INFORMATION AND COMMUNICATION TECHNOLOGIES FOR DEVELOPMENT (ICT4D)

ASSIGNMENT 3 - FINAL REPORT

iVet: ANIMAL HEALTH IN MALI

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1. INTRODUCTION

Nowadays, technology development is strictly correlated with globalization. Information and communication technologies have become essential components of our lives, as we are incapable of thinking about a world without them. New devices are launched every day, the spread of internet connections has built irreversible networks across all countries, and millions of people around the world are able to interact with each other at hundreds of kilometers apart. Nevertheless, the rapid expansion of technology has also yielded negative consequences, such as economic inequalities between developed countries and developing countries. Although intentions behind technology are positive, it is always taken for granted that contextual, environmental, social and economical conditions are similar in all countries of the world, considering that all needs are covered by the same types of technology. Consequently, technologies that work well on developed countries are neither suitable nor applicable in developing countries.

The most remarkable examples of developing countries in the world are located in Africa. Even though most of these regions have enjoyed a sustained economic growth during the last decades due to the increase of the demand for natural resources, there are more than 408 million of people who still live in extreme poverty, which has created enormous technological, economical and social gaps. The project described in this document aims to come up with a sustainable and useful technological solution for one of these countries. Namely Mali, which according to the United Nations Human Development Index in 2015, it ranks 176th out of 188 countries all over the world.

Since it is paramount to first understand the social context of the country, as well as the limitations and constraints we must face when building the application, several factors will be considered. Hence, this document will consists of the following sections: the first part will be focused on the problem statement and the contextual issues of the region, afterwards, a theoretical background and some literature references will be mentioned in order to give us some insights about the real conditions of the area and the way we should deploy our idea to make it robust and sustainable. Then, the next sections will describe the prototype itself, mentioning design, implementation, fidelity, validation, deployment and evaluation. Finally, we will make some remarks for the discussion and we will describe our future work.

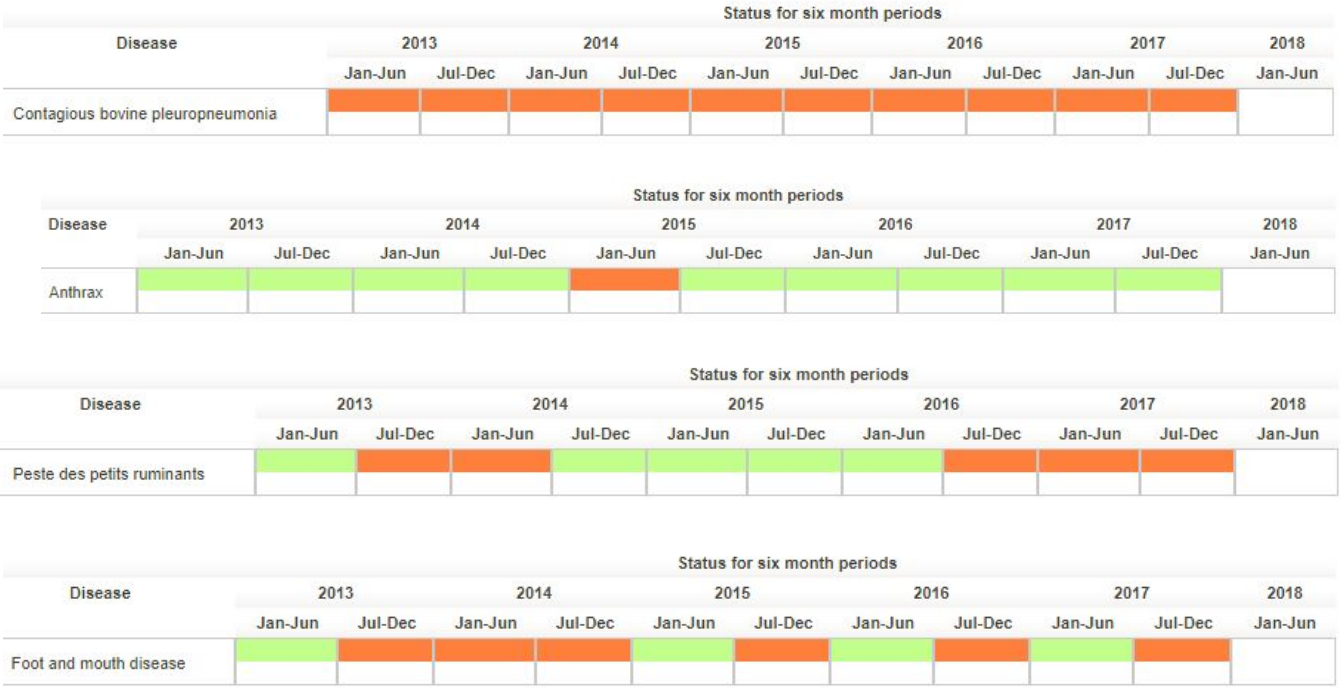
1.1 MOTIVATION AND PROBLEM STATEMENT

Mali is among the 25 poorest countries in the world. The country's revenue mainly depends on gold mining, iron ore extraction, exportation of agricultural commodities, livestock production and harvest. All these activities are confined to the area which is irrigated by the Niger River, as about 65% of the territory is desert or semidesert.

Livestock production represents approximately 20% of the Gross Domestic Product of the country in an average year. This activity is held by smallholders who live mainly in the North of the country, but due to droughts during the last decades, many of these farmers have

moved out from their homes to the south, which have affected the conditions of their animals.

Around 85% of Mali's agricultural households own some form of ruminants. Hence, cows, sheep and goats are commercially important for a farmer and his family, which implies that any ill animal will have a huge impact on the living conditions of the farmers and their families. For this reason, it is paramount to diagnose serious diseases such as Anthrax, Foot&Mouth, Contagious Bovine Pleuropneumonia (CBPP), and PPR (Peste de Petits Ruminants), which according to the website WAHIS of the OIE (World Organization For Animal Health)[1], they have occurred in Mali between 2013 and 2018 as it is shown in the graph below. As it is noteworthy, diseases have been either absent or limited to one or more zones, and the most common ones have been CBPP and Foot and Mouth.



As many smallholders are illiterate and there are not enough sources of information with regard to animal diseases, it is difficult for them to detect and diagnose the symptoms of

[1]*WAHIS Interface, Animal Health Information, 2018*
Source: http://www.oie.int/wahis_2/public/wahid.php/Countryinformation/Countrytimelines

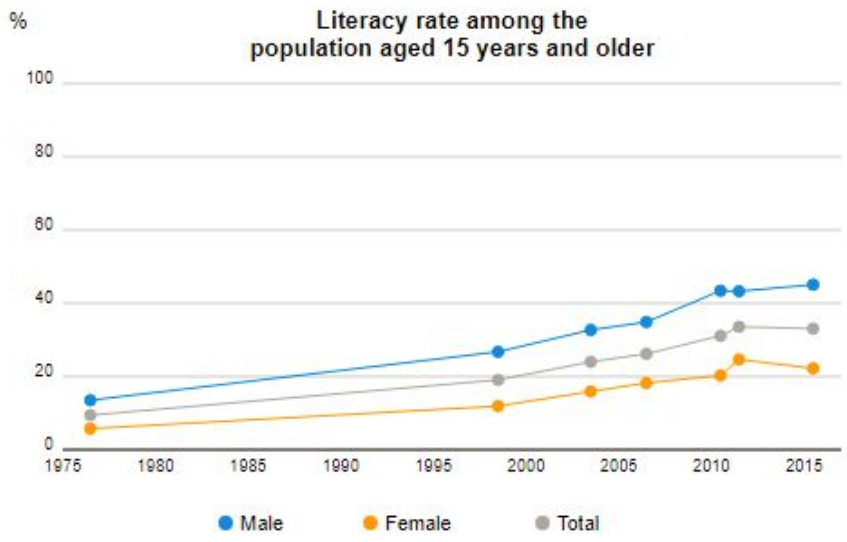
their sick animals by themselves. In addition, not every village has veterinarians available, and even when there is an available veterinarian close to the village, service fees and vaccinations suppose considerable amounts of money that most farmers are not able to pay.

The aim of this project is to build a diagnosis system that can be used by farmers to receive an accurate diagnosis based on the information provided by them, as well as a set of instructions they can follow from home, without taking the animals to the veterinarian. Besides the serious diseases already mentioned, other common symptoms should be included in the application, such as fever, cough and eye problems. The successful implementation of this application could yield enormous savings for farmers and better conditions for diagnosed animals.

1. CONTEXTUAL ISSUES

Before the project is carried out, it is mandatory to first understand the context and the conditions of the region in terms of literacy rates, electricity infrastructure, internet connection and communication devices.

Literacy rates: According to UNESCO, the average literacy rate among population aged 15 years and older in 2015 was around 30%, which tends to be lower for women than men. This percentage is way lower in rural areas, which represents around 60% of the total population of the country.



This percentage represents the people who can understand, read and write a short and simple statement of their everyday life. Additionally, it also involves ‘numeracy’ and the ability they have to make basic arithmetic calculations.

Internet connection: As in many countries in Africa, communication and information technologies are limited, as either they are extremely expensive or they are not accessible in remote rural areas. In 2015, according to the website of 100MegaMali (an initiative of Mali’s information and communications technology sector), the monthly cost of an internet

subscription for 384 bits per second (bps) in Mali was around 54,88 euros, which is one of the most expensive fees in Africa. Moreover, based on the website Internet Live Stats, only 12% of the population have access to internet.

Electricity infrastructure: Mali's national electrification rate is also a big concern, as it is estimated in 26%, which is lower than the Sub-Saharan Africa's average of 32%. From this percentage, only 9% corresponds to rural areas, which means that there are about 11 million of people without electricity all over the country, and about 800.000 users who have to use unreliable grids.

Communication devices: Radio broadcasting remains the most popular communication technology in Mali, as almost everyone is able to get access to it. Since internet connection is not affordable for most of the inhabitants of the country, Mali's telecoms has also become a dynamic and strong sector, as basic and cheap mobile phones can be purchased in large towns, and SIM cards are also available. The service is provided by two main mobile networks operators, which are Orange and Malitel, but recently, a third operator have started operations since February of this year, which is named Telecel, although the coverage is very limited to the capital city.

Most of the people only use simple models of mobile phones rather than smartphones or tablets, as the costs and level of illiteracy in the regions remain really high.

2. THEORETICAL BACKGROUND AND RELATED LITERATURE

Based on the paper "Developing ICT Services in a low-resource development context", the most relevant concerns involving ICT4D projects (which are tackled by the framework discussed on the paper) are:

1. **Local needs are unknown:** Every ICT4D project should focus on real needs of the prospective beneficiaries. It is important to keep in mind the differences between customer needs in Western societies and in the "Global South".
2. **The context is unknown:** Developers should take enough time to understand the circumstances of the end-users and the constrained-environment they live in.
3. **Low literacy:** In cases in which the levels of literacy are pretty low, the developers must be able to create voice-based tools and services.
4. **Availability of infrastructure and crucial technology:** In some rural regions, electricity is not available, as well as internet connection. Additionally, if they are available, they are quite expensive.
5. **Low purchasing power of end-users:** In rural regions and developing countries, the purchasing power is pretty low. Therefore, many technologies, if feasible, may not be afforded by people living there.
6. **Lacking understand of ICT possibilities:** Many end-users have neither used computers nor internet before, which could yield limitations for the implementation of many technologies.
7. **Conflicts between donor-sponsor and end-user goals:** It should exist a balance between the goals of funding agencies and end-users goals. The former ones have more generic and temporal goals, whereas end-users goals are much more specific.

By developing a framework for ICT4D service development which consists of: (1) context analysis (2) needs assessment (3) use case and requirements analysis (4) sustainability assessment and (5) developing and testing, one can consider all different factors which are relevant for the successful deployment of the project. In fact, according to the research, many ICT-enabled services in Africa fail because of the lack of a business model. Moreover, a lot of projects are supported and funded by international helping agencies (EU, World Bank, USAID, etc.), but most of them are short term projects (3-8 years). Hence, one of the main purposes of our project is to ensure that iVet is sustainable in time by creating strong relationships between all stakeholders, namely the Government and the veterinarians. iVet will gather the data from the farmers and then give an analysis and report to the vets and government. By using these results, it is believed that iVet can keep working for a long term and benefit farmers, vets and government in Mali.

The success of our service does not only depend on the connectivity and sustainability of the project, but also on the information the system will use to extract accurate diagnosis and procedures for the treatment of animals. As there are hundreds of different diseases, as well as different symptoms that sometimes do not only correspond to a unique disease, it is mandatory to identify the best way to keep our database updated.

Nowadays, Semantic Web is an important concept, whose key foundations are ontologies and annotations. The former describe all conceptualizations of a specific domain, whereas the latter provide information about the contents of the web resources. Some of the most important Semantic Web resources are DBPedia and GeoNames. With regard to this matter, the web innovator Sir Tim-Berners-Lee has proposed a Linked Data solution which consists of the following elements:

1. URI's (Uniform Resource Identifier) or web links to identify properties and entities in the dataset.
2. Standard data models (RDF) that could make possible the exchanging of data.
3. Linking to other URI's that provide more information about the same topic.

These Semantic Web Resources would allow us to get access to multiple data sources that contain reliable information about certain domains, which in our case are related to animals and diseases. Even though most data is only locally relevant, it should be shared across regions and aggregated to country/global level, so that it could be replicable and useful for many other stakeholders.

Precisely, AIMS (Agricultural Information Management Standards) is a website portal with information regarding agricultural tools, good practices and methodologies implemented worldwide. One of the most renowned vocabularies of this website is called AGROVOC[2], which aims to provide a massive collection of hierarchies and concepts related to agricultural and health matters. Moreover, another website which provides Linked Open Data is called AgroPortal, which contains a specific vocabulary called LOVInra[3] that has an animal diseases ontology and also an animal trait ontology for livestock. These information would be extremely helpful for our aim in this project. as we could feed our system according to the information these sources provide.

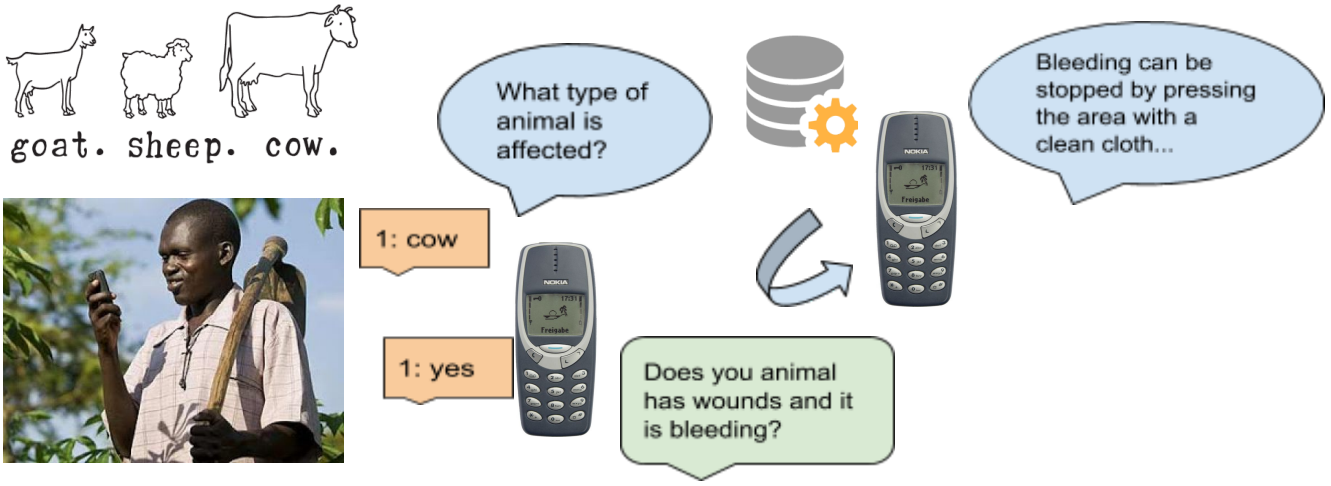
[2] *AGROVOC Vocabulary:* http://aims.fao.org/standards/agrovoc/functionalities/search
[3] *LOVInra Linked Open Vocabularies.* Source: https://lovinra.inra.fr/

4. SOLUTION DESIGN

4.1 USE CASE DESCRIPTION

Mamadoe is a farmer who lives in a rural village in Mali. For many farmers in Africa, such as him, livestock is an important source of incomes and food, so everyday he strives to keep his animals living in a healthy environment. One morning in June, Mamadoe realizes that 4 goats from his cattle have high fever, blisters inside their mouths and they are reluctant to move and eat. As he does not know what is the procedure he should follow to heal them, he remembers the name of the new application called iVet, so immediately, he looks for the application phone number in his mobile phone and he dials the number.

After answering some questions regarding the symptoms of their sick animals, the application informs him that his goats are likely to have a severe case of Foot&Mouth disease, which is the most contagious one. The application describes a list of procedures he must follow in order to stop the spread of the disease, so that Mohamed carefully follows the instructions, by confining the animals and proceeding with the disinfection of equipment, clothes and materials. In addition, the application gives him the option to either transfer the call to a veterinarian or ask for the phone numbers of some veterinarians he can contact later if needed.



4.2 PROTOTYPES

Providing farmers with the opportunity to identify diseases and know the procedure to prevent possible outbreaks would be extremely useful for them. To accomplish this, we created the application **iVet Animal Health** for farmers in Mali who want to get an accurate diagnosis for their animals by taking care of them from their own homes, by following simple instructions and saving money.

The following tables will describe the most important features of each prototype we designed, as well as the disadvantages each one yielded, and the additions the next version included to solve previous inconveniences (highlighted in bold).

Afterwards, the final prototype will be described according to the additions we decided to consider and the data model we used to feed the system.

VERSION 1 - ASSIGNMENT 1	
Evolution Voxeo and .vxml files	
Languages	English
Animals	Cow, sheep, goat
Diseases	Anthrax, Foot&Mouth, Contagious Bovine Pleuropneumonia (CBPP), Blackleg and PPR (Peste de Petits Ruminants)
Functionalities	- The farmer receives an automatic call which provides him with important considerations about the season, in order to prevent frequent diseases. (implemented as a choice menu). - Diagnosis of diseases. - The farmer will receive an automatic call, which asks whether the animal got better or not. (not implemented).
Disadvantages	- The system never provides information related to different diseases from the ones already mentioned. - The system is not able to recognize by itself which symptoms belong to which disease. Instead, each disease is categorized by a list of predefined symptoms, which yields a problem if the animal has some of them, but not all. - Since the diseases are too serious to be treated from home, the instructions provided are very limited. - The system does not provide any information to contact a veterinarian.
Feedback	*“What if there are multiple symptoms?; Perhaps simplify terminology used. Some elements in your app can be adjusted to the rural farmers a bit better, e.g. there is a high chance they are not able to sterilize their overalls.”*

Due to some considerations we received from the feedback, and some additions we consider were relevant to implement, the second version of our prototype did not include automatic calls, as they could yield higher costs for our service since we must provide an infrastructure which is able to save all phone numbers of all farmers and make calls every time a season starts. Hence, the overall service could arise prices that many farmers are not able to pay, which is not the purpose of our project.

Therefore, for this second prototype, we were mainly focused on the identification of symptoms and the description of the procedures for the treatment of diseases.

VERSION 2 - ASSIGNMENT 2	
Django-based VXML generating back-end Voice Service Development Kit (VSDK) **KasaDaka web interface**	
Languages	English, **French**
Animals	Cow, sheep, goat
Diseases	Foot&Mouth, Contagious Bovine Pleuropneumonia (CBPP), Blackleg and PPR (Peste de Petits Ruminants). **Common symptoms: Fever, Cough, Wounds and bleeding, Fractures, Diarrhoea, Eye problems and Foot rot.** **(All included in Table 1 from the Appendix)**
Functionalities	- Information provided in both English and French. - Diagnosis of diseases. **- Instructions to follow from home when animal have common symptoms.** - General instructions for more serious diseases. **- The farmer is provided with telephone numbers to call veterinarians.**
Disadvantages	- The system does not distinguish which diseases belong to cows, goats or sheep. Then, if a farmer has a cow, the system will also give him the option to get information about PPR, which is a disease that only affect goats and sheep. - The application cannot provide the farmer with more than one diagnosis when calling the application (e,g. in case the farmer has two different animals that are affected at the same time, but having different symptoms).
Feedback	*"Symptom voice fragments are too long. The vet decision system could be somehow expanded."*

For the final version of the application, we decided to include some important functionalities in order to tackle some of the disadvantages of previous versions and also consider improvements based on the feedback received.

FINAL PROTOTYPE - ASSIGNMENT 3	
Django-based VXML generating back-end Voice Service Development Kit (VSDK)	
Languages	English, French
Animals	Cow, sheep, goat

Diseases	Foot&Mouth, Contagious Bovine Pleuropneumonia (CBPP), Blackleg and PPR (Peste de Petits Ruminants). Common symptoms: Fever, Cough, Wounds and bleeding, Fractures, Diarrhoea, Eye problems and Foot rot. (All included in Table 1 from the Appendix)
Functionalities	- Information provided in both English and French. - Diagnosis of diseases. **-** Instructions to follow from home when animal have common symptoms. - **The symptoms are mentioned in sequence, so that we avoid long audio files.** **- Diseases are distinguished based on the type of animal that was selected.** - General instructions for more serious diseases. **-** The farmer is provided with telephone numbers to call veterinarians. **- The system allows the farmer to receive more than one diagnosis without dialing the application several times.** **- The system records the number of animals that are affected, so that this information can be used by the government to carry out prevention and vaccination programs when needed.** **- The farmer is required to insert the number of animals with the same symptoms and also the total number of animals he has in the farm, in order to know whether there are possible outbreaks.**

4.3 DATA MODEL DESCRIPTION

The backbone of our application is the data model, which consists of six elements shown in the diagram below. Each element corresponds to a class of our system, which has important attributes that will be described as follows:

1. **Farmer:** Each farmer who has access to our service must have a telephone number. Other important attributes are: location, the total number of animals he owns and also the number of animals that are affected by the disease. If the animals have a serious disease, the latter information allows us to calculate the proportion of affected animals in certain regions, which can be shared with the Government in order to start working on prevention and vaccination programs.

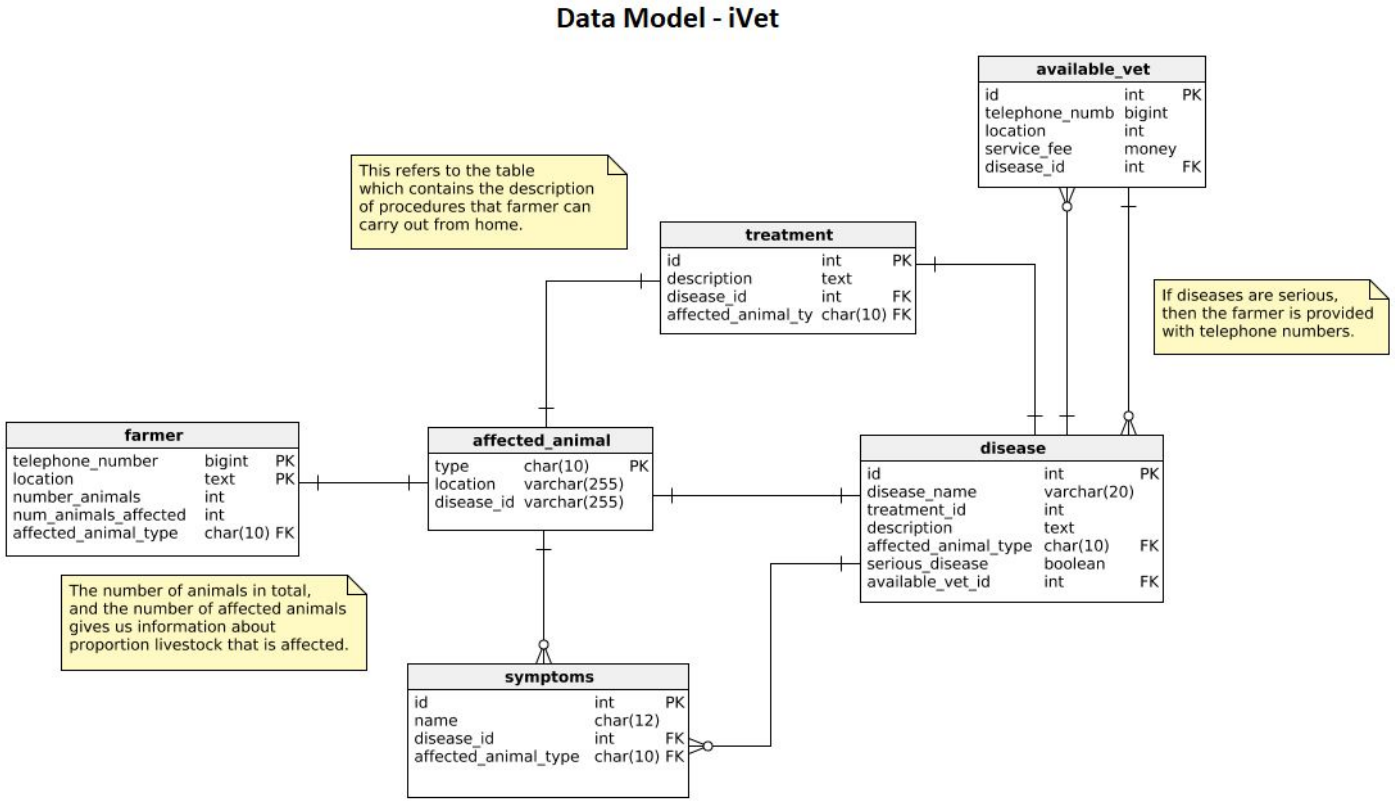
2. **Affected animals:** The scope of our service is mainly focused on three types of animals: cows, goats and sheep. Each type of animal is affected by different diseases that must be distinguished by the system. We assumed each animal has the same location of the farmer.

3. **Symptoms:** Each animal can show multiple symptoms, and each symptom corresponds to a disease. Symptoms must be identified by a unique ID.

4. **Treatment:** Each farmer must receive instructions on how to treat the affected animal, according to the disease that has been identified after asking a sequence of questions to the farmer. The treatment should have a description which clearly states the procedure and the elements the farmer must use to perform it.

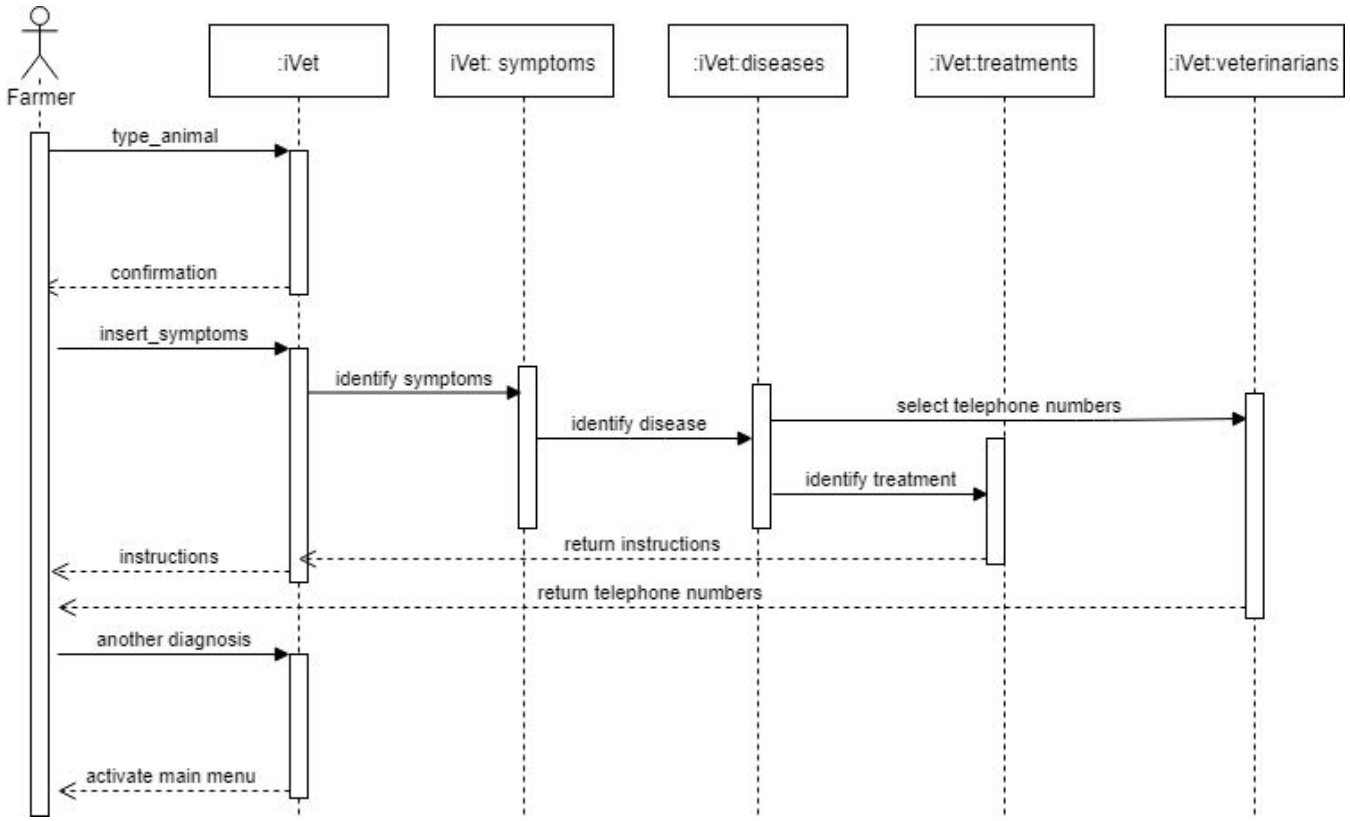
5. **Disease:** All diseases are categorized according to the type of animal and according to available veterinarians that can be responsible for the treatment (in case it is a serious disease that cannot be treated by following the instructions from home). In addition, each disease can have multiple symptoms, but only one treatment.

6. **Available veterinarians:** The database must contain a list of available veterinarians who can be contacted by telephone in case the farmer needs further assistance to treat their animals. This table will also contain information regarding service fees.



4.4 INTERACTION DESCRIPTION

Taking into account the previous diagram and its description, we also designed a simple sequence diagram which briefly presents the most relevant interactions between classes of the system. As we notice, the most important information the system needs is based on local diseases, simple instructions that farmers can follow from home, number phones of veterinarians and symptoms (of both mild and serious diseases).



4.5 ADDITIONAL DIAGRAMS

In order to describe the workflow and all different interactions the stakeholders have when using the application iVet, the following diagrams were created:

1. UML activity diagram (Figure 1)
2. UML use case diagram (Figure 2)
3. Call-flow diagram (Figure 3)

These diagrams are shown in the Appendix of this document.

5. IMPLEMENTATION AND VALIDATION OF THE PROTOTYPE

The project was build in a Django-based VXML generating back-end, named Voice Service Development Kit (VSDK). The main advantage of this tool is that it is not necessary to have internet connection to use it, as it will be running on a Raspberry Pi. For the sake of this project, to host the Django application, we created a Heroku account whose application is reachable by copying the following URL http://enigmatic-reaches-55329.herokuapp.com/.

The voice service was built through the KasaDaka web interface by using audio files created with a Text to Speech Online Website which allowed us to record messages in English and French in a correct .wav format. Hence, each voice label contains an audio file for each language.

To test both languages when using the application, select the correct language in the “Voice service” called “Animal’s diseases” on the web interface. To test the English version, select “English (en)” in the Supported languages section, and then save the changes. Likewise, to test the French version, select “French (fr)” and save the changes. Then, copy the following URL http://ict4d.kasadaka.com in the browser, and fill in the user name as “mali” and the password as “bamako”. The VoiceXML URL for our application is http://enigmatic-reaches-55329.herokuapp.com/vxml/start/1 and the number 020-3697664 can be dialed to listen to our prototype.

The following video shows an example of Mamadoe and Moussa (the main characters of our use case script) using our system iVet in both languages: https://gallery.moovly.com/video/516cfa25-ecc6-4705-bf82-686acd49c3b6

6. SCOPE AND FIDELITY OF THE PROTOTYPE

To better understand how iVet works, as well as its main features, we created the following video: https://gallery.moovly.com/video/4290fb4b-1051-4289-98fe-c88ce2d5d42c**.**

iVet includes two languages, it also covers the main sorts of animals: goat, sheep, cow, serious diseases, common diseases and also some procedures of how to treat them. In addition, it records the number of infected and non-infected animals which can be calculated and analyzed, so that we could give a warning about possible outbreaks to the farmers in the area and also to the Government of Mali. The not-implemented feature of the iVet which can be added is the layout where infection cases can be saved and updated through the time and the area/location in a database that eventually can be shared to the Government, veterinarians and Non-profit organizations.

Moreover, by using the KasaDaka interface, the administrator of the application can add new diseases and treatments. However, it would be necessary to set up some meetings with local farmers and veterinarians to check whether the symptoms are clear and well described, since there might exist some diseases that we have not considered yet. Furthermore, even though it is quite easy to add new voice labels and treatments through the interface, the dashboard should have instructions of how to use it, given that in most of the cases, developers will not be there to provide them with further assistance.

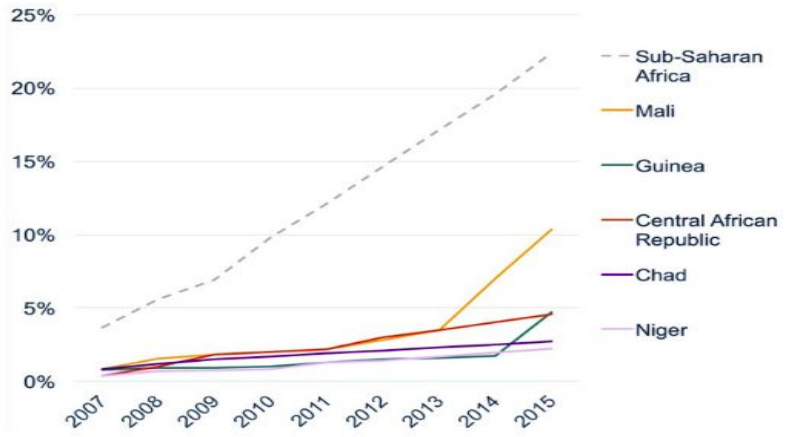
7. DEPLOYMENT AND SUSTAINABILITY PLAN

In order to keep the system up to date and make alterations (e.g. add new/local diseases), there should be access to a web version of the application. As a matter of fact, according to the figure below, Mali doubled the internet usage from 2013 to 2015. In 2015, the government adopted Plan Mali Digital 2020, a national strategy of development of the digital economy, which aims to further develop in the ICT sector. These improvements of internet usage makes the use of the Raspberry Pi easier.

To deploy our service, we will require a computer centre at a reasonable distance from the village and a mobile phone to keep contact with the host of the application. This person must know at least some basic functionalities about computers and mathematics (how to access a web browser, how to make simple calculations, how to make voice labels in the right format (.wav), how to interact with the developers in case of finding programming issues, etc). The

next subsection will describe some cost considerations regarding the general implementation.

Internet penetration (2007–2016)



Source: GSMA Intelligence; World Bank World Development Indicators

7.1 COST CONSIDERATIONS

The system will be free of charge for the first few months, in order to stimulate users to get acquainted with it. Eventually, after this period, in order to keep the system running, there will be some costs held by farmers when contacting the application (i.e. telephone costs).

Furthermore, locals will be hired and educated to be able to carry out administrative tasks in order to keep the application up to date. Farmers can eventually save some costs using the application, by limiting their calls and visits to the veterinarian only to those cases when it is necessary.

The following Table presents some estimations we made for the costs, according to the information provided by: the website of Malitel (mobile operator) and some Mali statistics websites.

Farmers		
Component	**Cost**	**Description**
National Rates for the Prepaid plan per minute (Malitel)	108 FCFA	Approximately corresponds to 0,16 euros.
Our service		
Basic computer		250 euros
ADSL Wifi subscription (512 kbit/s - 2 Mb/s)	9900 FCFA 35000 FCFA	Between 15 euros and 53 euros.
Host	70.354 FCFA	Average monthly salary, which corresponds to 107 euros.

7.2 SUSTAINABILITY OF IVET

Livestock is estimated at 10,941,300 cattles, 15,900,300 sheep and 22,141,497 goats in 2016[4]. In order to help and increase Mali's income, enhancing the volume and value of the livestock is the main goal. Currently, there are some projects related to livestock production supported and funded by the World Bank, *Mali Livestock Sector Development Support Project (PADEL-M)*[5] and the United States Agency for International Development (USAID), *Feed the Future Mali Livestock Technology Scaling Program (FtF-MLTSP)*[6]. One of the main tasks of both projects is to promote animal health, while many common livestock diseases are known as they can be vaccinated. However, due to some challenges which will be discussed later, not all the livestock can be monitored and vaccinated. Furthermore, iVet must play an important role by encouraging animal health by keeping the service running for a long period of time.

The main challenges when delivering animal health services are: the cost of vaccination, the lack of knowledge about animal diseases, the lack of information about the amount of animals (demand for vaccines), and how to keep vaccines in good conditions. The aim is to increase the percentage of livestock that is vaccinated, especially for cattle, goat and sheep. This task must be supported by international and financial agencies of the country.

iVet can help to monitor and prevent possible outbreaks by collecting data regarding the animal population of the farmer and also including the number of sick animals. By using this data, iVet can calculate the infected ratio and give a warning for the possible outbreak. *For example,* within a week, 100 cows in 10 calls have been reported and diagnosed with Foot & Mouth disease, which means that 10% of the total population of cows are infected in the area. If the threshold of the percentage of animal are infected in a certain disease, the system will send the message (warning) to the government, private veterinarians and farmers in the area.

With the information collected by iVet, we can improve the communication between the government of Mali and local/private veterinarians. Moreover, this information can be presented as valuable data as result of international projects carried out in the zone, which can strengthen the reputation of institutions, as well as ensure the continuity of all projects in the long term. The following diagram shows an overview of how iVet connects the main activities and the stakeholders of the model in general.

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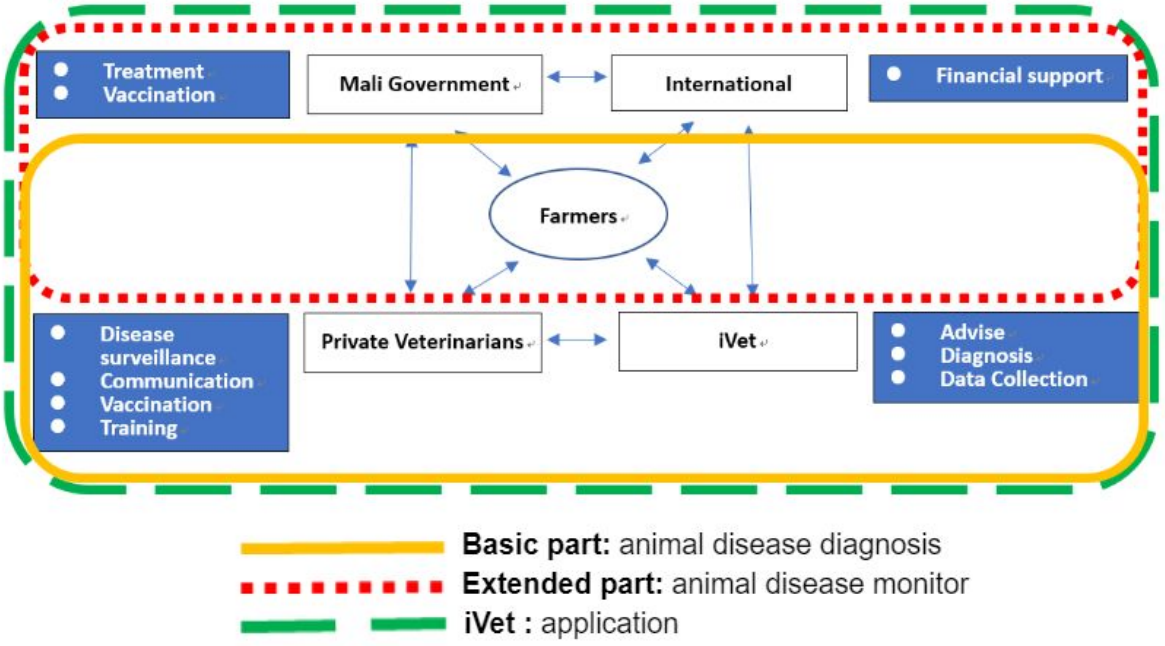
[4] Mali, Key Indicators, http://mali.countrystat.org/key-indicators/en/

[5] The World Bank, Mali Livestock Sector Development Support Project(PADEL-M), http://projects.worldbank.org/P160641?lang=en

[6] USAID,Feed the Future, www.usaid.gov/what-we-do/agriculture-and-food-security/increasing-food-security-through-feed-future



8. EVALUATION OF THE PROTOTYPE

The iVet application can help to raise the awareness and knowledge about animal diseases, and provide several diagnosis for a low cost. Since Mali is a poor country and the literacy is low, the prototype has to be made as easy and cheap as possible. For the farmers, the priority is to help detect diseases and provide them with information about how to take care of the animals when the animal is in need. For instance, when an animal has something harmless, such as foot rot but the farmer does not know that the animal need to be brought to a dry place, simple information like this could be really useful. Moreover, dangerous and deadly diseases are hard to detect through the symptoms that are described by the prototype. For instance, the symptom description of Peste de Petits Ruminants (PPR): “Does your animal show nasal discharges? Does the animal show severe diarrhoea and depression?”. When an animal has all of these symptoms, there is a big change the animal is having PPR, but the PPR virus cross-reacts with the rinderpest virus. Therefore, a consideration we have made is to remain a compact story and a simple explanation of the symptoms. However, a downside of this simple explanation is that it can be hard to distinguish between similar diseases.

This prototype is not meant to replace the responsibilities of all veterinarians. In fact, when the farmer confirms on the menu that the animal has the symptoms described by the prototype, the farmer is highly suggested to call a veterinarian, because although the system is reliable, we are aware of possible misinformation or possible incorrect diagnosis. Hence, the system provides the farmer with a telephone number to contact the veterinarian if he wants to. In our first assignment, we wanted the prototype to call a vet automatically when the famer confirmed one of the four serious infectious diseases. However, as Francis Dittoh, a PhD researcher at UDS, described in an interview about this subject: “Farmers are married to poverty”. Farmers will not call the application anymore if there is a chance that the system

automatically calls a vet and thus the farmer must pay for the call. For this reason, in this last prototype, when the farmer confirms one of the serious infectious diseases, the prototype only recommends the farmer to call the local vet and provides him with the phone number. In the meantime, the system also tells the farmer what needs to be done with the animal.

Finally, iVet also monitors and prevents possible outbreaks. When the farmer confirms one of his animals has a serious infectious disease, the prototype asks how many of the animals have these symptoms. With those numbers, iVet can analyse the infected rate of animals and provide an outbreak warning if needed. This function makes iVet more valuable and can benefit not only farmers and veterinarians, but also the government of Mali. For clarification, we made a video to explain the iVet and background information

9. DISCUSSION

The application of Information and Communication Technologies (ICT) for development gives the developers in the fields of computer science, artificial intelligence and information sciences a different perspective of how to implement the proper technologies under limited circumstances. In this case, with the consideration of low literacy and lack of infrastructure in Mali, iVet is created by bridging the digital division, and providing equitable access to technologies for the farmers. Farmers can get easily access to reliable information, which can improve their knowledge about diseases and increase their income. However, some limitations of the iVet are the cost of making the phone call, the local language support (more than 80 languages), GPS location tracker, and the reference information/data of animals (including the amount of the animal disease and vaccination) from the government of Mali. Governments and veterinarians in developed countries are both relevant for disease control and response of animals. However, in developing countries, such as Mali, it is difficult to do so due to lack of personnel, technology and financial support. Under such circumstances, iVet can be used as preliminary diagnosis for animal health, although it might have some side effects on veterinarians. For instance, if our service turns out to be really effective, farmers will tend to use our application more than the veterinarians assistance, which could eventually decrease the income they receive from their service.

Nevertheless, veterinarians also benefit from iVet by getting information about animal diseases (the number of reported case, distribution of diseases across all regions, etc.), keeping contact with farmers, and promoting vaccination programs, which could make possible the existence of a win-to-win scenario. Moreover, farmers gain some knowledge about animal diseases and advocate the importance of animal health across their villages.

10. CONCLUSIONS AND FUTURE WORK

iVet certainly can help farmers, veterinarians and the government to have a better communication and management. Even in the future with Internet access, iVet can be easily converted into a web version. The first task that needs to be done for future work is to keep tracking and storing the data from farmers, so that we can analyze it and transform this data into accurate statistics for the prevention of certain diseases. With enough data, iVet could

even predict possible outbreaks based on the location, as well as the number of vaccines needed.

For future versions of iVet, we will consider the following additions:

1. A dashboard with informative graphics for administrators, and a database connected to Linked Open Data to keep updated all the information needed. This way, we can feed the system by including more diseases, symptoms and treatments.
2. Evaluate whether transfering the call to a veterinarian is indeed a suitable option for farmers (as probably most of them only want to know the telephone numbers, instead of paying for a call and service fee that they never decided to pay).
3. The KasaDaka interface will contain a tutorial for people who host the application.
4. The system must be tested in site, since this is the only way we can ensure the service works and the mobile operators can provide us with all connections that we need to make it sustainable.
5. Databases including telephone numbers of veterinarians and number of affected animals.

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12. APPENDIX

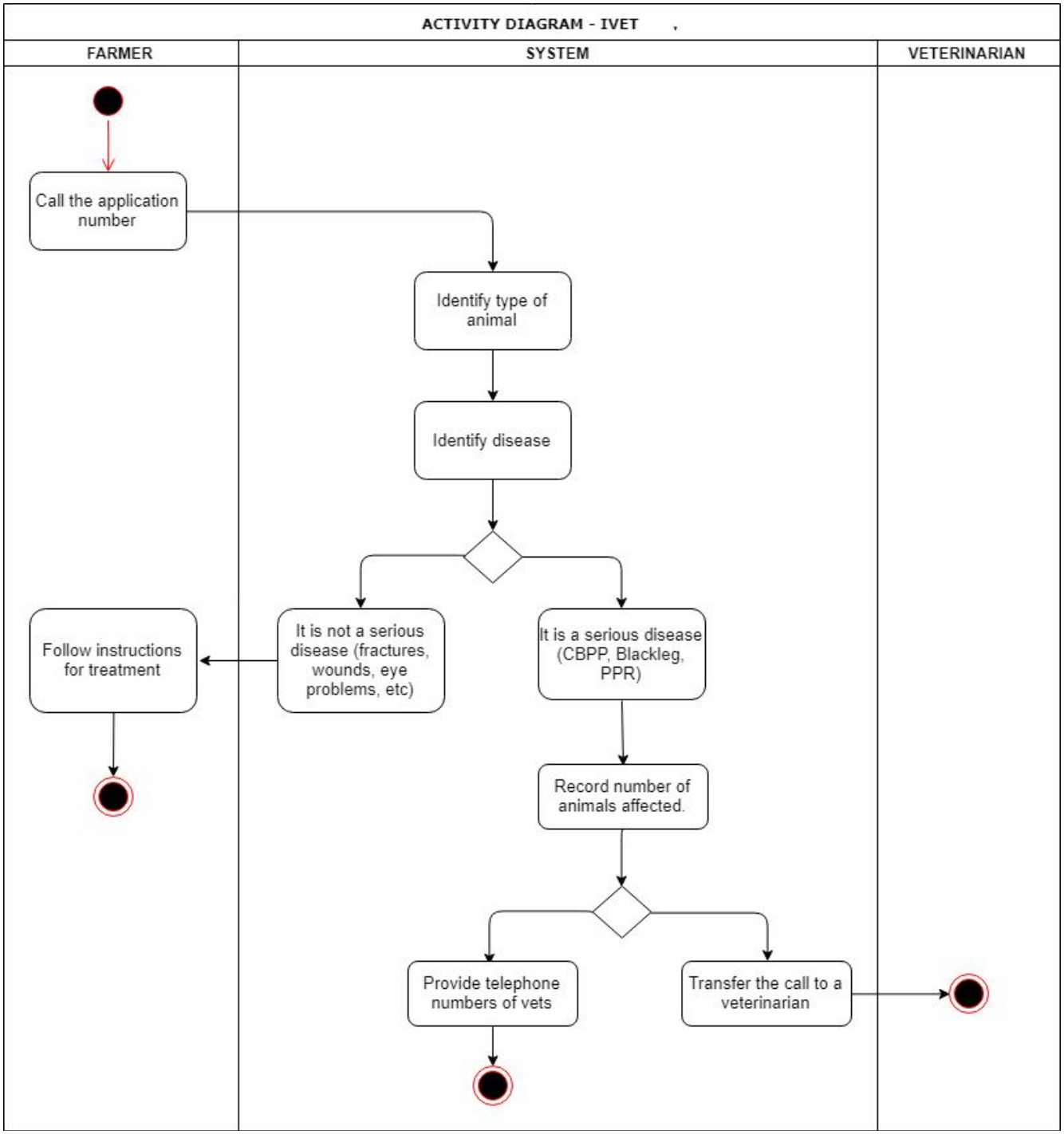

Figure 1: UML activity diagram for iVet.

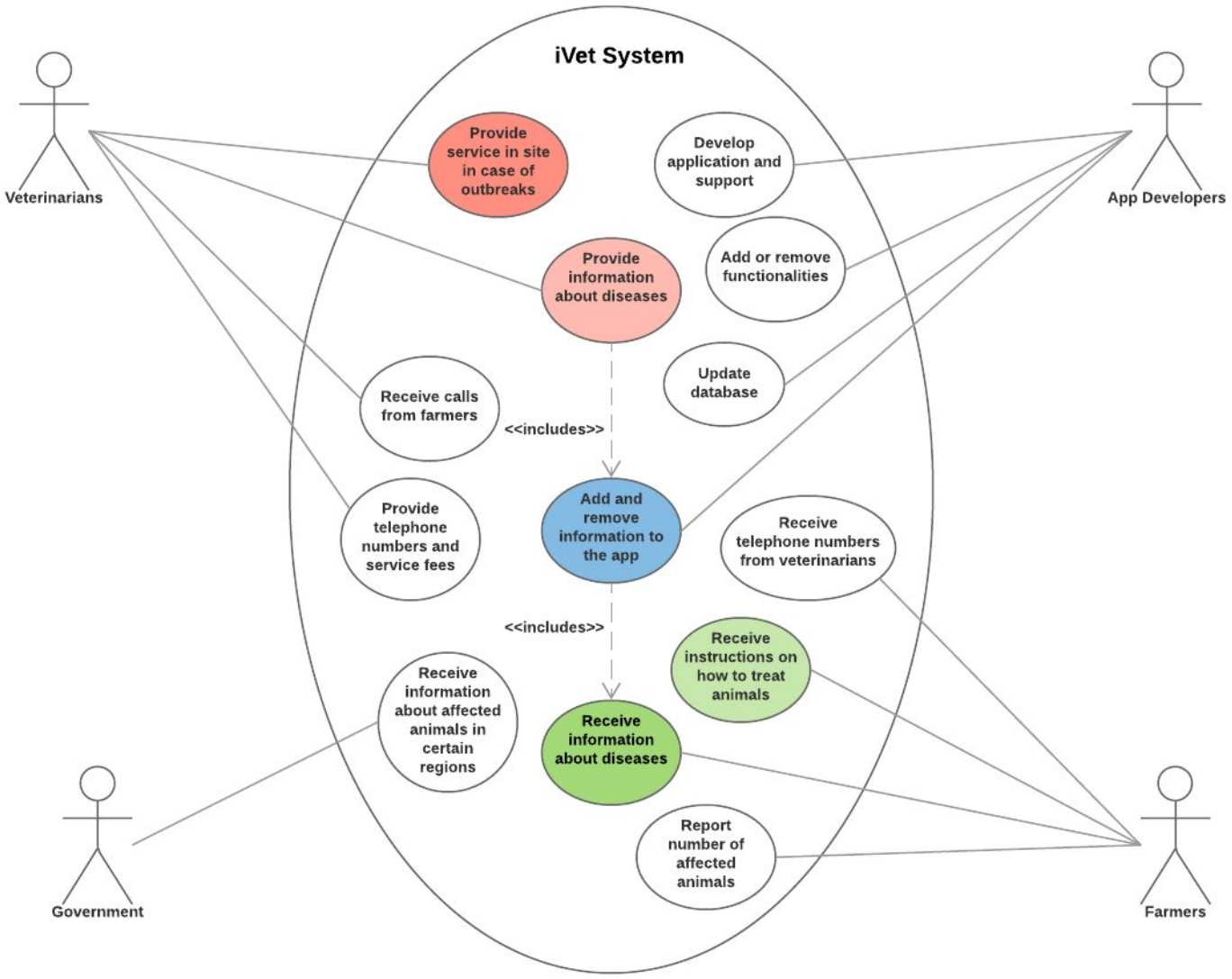

Figure 2: UML use case diagram for iVet.

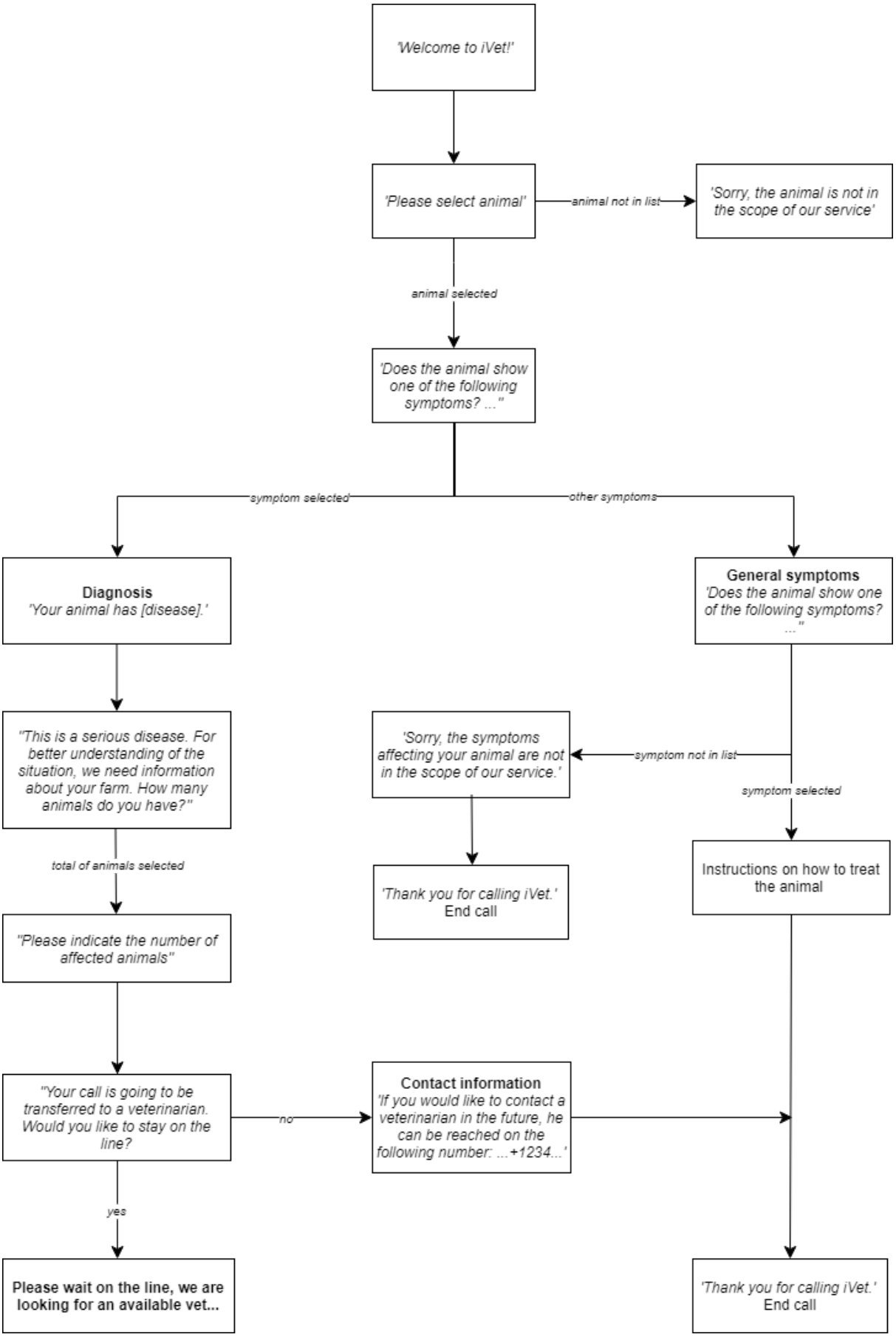

Figure 3: Call flow for the system iVet