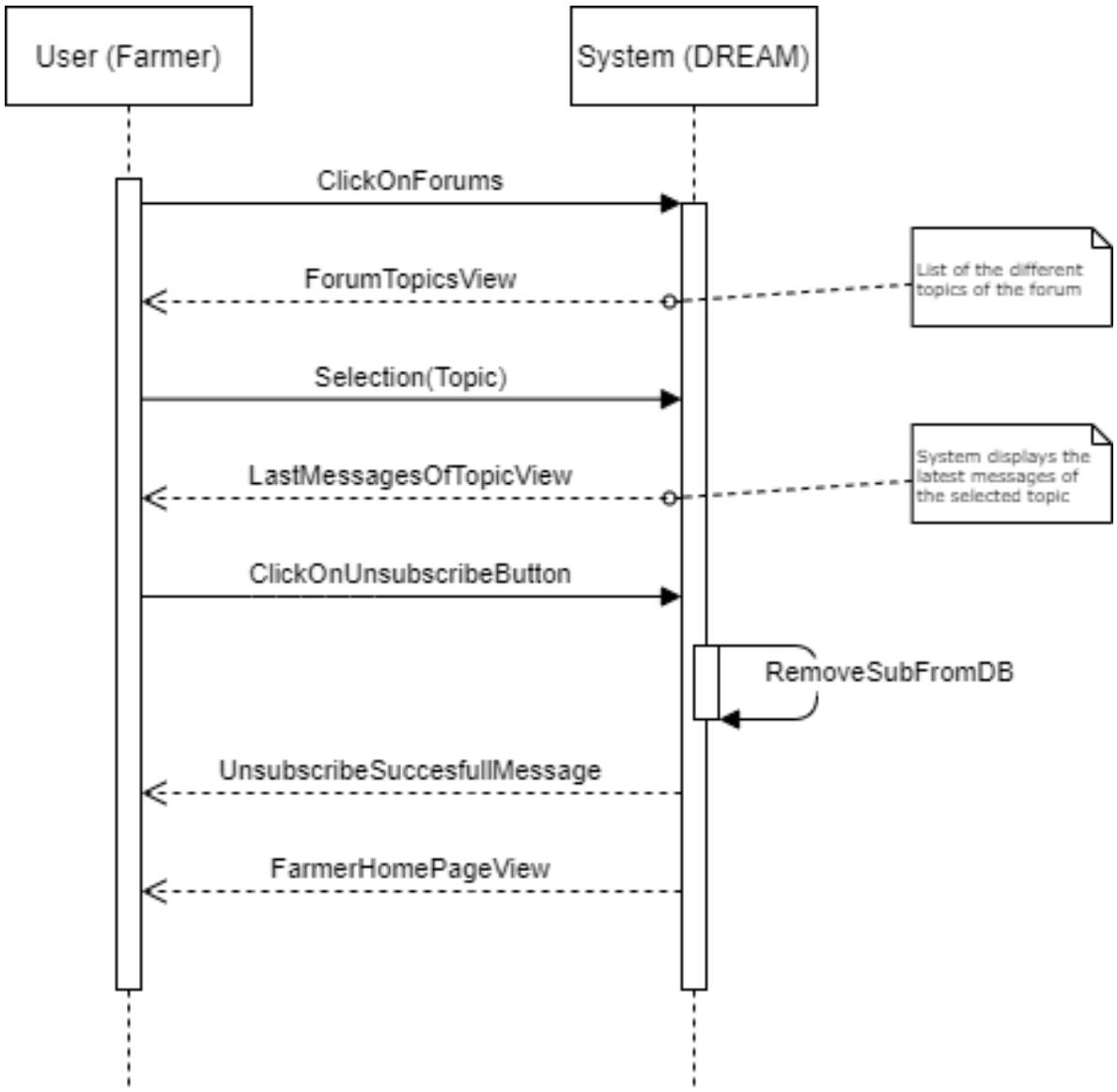
Farmer responds on a discussion forum

ID	10
Name	Farmer subscribes to a topic
Actor	Farmer
Entry Conditions	• Farmer has logged in • Farmer is on his home page • Farmer is not already subscribed to the topic
Input	
Events Flow	• Farmer clicks on “Forums” • System displays a page with different topics • Farmer selects the topic • System displays: – The latest messages related to the selected topic – A search bar to permit the search of messages containing the written key words – The button “New Post” – The button “Subscribe” • Farmer clicks the button “Subscribe” • System shows a message saying “You have successfully subscribed to the topic, you will be notified when a new message is added to this topic section” • System displays the page of the chosen topic
Exit Conditions	Subscription has been successfully performed
Output	The subscription is stored in the database of the application
Exceptions	



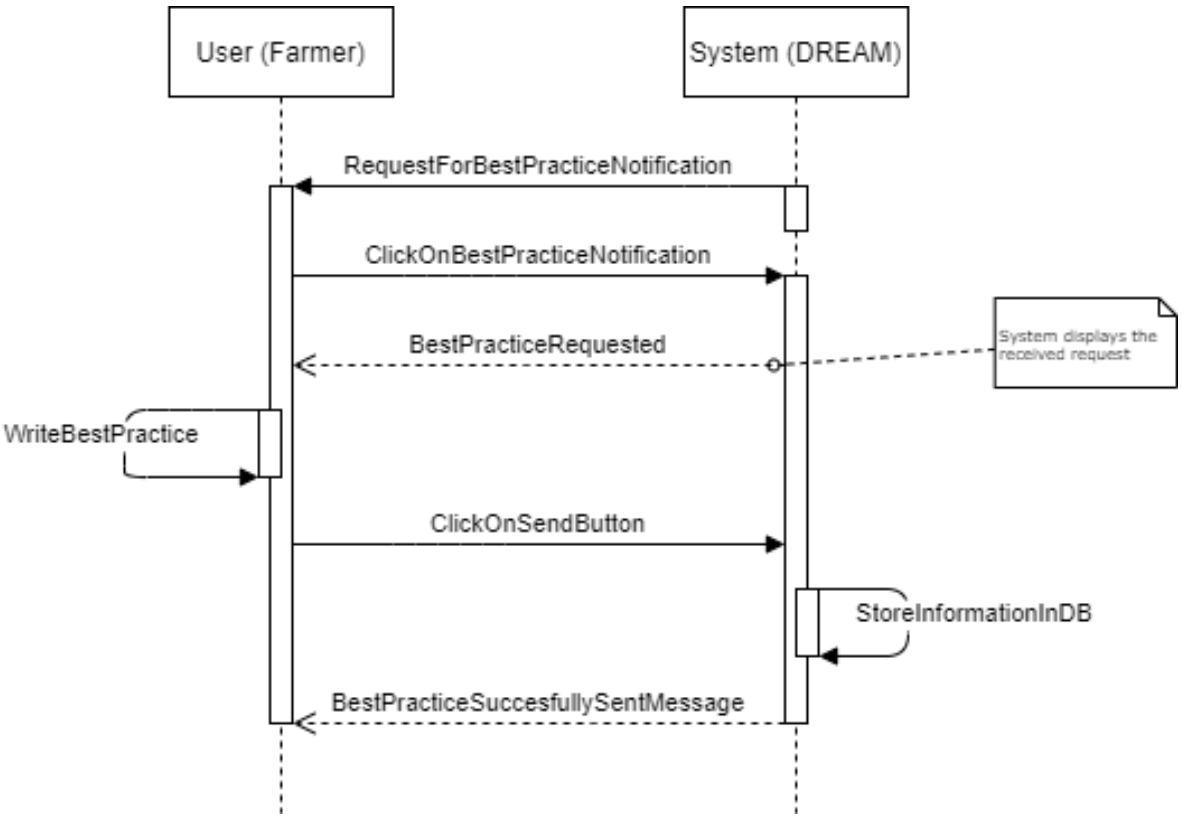
Farmer subscribes to a topic

ID	11
Name	Farmer unsubscribes to a topic
Actor	Farmer
Entry Conditions	• Farmer has logged in • Farmer is on his home page • Farmer is already subscribed to the topic
Input	
Events Flow	• Farmer clicks on “Forums” • System displays a page with different topics • Farmer selects the topic • System displays: – The latest messages related to the selected topic – A search bar to permit the search of messages containing the written key words – The button “New Post” – The button “Unsubscribe” • Farmer clicks the button “Unsubscribe” • System shows a message saying “You have successfully unsubscribed to the topic, you will no more be notified when a new message is added to this topic section” • Farmer displays farmer’s home page
Exit Conditions	Unsubscription has been successfully performed
Output	The subscription is removed from the database of the application
Exceptions	



Farmer unsubscribes from a topic

ID	12
Name	Farmer inserts “Best Practices”
Actor	Farmer
Entry Conditions	• Farmer has logged in • Farmer has received a notification “Request for best practices”
Input	Best practices
Events Flow	• Farmer clicks on the notification “Request for Best Practices” • System displays a page with the text of the received request, a text field for the response and a button “Send” • Farmer inserts the response and clicks “Send” button • System shows a message “Best practices successfully sent” – The system doesn’t actually send the best practices to the policy maker but instead collects some info useful to identify the condition of the farmer (location, production, recent weather...) and stores the response associated with that information in the database. These best practices will be shown as personalized suggestions to Farmers in a similar condition.
Exit Conditions	Best practices have successfully been inserted
Output	Best practices and farmer’s condition are stored in the database of the application
Exceptions	• Farmer selects the “Send” button with an empty message inserted. Systems shows an error message ”You can’t respond with an empty text” and displays again the page with the text field and the button. • Farmer inserts a message in the text field of over 200 characters. Systems shows an error message “A best practice can have at most 200 characters” and displays again the page with the text field (filled with old message) and the button.

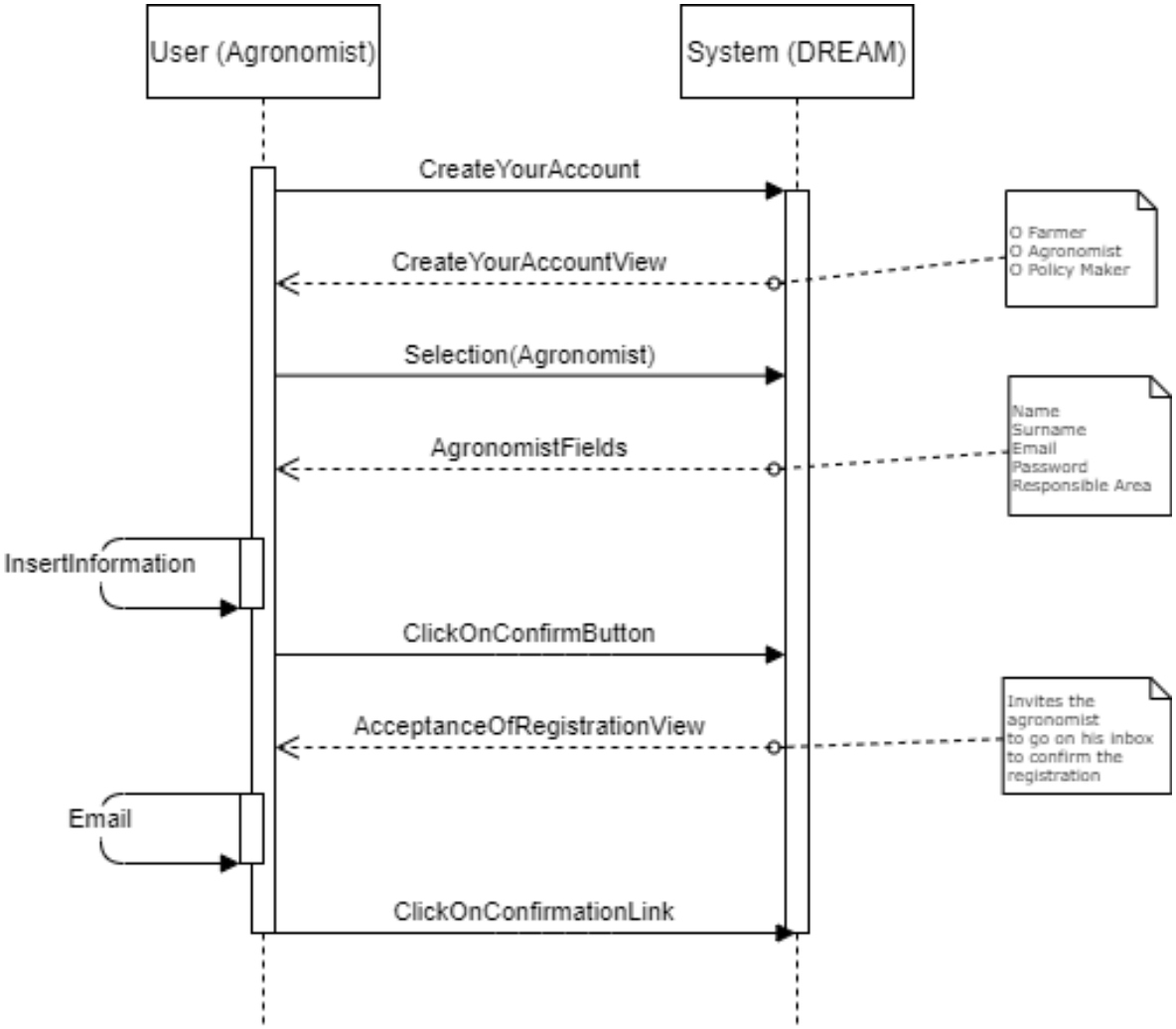


Farmer inserts “Best Practices”

3.2.2 Agronomists use cases

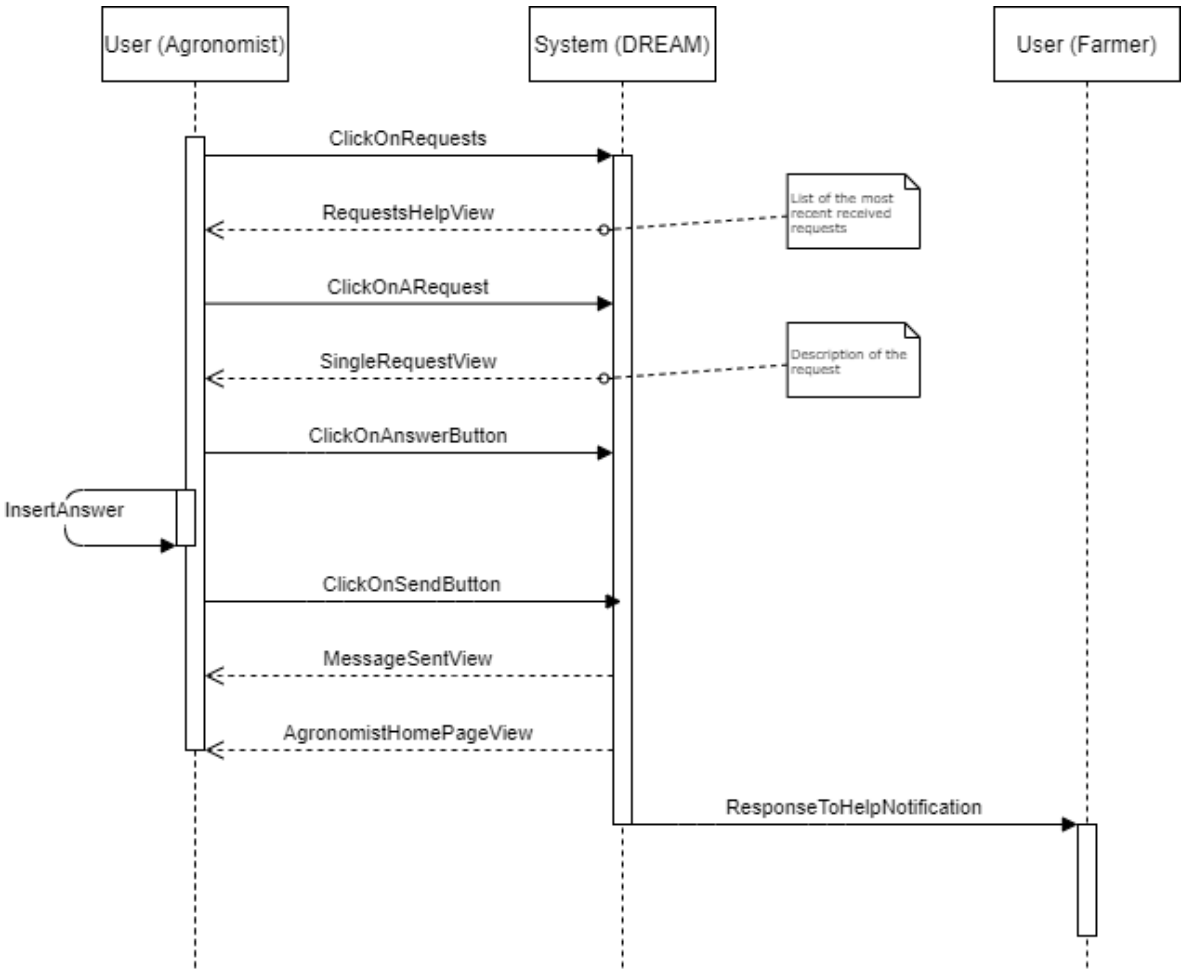
ID	13
Name	Sign Up Agronomist
Actor	Agronomist
Entry Conditions	Agronomist has downloaded and opened the application on his smartphone (on the "Initial App Screen"), or has opened the web page on his personal computer (on the "Initial Web Page").
Input	• Email to use for the registration • Personal data (name, surname) • Responsible area data
Events Flow	• Agronomist clicks on "Create your Account" • System displays a list of alternatives: – Farmer – Agronomist – Policy Maker • Agronomist selects "Agronomist" • System displays a list of fields that the agronomist must compile: – Name – Surname – Email – Password – Responsible Area • Agronomist inserts the mandatory data and accepts the Terms of Services • Agronomist clicks on "Confirm" button • System displays the acceptance of registration and invites agronomist to go on his inbox in order to confirm the registration • Agronomist opens his inbox, checks the emails and clicks on confirmation link
Exit Conditions	Agronomist registration has been successful: agronomist data is stored in the database of the system. Agronomist can now login with his credentials (email and password)
Output	• The email of the agronomist is stored in the database of the application • The agronomist receives the email of confirmation

Exceptions	• Agronomist inserts an email which is already stored in the database. So, after the agronomist inserts his data and clicks on confirm, the application displays an error page which tells that agronomist is already registered to the service and invites him to login with that email. • Agronomist inserts an invalid email. So, after the agronomist clicks on the confirm button, the application displays the same page and an error message, which suggests to the agronomist to check the email inserted or to change it. • Agronomist inserts invalid data (e.g., agronomist is not responsible for the specified area), so, after the agronomist clicks on confirm, the application displays an error page which tells that agronomist has inserted invalid data and invites him to try again the registration.



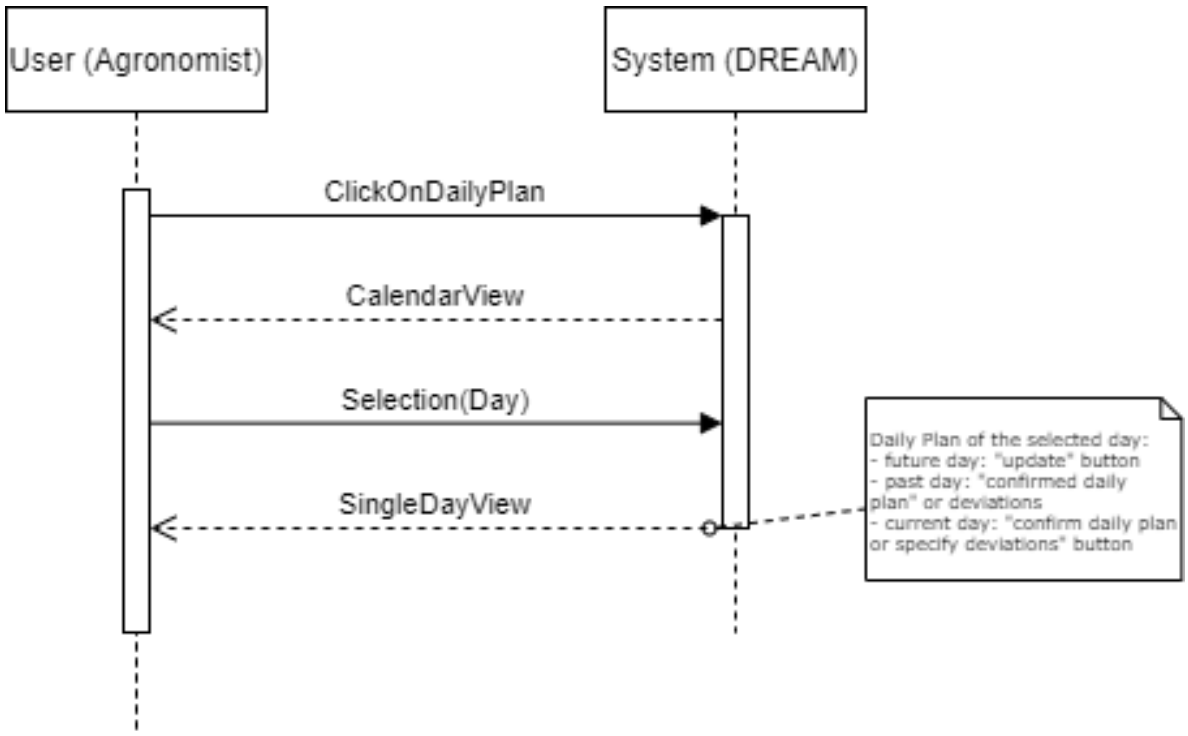
Sign Up Agronomist

ID	14
Name	Agronomist answers to "Request for Help and Suggestions" of farmers
Actor	Agronomist
Entry Conditions	• Agronomist has logged in • Agronomist has received a request for help
Input	Text of the response
Events Flow	• Agronomist clicks on "Requests" – If agronomist directly clicks on the notification of the request, jumps directly to 4th point • System displays a page with a list of the most recent received requests • Agronomist selects a request • System displays the request and an "Answer" button • Agronomist reads the request and selects the "Answer" button • System displays a text field for the response and a "Send" button • Agronomist inserts the text and presses the "Send" button • System shows a message saying "Message sent" • System displays agronomist's home page • System sends a notification to the sender of the request
Exit Conditions	Response has been sent successfully
Output	• The response is stored in the database of the application • Sender of the request gets a notification
Exceptions	• Agronomist selects the "Send" button with an empty message for the response. Systems shows an error message "A response can't be empty" and displays again the page with the text field and the button. • Agronomist inserts a message in the text field of over 400 characters. Systems shows an error message "A response can have at most 400 characters" and displays again the page with the text field (filled with old message) and the button.



Agronomist answers to "Request for Help and Suggestions" of farmers

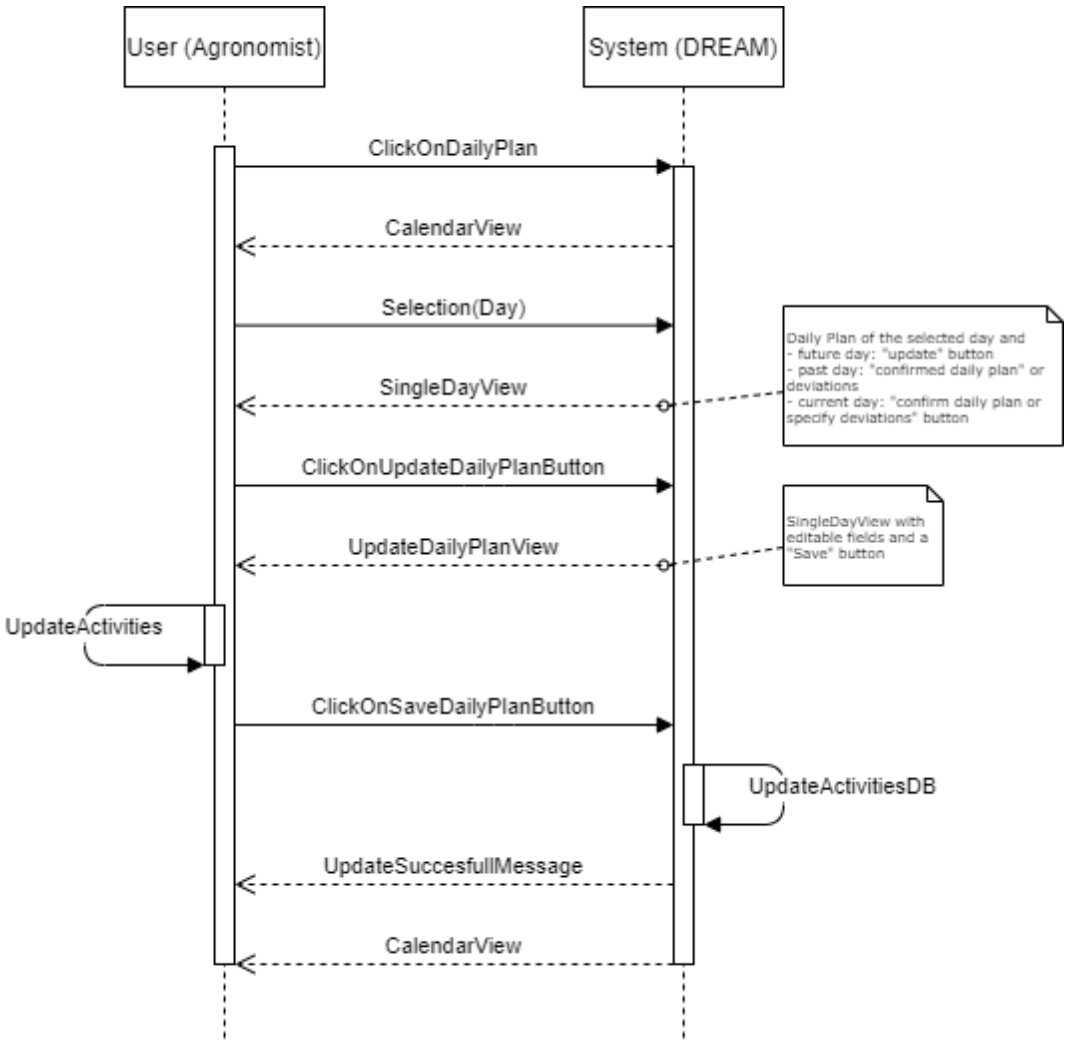
ID	15
Name	Agronomist visualizes daily plan
Actor	Agronomist
Entry Conditions	• Agronomist has logged in • Agronomist is on his home page • Agronomist has already inserted the daily plan he wants to read
Input	
Events Flow	• Agronomist clicks on “Daily Plan” – If agronomist is interested in the daily plan of the following day clicks directly “Read More”, and jumps directly to 4th point • System displays a calendar where a day is coloured if the daily plan of that day has already been inserted • Agronomist selects one of the coloured days • System displays the daily plan of the selected day with: – If the daily plan is of a future day -¿ a button “Update” – If the daily plan is of a past day -¿ the String “Confirmed Daily Plan” or the specified deviations – If the daily plan is of the current day -¿ the String “Confirmed Daily Plan” or the specified deviations if they’ve already been inserted, otherwise the button “Confirm/Specify Deviations”
Exit Conditions	Daily plan is successfully visualized
Output	Daily plan is shown to the Agronomist
Exceptions	• Agronomist selects a non-coloured day. The system shows the page of the insertion of a daily plan and continues with that use-case. • Agronomist has no daily plan available (all days are non-coloured). The agronomist can only return to the home page or add a new daily plan.



Agronomist visualizes daily plan

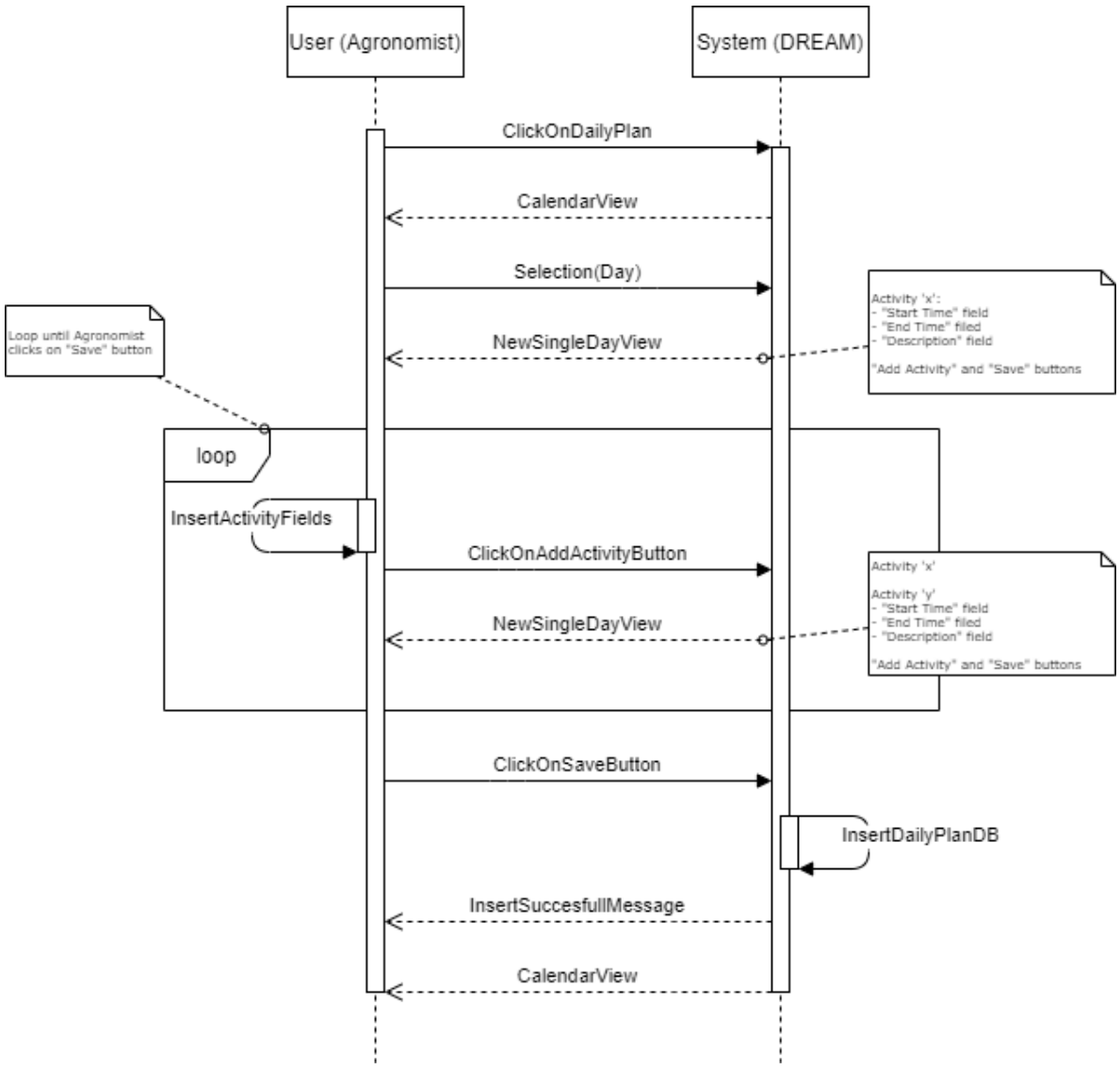
ID	16
Name	Agronomist updates a daily plan
Actor	Agronomist
Entry Conditions	• Agronomist has logged in • Agronomist is on his home page • Agronomist has already inserted the daily plan he wants to update • Agronomist is performing the update at least one day before the one of the daily plan
Input	Changes in the daily plan
Events Flow	• Agronomist clicks on "Daily Plan" – If agronomist is interested in the daily plan of the following day clicks directly "Read More", and jumps directly to 4th point • System displays a calendar where a day is coloured if the daily plan of that day has already been inserted • Agronomist selects one of the coloured days • System displays the daily plan of the selected day with: – If the daily plan is of a future day -¿ a button "Update" – If the daily plan is of a past day -¿ the String "Confirmed Daily Plan" or the specified deviations – If the daily plan is of the current day -¿ the String "Confirmed Daily Plan" or the specified deviations if they've already been inserted, otherwise the button "Confirm/Specify Deviations" • Agronomist clicks on the "Update" button (assuming it's present) • System shows a "Save" button and each activity of the daily plan with its own start, end time and description, all in editable fields. • Agronomist updates the daily plan modifying the editable fields and clicks on "Save" button • System shows a message "Daily plan updated successfully" • System displays the calendar of the daily plans
Exit Conditions	Daily plan is updated successfully
Output	The selected daily plan is updated in the database of the application

Exceptions	• Agronomist selects a non-coloured day. The system shows the page of the insertion of a daily plan and continues with that use-case. • Agronomist has no daily plan available (all days are non-coloured). The agronomist can only return to the home page or add a new daily plan. • Agronomist tries to modify the daily plan overlapping 2 events. The system shows a message saying "You can't overlap 2 visits" and displays again the editable daily plan. • Agronomist tries to modify the daily plan by leaving one of the fields empty. The system shows a message saying "All the fields must be filled" and displays again the editable daily plan. • Agronomist tries to modify the daily plan of the current day or of a past day. System simply doesn't display the "Update" button



Agronomist updates daily plan

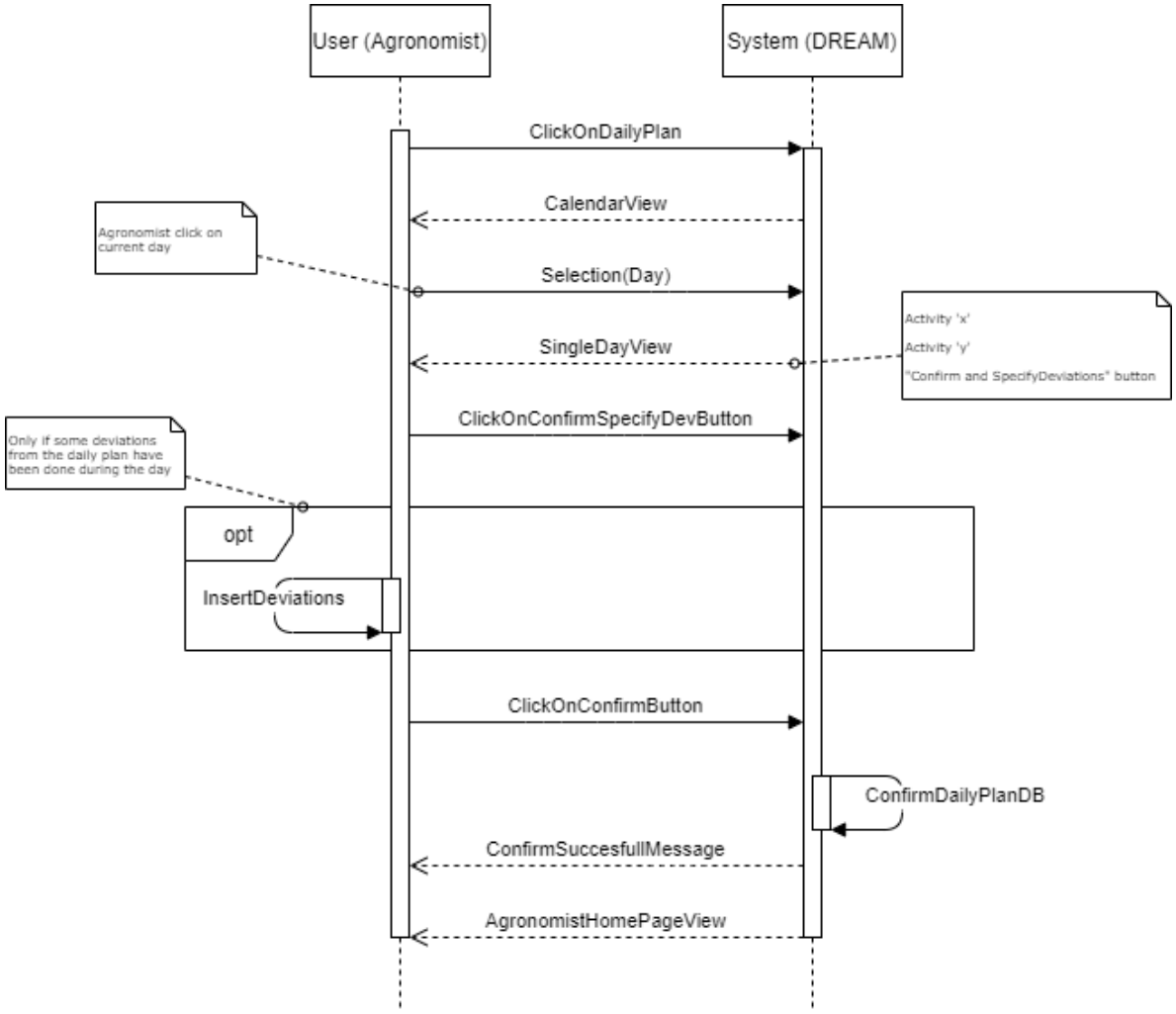
ID	17
Name	Agronomist inserts a daily plan
Actor	Agronomist
Entry Conditions	• Agronomist has logged in • Agronomist is on his home page
Input	New daily plan
Events Flow	• Agronomist clicks on "Daily Plan" • System displays a calendar where a day is coloured if the daily plan of that day has already been inserted • Agronomist selects one of the non-coloured days • System displays – 3 editable fields (start, end time and description of the task) for the first activity – The button "Add Activity" – The button "Save" • Agronomist compiles the editable fields of the activity – Selects "Save" if all the tasks of his daily plan have been inserted (go ahead to 6th point) – Selects "Add Activity" if he wants to add another activity, and the system displays the 3 fields of a new activity and the 2 buttons (back to 3rd point) • System checks if the daily plan is coherent and shows a message "Daily plan inserted successfully" • System displays the calendar of the daily plans
Exit Conditions	Daily plan is inserted successfully
Output	The daily plan is inserted in the database of the application
Exceptions	• Agronomist selects a coloured day. The system shows the daily plan as in the visualize/update daily plan use cases. • Agronomist tries to insert a daily plan overlapping 2 events. The system shows a message saying "You can't overlap 2 visits" and displays again the editable daily plan. • Agronomist tries to insert a daily plan with one (or 2) of the fields of an activity empty. The system shows a message saying "All the fields must be filled" and displays again the editable daily plan.



Agronomist inserts daily plan

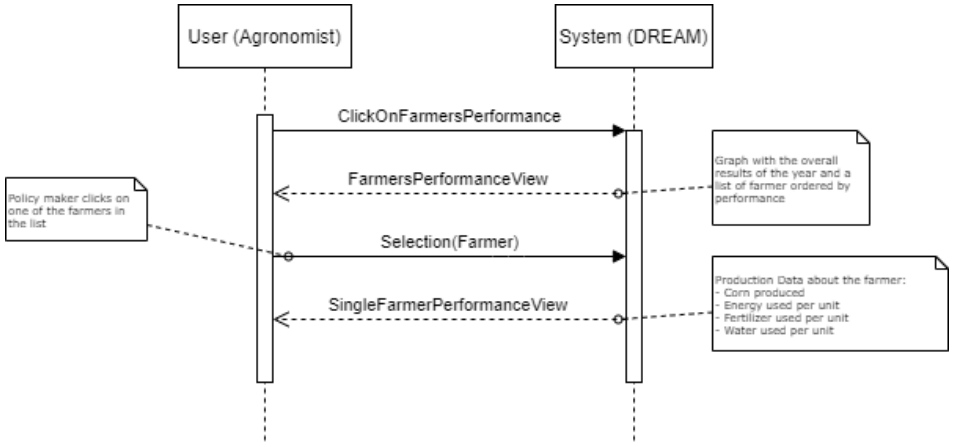
ID	18
Name	Agronomist confirms the execution of the daily plan, or specifies deviations
Actor	Agronomist
Entry Conditions	• Agronomist has logged in • Agronomist is on his home page
Input	Optional: deviations from the daily plan
Events Flow	• Agronomist clicks on "Daily Plan" • System displays a calendar where a day is coloured if the daily plan of that day has already been inserted • Agronomist selects the current day • System displays the daily plan of the selected day with the button "Confirm/Specify Deviations" • Agronomist clicks "Confirm/Specify Deviations" • System displays a page with a field "Add here your deviations from the daily plan" and a button "Confirm" • Farmer inserts deviations if presents and clicks "Confirm" (if no deviations are specified the daily plan will be considered as without any deviations, so executed perfectly) • System shows the message "Today's work successfully confirmed" • System displays agronomist's home page
Exit Conditions	Daily plan is successfully confirmed or deviations are successfully specified
Output	The confirmation (and eventual deviations) of the daily plan is inserted in the database of the application

Exceptions	
	• Agronomist still hasn't inserted a daily plan for the current day. The system continues with the insert daily plan use case, and only after the insertion the user will be able to restart with this use case • Agronomist selects a day which is not the current one. The system simply won't' display the button "Confirm/specify deviations" but will display the daily plan of the selected day with: – if has selected a future day -¿ a button "Update" – if has selected a past day -¿ the String "confirmed daily plan" or the specified deviations • Agronomist tries to confirm/specify deviations to the current day but he has already done it. The system simply displays the daily plan of the selected day with the String "confirmed daily plan" or the specified deviations if they've been inserted



Agronomist confirms daily plan or specify deviations

ID	19
Name	Agronomist visualizes performances (production data) of the farmers
Actor	Agronomist
Entry Conditions	• Agronomist has logged in • Agronomist is on his home page
Input	
Events Flow	• Agronomist clicks on "Farmer's performance" – If agronomist clicks on a received notification of a reported bad performing farmer, in this case jump directly to 4) • System displays: – A graph with the result of the current year of his area compared to the same period of the previous one – A list of farmers ordered by performances from the best one to the worst one – A button "Order from worst performances" to reverse the order • Agronomist selects one of the farmers • System displays the production of the selected farmer – Amount of corn produced – Amount of energy used per unit – Amount of fertilizer used per unit – Amount of water used per unit
Exit Conditions	Agronomist has successfully checked the production of the selected farmer
Output	Agronomist sees farmer's performances
Exceptions	

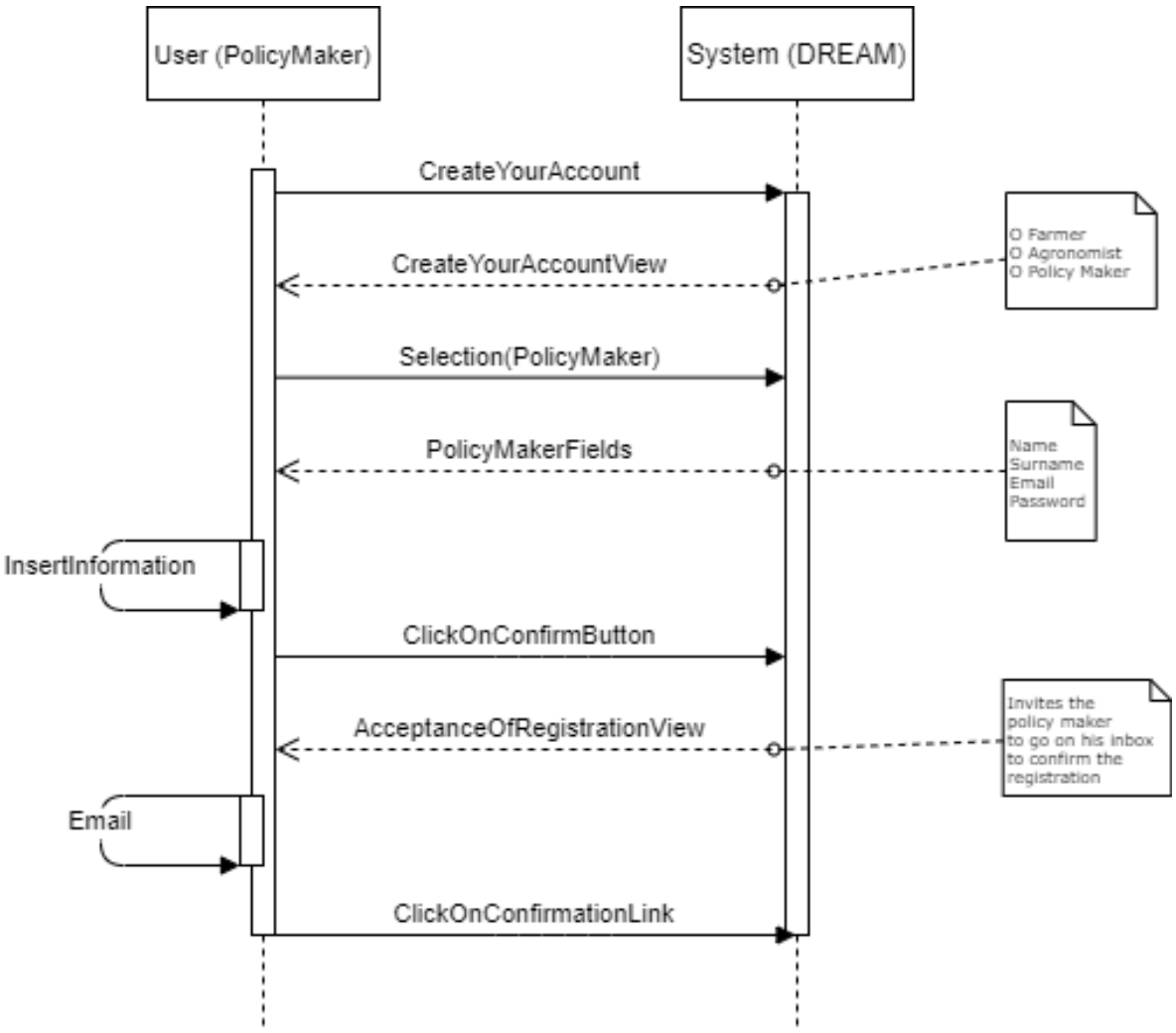


Agronomist visualizes performances (production data) of the farmers

3.2.3 Policy Maker use cases

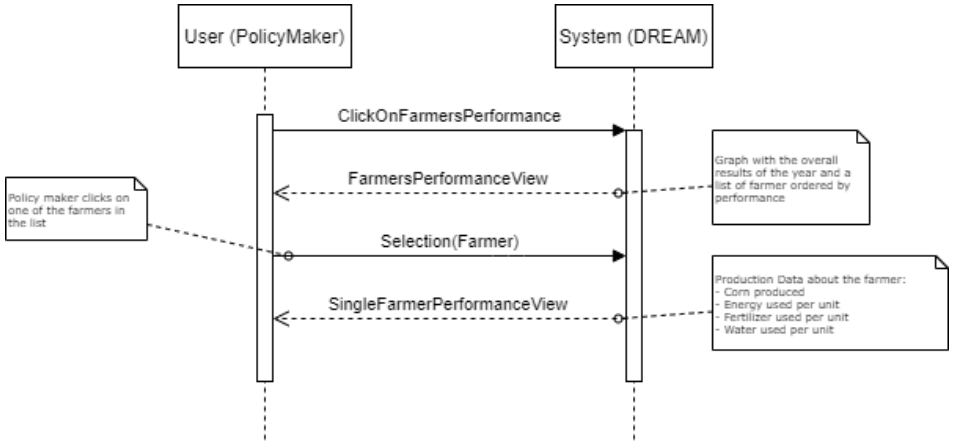
ID	20
Name	Sign Up Agronomist
Actor	Policy Maker
Entry Conditions	Policy Maker has downloaded and opened the application on his smartphone (on the "Initial App Screen"), or has opened the web page on his personal computer (on the "Initial Web Page").
Input	• Email to use for the registration • Personal data (name, surname)
Events Flow	• Policy maker clicks on "Create your Account" • System displays a list of alternatives: – Farmer – Agronomist – Policy Maker • Policy Maker selects "Policy Maker" • System displays a list of fields that the policy maker must compile: – Name – Surname – Email – Password • Policy Maker inserts the mandatory data and accepts the Terms of Services • Policy Maker clicks on "Confirm" button • System displays the acceptance of registration and invites policy maker to go on his inbox in order to confirm the registration • Policy Maker opens his inbox, checks the emails and clicks on confirmation link
Exit Conditions	Policy maker registration has been successful: policy maker data is stored in the database of the system. Policy maker can now login with his credentials (email and password)
Output	• The email of the policy maker is stored in the database of the application • The policy maker receives the email of confirmation

Exceptions	• Policy maker inserts an email which is already stored in the database. So, after the policy maker inserts his data and clicks on confirm, the application displays an error page which tells that policy maker is already registered to the service and invites him to login with that email. • Policy maker inserts an invalid email. So, after the policy maker clicks on the confirm button, the application displays the same page and an error message, which suggests to the policy maker to check the email inserted or to change it. • Policy maker inserts invalid data (e.g., the user is not a policy maker), so, after the policy maker clicks on confirm, the application displays an error page which tells that policy maker has inserted invalid data and invites him to try again the registration.



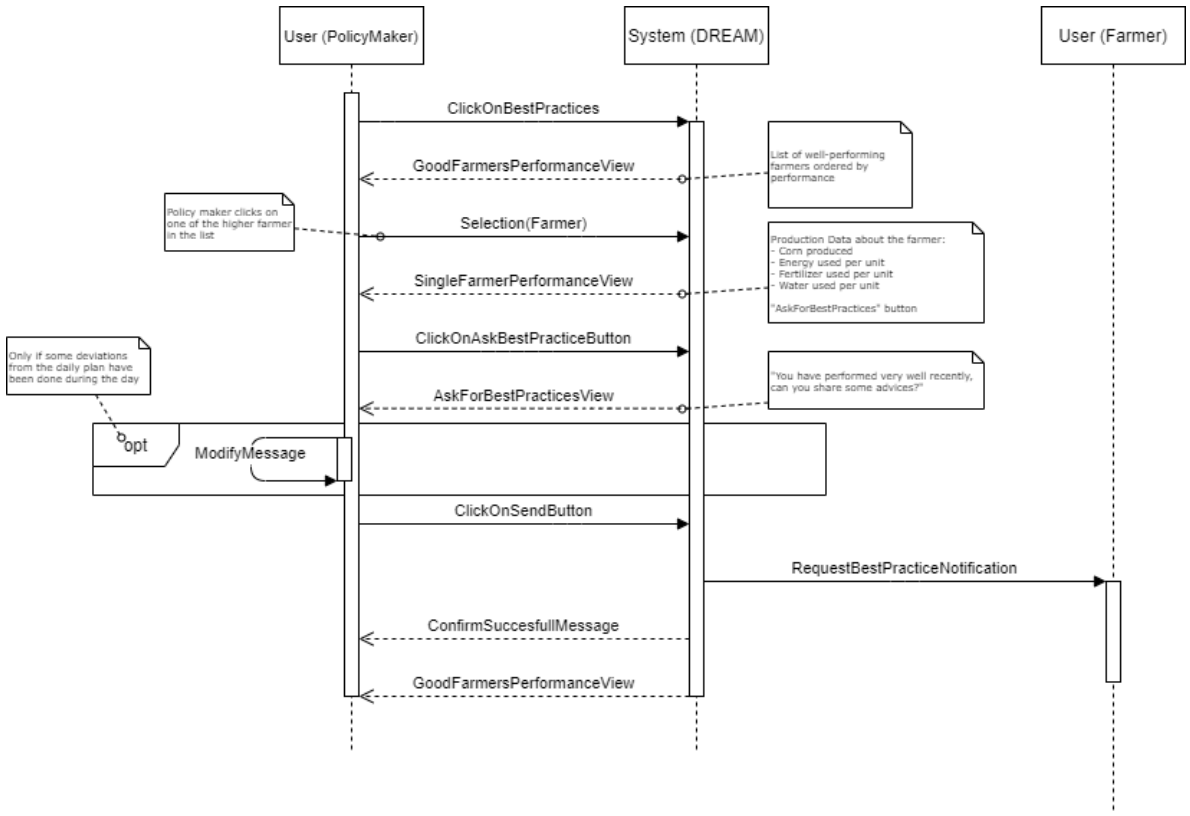
Sign Up Policy Maker

ID	21
Name	Policy Maker visualize performances (production data) of the farmers
Actor	Policy Maker
Entry Conditions	• Policy maker has logged in • Policy maker is on his home page
Input	
Events Flow	• Policy maker clicks on "Farmer's performance" • System displays: – A graph with the overall result of the current year compared to the same period of the previous one – A list of farmers ordered by performances from the best one to the worst one – A button "Order from worst performances" to reverse the order • Policy maker selects one of the farmers • System displays the production of the selected farmer: – Amount of corn produced – Amount of energy used per unit – Amount of fertilizer used per unit – Amount of water used per unit – If the farmer is performing better than the average (and hasn't received a best-practices request in the last 40 days) a button "Ask for best practices"
Exit Conditions	Policy maker has successfully checked the overall production and the production of a selected farmer
Output	Policy maker sees information about crops and farmers production
Exceptions	



Policy Maker Visualize Performance Data of Farmers

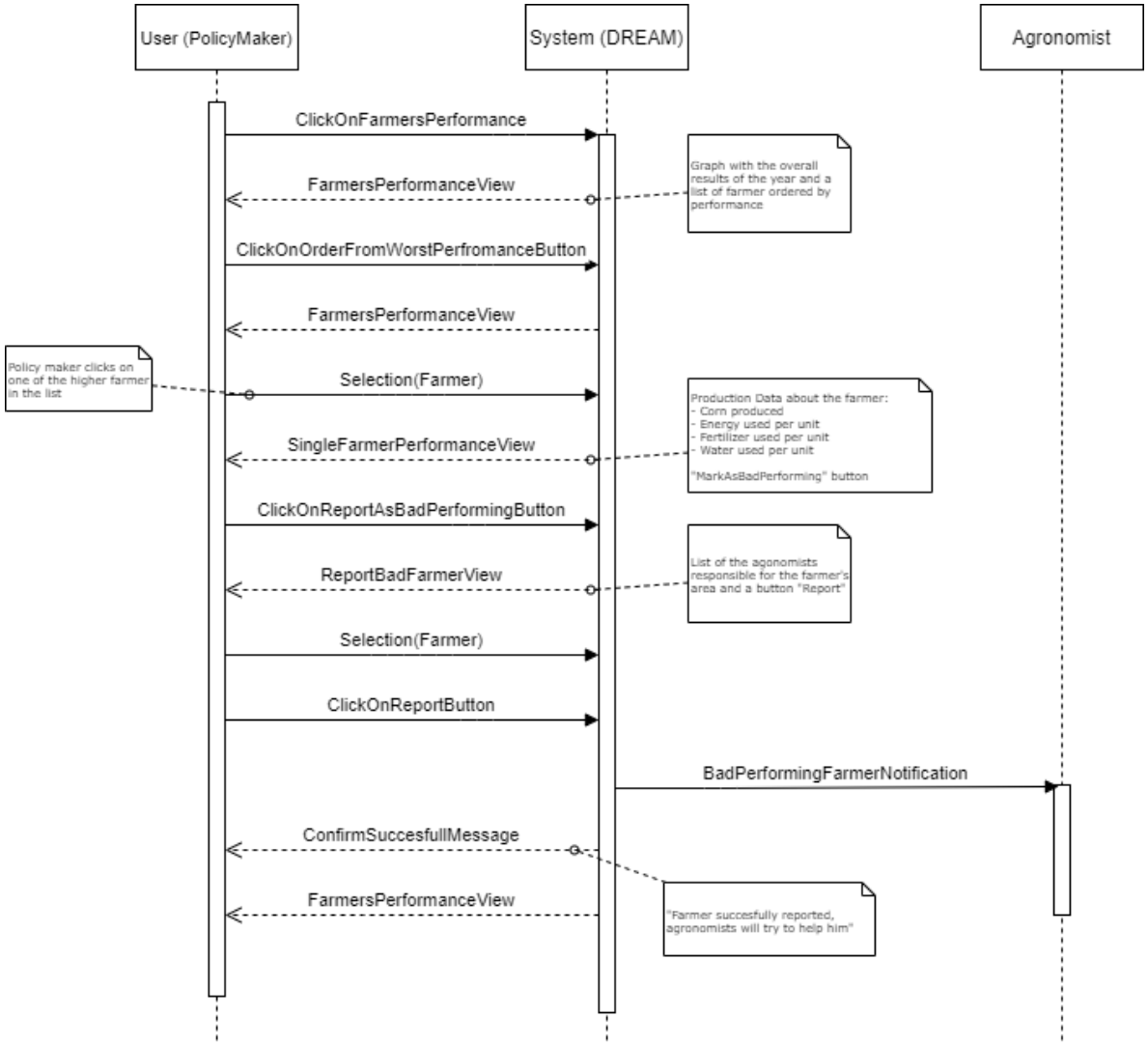
ID	22
Name	Policy Maker asks for “Best Practices” to a farmer
Actor	Policy Maker
Entry Conditions	• Policy maker has logged in • Policy maker is on his home page
Input	
Events Flow	• Policy maker clicks on “Best Practices” – Policy Maker can also click on “Farmer’s performance”, select a farmer and click on “Ask for best practices” if the button is present; in this case jump directly to 5th point. • System displays a list of the farmers performing better than the average ordered by performances (from the best one) where farmers which have already received a request in the past 40 days are marked. • Policy maker selects one of the top farmers (the higher it is the best it is performing) • System displays the production of the selected farmer: – Amount of corn produced – Amount of energy used per unit – Amount of fertilizer used per unit – Amount of water used per unit – A button “Ask for Best Practices” • System displays a text field pre-compiled saying “You have performed very well recently, can you share some advice?” and a button “Send” • Policy maker modifies the message if needed and clicks “Send” button • System notifies the farmer receiver of the request • System shows the message “Request of best practices successfully sent” • System displays the “Best Practices” section
Exit Conditions	Policy maker has successfully requested best practices to a well performing farmer
Output	Request of best practices is sent to selected the farmer
Exceptions	Policy maker selects a marked farmer, trying to ask for best practices to a farmer which has already received a request in the last 40 days. When the policy maker clicks on “Ask for best practices”, the system shows the message “You have already requested best practices to this farmer in the last 40 days” and displays the Best practices section again.



Policy Maker Ask for Best Practices to well-performing Farmers

ID	23
Name	Policy maker reports a bad performing farmer
Actor	Policy Maker
Entry Conditions	• Policy maker has logged in • Policy maker is on his home page
Input	
Events Flow	• Policy maker clicks on "Farmer's performance" • System displays – A graph with the overall result of the current year compared to the same period of the previous one – A list of farmers ordered by performances from the best one to the worst one – A button "Order from worst performances" to reverse the order • Policy maker clicks the button "Order from worst performances" • System displays again the same page but with farmers ordered in the opposite direction (worst on top) and this time the button "Order from good performances" • Policy maker selects a bad performing farmer • System displays the production of the selected farmer – Amount of corn produced – Amount of energy used per unit – Amount of fertilizer used per unit – Amount of water used per unit – If the farmer is performing worse than the average a button "Report as bad Performing" • Policy maker clicks "Report as bad performing" • System shows the agronomists responsible for the area to which the farmer is related (could be more than 1) and a button "Report" • Policy maker selects an agronomist and clicks "Report" • System notifies the selected agronomist with the received report • System shows the message "Report successfully sent" • System displays "Farmer's performances" section
Exit Conditions	Policy maker has successfully reported the bad performing farmer

Output	Selected agronomist receives the report with the bad performing farmer
Exceptions	Policy maker clicks “Report as bad performing” on a farmer already reported in the last 40 days. The system shows the message “You have already reported this farmer in the last 40 days” and displays the “Farmer’s performances” section again.

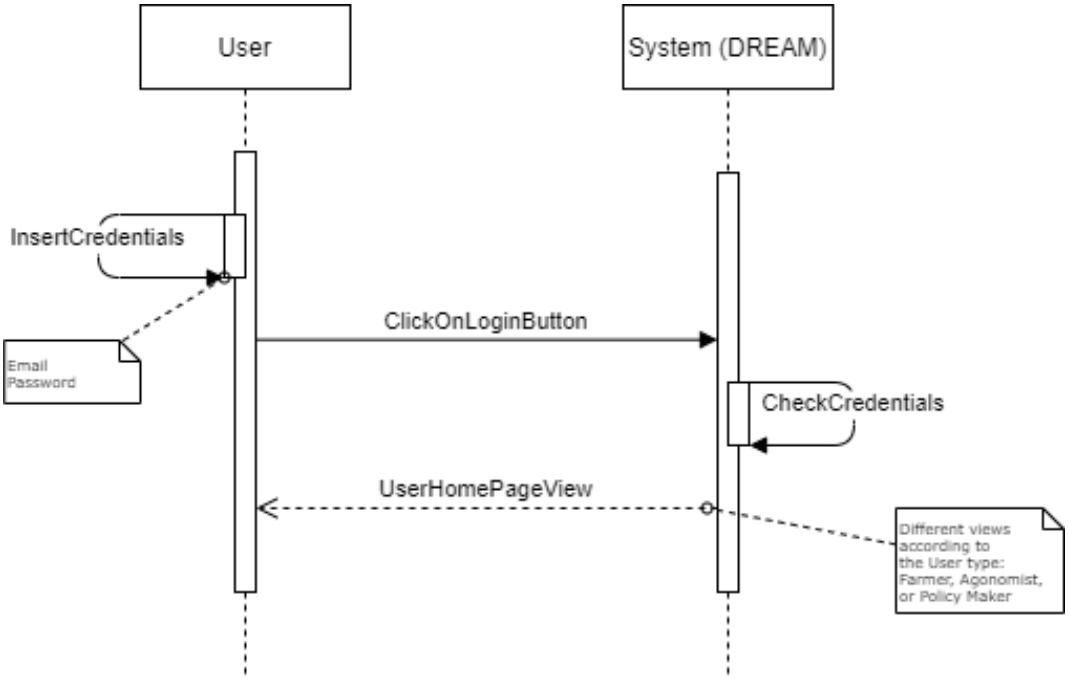


Policy Maker reports a bad-performing Farmer

3.2.4 User use cases

User stands for general actor, so it could be agronomist, farmer or policy maker.

ID	24
Name	Login user
Actor	User (agronomist, farmer, or policy maker)
Entry Conditions	• User has downloaded and opened the application on his smartphone (on the "Initial App Screen"), or has opened the web page on his personal computer (on the "Initial Web Page"). • User has registered to the service
Input	• Email • Password Email
Events Flow	• User inserts "Email" and "Password" in apposite fields • User clicks on "Login" • System checks the correctness of the credential inserted • System displays user's home page
Exit Conditions	User is logged in
Output	System shows user's home page
Exceptions	User inserts wrong credentials. The system displays the login page with an error saying "Wrong credentials".



User Login

3.2.5 Requirements

- R1: The system shall allow the registration of new users of three different types: farmer, agronomists and policy makers.
- R2: The system shall elaborate a list of suggestions for the registered farmer user.
- R3: The system shall allow the farmer user to send help or suggestions requests to a selected agronomist user or farmer user.
- R4: The system shall send a notification to the farmer user when he receives requests for best practices or new answers or requests in the help requests or forum threads.
- R5: The system shall allow a farmer user to read and respond to threads in the farmer forums.
- R6: The system shall allow a farmer to insert production data.
- R7: The system shall allow the farmer user to respond to a request for best practices.
- R8: The system shall present an accurate weather forecast for the days following the current one to both farmer users and agronomists.
- R9: The systems shall allow an agronomist user to respond to help and suggestions requests received by farmer users.
- R10: The system shall send a notification to the agronomist user when a help request is received or a farmer is reported as "bad performing".
- R11: The system shall present to agronomist users and policy maker users all the performance data that are available.
- R12: The system shall allow agronomist users to insert and modify a daily plan
- R13: The system shall allow the agronomist to confirm the execution of the daily plan or specify its deviations
- R14: The system shall not allow the creation of a daily plan if a farmer is not receiving it's mandatory visits, that must be at least twice a year, and the day is the last available. Consequently it shall notify the exception to the agronomist user.
- R15: The system shall present the daily plan to the agronomist user.
- R16: The system shall allow policy maker users to send to farmer users requests for best practices. 17: The system shall allow policy maker to report bad performing farmers to agronomists

This paragraph will summarize the goals described in section 1.2, showing the requirements and the domain assumptions for each of them.

- G1: Increase the overall welfare and production of the Telangana region.
  - R2 - R3 - R5 - R6 - R7 - R8 - R9 - R11 - R17
  - D1: Users (farmers, agronomists, and policy makers) do not insert false information in the system.
  - D2: Farmers reply as best as they can, giving the best advice, to requests for help and suggestions by other farmers.
  - D6: Users have access to a stable Internet connection.
- G2: Aid policy makers in the decisional process.
  - R1 - R6 - R11 - R16 - R17
  - D1: Users (farmers, agronomists, and policy makers) do not insert false information in the system.
  - D6: Users have access to a stable Internet connection.
- G3: Aid the farmers in the management of their productions.
  - R1 - R2 - R3 - R4 - R5 - R6 - R7 - R8 - R9
  - D1: Users (farmers, agronomists, and policy makers) do not insert false information in the system.
  - D2: Farmers reply as best as they can, giving the best advice, to requests for help and suggestions by other farmers.
  - D4: Each area has at least one responsible agronomist.
  - D5: Each farm is assigned to a specific area and has a unique identifier.
  - D6: Users have access to a stable Internet connection.
  - D7: The location of a farm is known by the application, and the responsible agronomist is able to reach the farm.
- G4: Aid agronomist works to help farmers and check crops production.
  - R1 - R3 - R6 - R8 - R9 - R10 - R11 - R12 - R13 - R14 - R15 - R17
  - D1: Users (farmers, agronomists, and policy makers) do not insert false information in the system.
  - D3: Agronomists know the area they are responsible for.
  - D4: Each area has at least one responsible agronomist.
  - D6: Users have access to a stable Internet connection.
  - D7: The location of a farm is known by the application, and the responsible agronomist is able to reach the farm.

3.3 Software System Attributes

3.3.1 Reliability

The system should be able to run continuously (with maintenance interruption scheduled in less crowded hours) in order to keep all the functionalities accessible with no interruptions (such as the forum). The highest number of simultaneous users is expected at the end of each day when all the agronomists confirm (or specify deviations) their daily plan and farmers control weather forecasts of the following day.

3.3.2 Availability

The system must have a minimum availability of 96

3.3.3 Security

All the information (such as registration data) must be kept private to all non authenticated and authorized users (ex. The location of each farm must be known only to the agronomists related to that area). Communication between parties should take place on secure channels in order to provide encryption, authentication and integrity (to prevent interception, modification and fabrication of messages).

3.3.4 Maintainability

The code will be well-documented using JavaDoc to enable developers to easily understand it. It will be designed in order to permit future additions of functionalities with minimum effort and will follow the object oriented model-controller-view pattern (to achieve a higher separation of concerns).

3.3.5 Portability

The back-end server software will be written in Java and will be able to run on every platform that supports the JVM. The front end will be supported by the current versions of Safari, Mozilla Firefox and Chrome, and by the latest 3 versions of Android/IOS for the mobile application.

4 Formal analysis using Alloy

4.1 Alloy Code

```
sig Text{}

abstract sig User {
        email: one Email,
        password: one Text,
        name: one Text,
        surname: one Text
}

sig Email{}

sig Farmer extends User {
        farm: one Farm
}

sig Farm {
        farmName: one Text,
        farmPosition: one Position,
        belongingArea: one Area,
        ownerName: one Farmer
}

sig Position{}

sig Agronomist extends User {
        area: one Area,
        plan: one Plan
}

sig Area{}

sig PolicyMaker extends User {}

sig Plan {
        visits: some Visit
}

sig Visit {
        day: one Day,
        initialHour: one Hour,
        endHour: one Hour,
        motivation: one Text,
        farm: one Farm
}

sig Day{}
sig Hour{}

sig ProductionData {
        data: set FarmerProduction
}

sig FarmerProduction {
        cropType: one CropType,
        weather: one WeatherForecast,
        cropQuantity: one CropQ,
        energy: one EnergyQ,
        fertilizer: one Fertilizer,
        water: one WaterQ,
        farm: one Farm,
        day: one Day
}

sig CropType{}
sig CropQ{}
sig EnergyQ{}
sig Fertilizer{}
sig WaterQ{}

sig BestPractices {
        bestPractice: set BestPractice
}

sig BestPractice {
        content: one Text,
        farmerData: one FarmerProduction,
        request: one BestPracticeRequest
}
```

```
sig BestPracticeRequest {
        recipientEmail: one Email,
        day: one Day,
        hour: one Hour
}

sig WeatherForecast {
        forecasts: some Forecast
}

sig Forecast {
        day: one Day,
        time: one Hour,
        position: one Position,
        weather: one Weather, //rain, sun, ...
        temperature: one TemperatureQ,
        humidity: one HumidityQ,
        wind: one WindQ
}

sig Weather{}
sig TemperatureQ{}
sig HumidityQ{}
sig WindQ{}

sig HelpAndSuggestions {
        list: set Conversation
}

sig Conversation{
        content: some Message,
        participantUsers: some Email
}

sig Message {
        text: one Text,
        email: one Email,
        day: one Day,
        time: one Hour
}

sig Forum {
        pages: set ForumPage
}

sig ForumPage {
        category: one Text,
        name: one Text,
        posts: set ForumThread
}

sig ForumThread {
        postTitle: one Text,
        creatorFarmer: one Farmer,
        object: one Text,
        messages: set Message
}

sig PersonalizedSuggestions {
        suggestions: set Suggestions,
        destinationFarmer: one Farmer
}

sig Suggestions{}

-----------------------------------------------------------------



fact {
        //Two user can't have the same email address
        no disj u1, u2: User | u1.email = u2.email
}

fact {
        //Every Area has at least one responsible agronomist
        all a: Area |
                some b : Agronomist | b.area = a
}

fact {
        //Every farmer is associated to one and only one farm
```

```
        all f: Farmer, f2: Farm |
                        (f.farm = f2 implies f2.ownerName = f) and
                        (f2.ownerName = f implies f.farm = f2)
}

fact {
        //Two farm can't be in the same position
        no disj f1, f2: Farm | f1.farmPosition = f2.farmPosition
}

fact {
        //Every farmer has a unique personalized suggestion
        all f: Farmer |
                one sug: PersonalizedSuggestions | sug.destinationFarmer = f
}

fact {
        //Every agronomist has a unique plan
        all p : Plan |
                one a : Agronomist | a.plan = p
}

fact {
        //Every mail in a message should belong to a user
        all e: Message.email |
                some u : User | u.email = e
}

fact {
        //Every mail in a conversation should belong to a user
        all e: Conversation.participantUsers |
                some u : User | u.email = e
}

fact {
        //Can't have different forecast for the same time and day
        no disj f1, f2: Forecast |
                f1.day = f2.day and f1.time = f2.time and f1.position = f2.position and
                (f1.temperature ≠ f2.temperature or f1.weather ≠ f2.weather or f1.humidity ≠ f2.
                    ↪ humidity or f1.wind ≠ f2.wind)

}

fact {
        //Message in a conversation must have email only from user participating to the
            ↪ conversation
        all conv: Conversation |
                all mess: conv.content | some participant: conv.participantUsers | mess.email =
                    ↪ participant
}

fact {
        //All forum thread must participate to one Forum page
        all ft : ForumThread |
                one fp : ForumPage | ft in fp.posts
}

fact {
        //The email of the Best practice request must belong to a farmer
        all bpr: BestPracticeRequest |
                one farmer: Farmer | farmer.email = bpr.recipientEmail
}

fact {
        //You can't have a Conversation with a policy maker
        no convEm: Conversation.participantUsers |
                some pm: PolicyMaker | pm.email = convEm
}

fact {
        //All conversation must participate to HelpAndSuggestions
        all c: Conversation |
                c in HelpAndSuggestions.list

}

fact {
        //All Visit must participate to a Plan
        all v: Visit |
                v in Plan.visits

}

fact {
```

```
        //A BestPracticeRequest must have mail corresponding to the BestPractice
        all bp: BestPractice |
                bp.request.recipientEmail = bp.farmerData.farm.ownerName.email
}

fact {
        //only farmers can participate to the forum
        all forumEm: ForumThread.messages.email |
                some f: Farmer | f.email = forumEm
}

fact {
        //every visits should belong to the area of competence of the agronomist
        all a: Agronomist |
                all visit: a.plan.visits | a.area = visit.farm.belongingArea
}

fact {
        //all FarmerProduction should belong to ProductionData
        all fp: FarmerProduction |
                one pd: ProductionData | fp in pd.data
}


-------------------------------------------------------------------


//Every farmer has at least one connected agronomist
assert farmerHasAgronomist {
        all f: Farmer |
                some a: Agronomist | a.area = f.farm.belongingArea
}
//check farmerHasAgronomist

//Every message in conversation must belong to a farmer or an agronomist
assert noPolicyMakerInConversation {
        all c: Conversation |
                all userEm : c.participantUsers |
                        (some f: Farmer | f.email = userEm) or (some a: Agronomist | a.email =
                            ↪ userEm)
}
//check noPolicyMakerInConversation

//No message in a conversation has an email different from the participant to the conversation
assert noMessageFromStranger {
        no conv: Conversation |
                some message: conv.content |
                        message.email not in conv.participantUsers
}
//check noMessageFromStranger


-------------------------------------------------------------------


//The first world has the aim to present all communication method present to the farmer
pred world1 {
        #Farmer = 2
        #Agronomist = 1
        #Visit = 2
        #PolicyMaker = 0
        #HelpAndSuggestions = 1
        #Conversation = 2
        #BestPracticeRequest = 0
        #BestPractice = 0
        #ForumThread = 1
        #ForumPage = 2
        #Suggestions = 1
        #Forecast = 0
        #ProductionData = 0
        #WeatherForecast = 0
        #Message = 3
}

//The second world puts the emphasis on the Agronomist and his instruments
pred world2 {
        #Farmer = 2
        #Agronomist = 3
        #Visit = 4
        #PolicyMaker = 0
        #HelpAndSuggestions = 0
        #Conversation = 0
        #BestPracticeRequest = 0
        #BestPractice = 0
```

```
        #ForumThread = 0
        #Suggestions = 0
        #Forecast = 0
        #ProductionData = 0
        #WeatherForecast = 0
        #Message = 0
        #Area = 2
        #Forum = 0
        #ForumPage = 0
}

//The third world show what is inherent with the policy maker
pred world3 {
        #Farmer = 2
        #Agronomist = 1
        #Visit = 1
        #PolicyMaker = 2
        #HelpAndSuggestions = 0
        #Conversation = 0
        #BestPracticeRequest = 2
        #BestPractice = 2
        #ForumThread = 0
        #Suggestions = 0
        #Forecast = 1
        #ProductionData = 1
        #FarmerProduction = 2
        #WeatherForecast = 1
        #Message = 0
        #Area = 1
        #Forum = 0
        #ForumPage = 0
        no disj bpr1, bpr2 : BestPracticeRequest | bpr1.recipientEmail = bpr2.recipientEmail
}

//run world1 for 5
//run world2 for 5
//run world3 for 5
```

4.2 Worlds

4.2.1 World 1

This world is built to show all the entities that are of most interest to the farmer, to showcase all the possible means of communication he has.

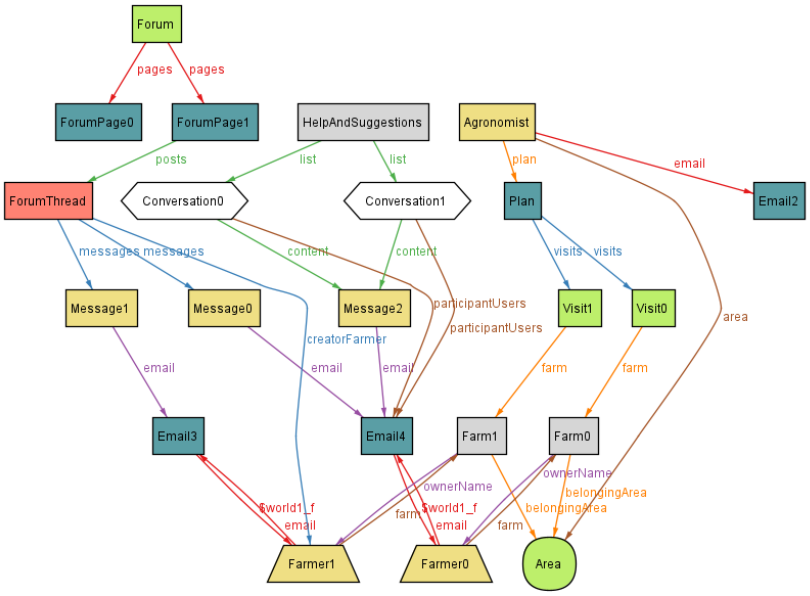


Figure 7: World 1.

4.2.2 World 2

This world is built to showcase the plan functionality for the agronomist.

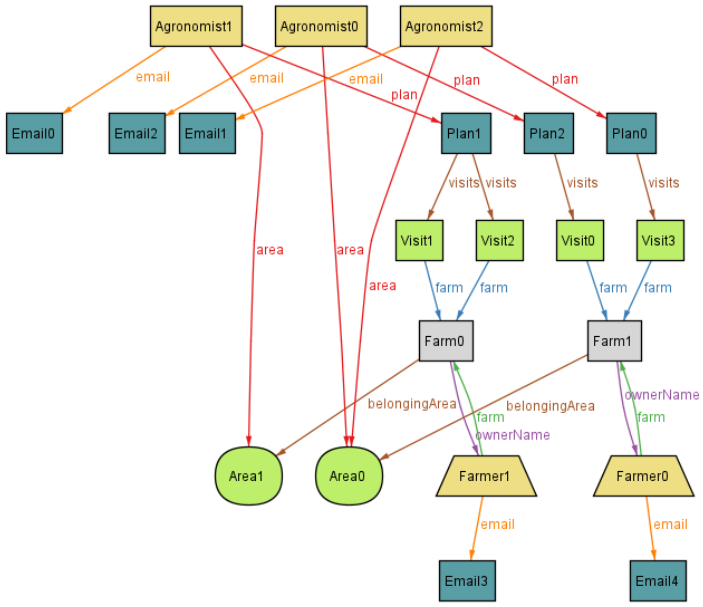


Figure 8: World 2.

4.2.3 World 3

This world is built to present to the Policy maker the instruments that he could use to aid his work.

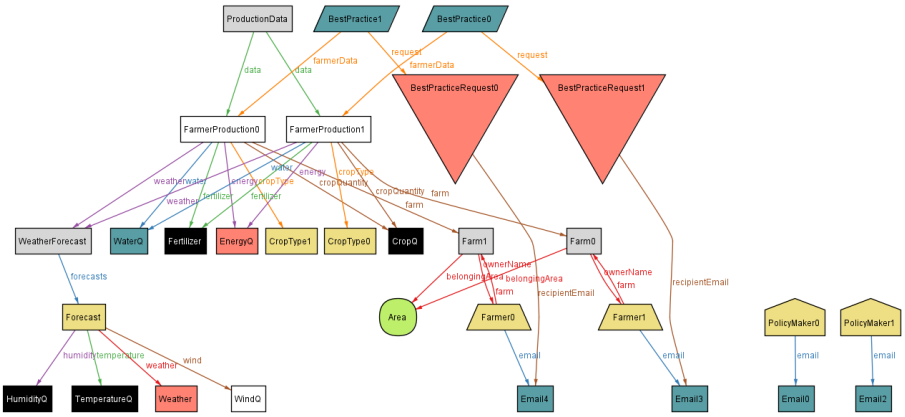


Figure 9: World 3.

5 Effort Spent

	Cap1	Cap2	Cap3	Cap4	Latex
Brunati	4h	3h	14h30min	4h	
Cappelletti	2h30min	5h	7h30min	4h	10h
Curti	4h	3h	5h	11h	