DigiVet

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Course: Knowledge Engineering

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1. Context Analysis

1.1. Worksheet OM-1

Identifying knowledge-oriented problems and opportunities in the organization.

Organization Model	**Problems and Opportunities Worksheet OM-1**
PROBLEMS AND OPPORTUNITIES	The high amount of sick animals owned by subsistence farmers in rural Ghana that end up dead.
ORGANIZATIONAL CONTEXT	Mission, vision, goals of the organization: **Mission:** Identify diseases and disease patterns in sick animals, in order to warn farmers when to take their animals to the vet and to gain general knowledge about their animals. **Vision:** Developing a knowledge based system in order to support users in the decision whether or not to go to a veterinarian given a set of symptoms, and providing general information. **Goals:** Accelerate the decision of farmers to bring their sick animals to a veterinarian, in order to be proactive.
	Important external factors the organization has to deal with: - Illiterate users - Offline environment (no internet connection, little to no electricity) - Knowledge of animal diseases in rural West-Africa - Educational level of end users - easy to use system - Economic state of end users - affordable system
	Strategy of the organization: - Lower the threshold that prevents farmers to go to the veterinarian proactively by introducing the system in their local environment. This will hopefully reduce the mortality rate in animals. - Improving general knowledge to the farmers about their animals.
	Its value chain and the major value drivers: - Local NGOs - University of Development Studies, Tamale (UDS)
SOLUTIONS	- An affordable, easy to use and voice-based system based on the Raspberry Pi containing local expert knowledge.

1.2. Worksheet OM-2

Description of organizational aspects that have an impact on and/or are affected by chosen knowledge solutions.

Organization Model	Variant Aspects Worksheet OM-2
STRUCTURE	See figure 1. The local organization is put at the top, this organization will finalize the service once it is ready to be distributed. The system is linked to developers, which will be us. The users are farmers, the guardian and veterinarians. The farmers are the direct users of the system, which will be placed under the supervision of a guardian. This guardian will have a specific function, for example the chief of a village. The veterinarian will not directly be involved with the system, but will be communicated with through the system.
PROCESS	See figure 2.
PEOPLE	The people involved are: ● Farmers ● Veterinarians ● Guardian (Chief of village or local NGO) ● Employees of local organization
RESOURCES	Raspberry Pi 2 model B, Huawei 3G USB Dongle, 3.5" Tontec screen
KNOWLEDGE	There is a need for veterinary knowledge coming from either local veterinarians or Western veterinarians who have experiences in the local context. The needed knowledge regards the animals that are to be found in the area as well as the symptoms and disease patterns that they can have. It is important to identify common practice regarding the visiting a vet by a farmer.
CULTURE AND POWER	It is not common practice for rural farmers to visit a veterinarian with their sick animals, which is why diagnosis and treatment of the animal in question is often done too late. The farmers have a rough way of dealing with their animals (compared to how we treat our animals in the Netherlands) and depend on veterinarians when it comes to knowledge about animal health. For this reason we want to increase the general knowledge of the farmers by providing them information about their animals. Our aim is to prioritize the diagnosing of these animals in order to prevent unnecessary high mortality rate. The proactive diagnosing of animals will in the long reduce treatment costs for farmers, since surgery and heavy medication can be prevented.

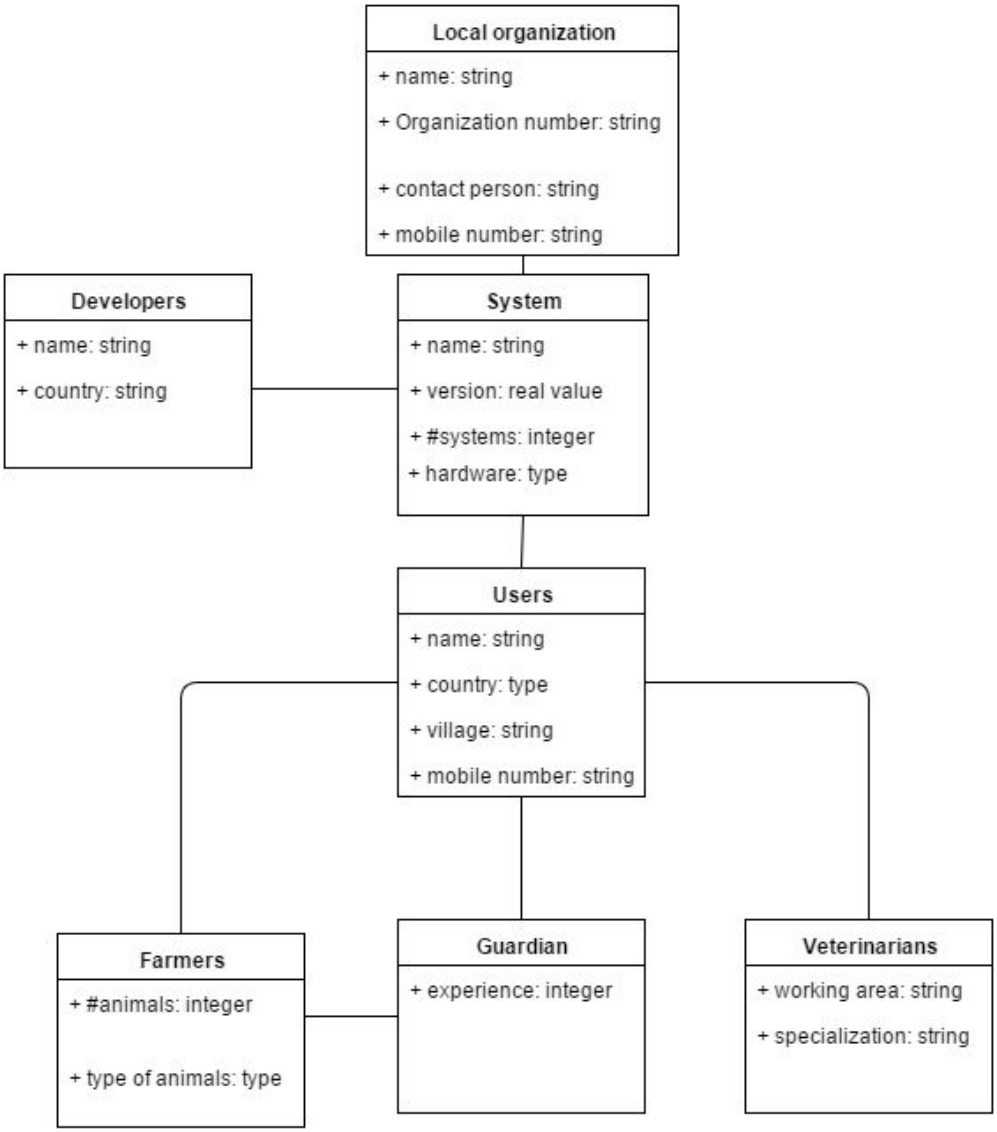

Figure 1. Structure.

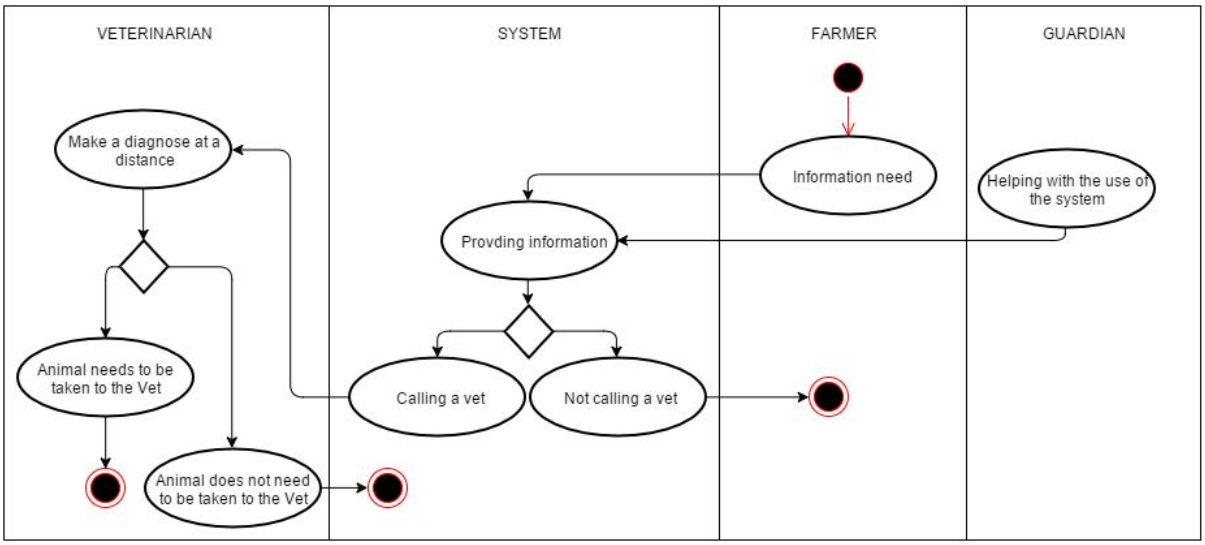

Figure 2. Process.

1.3. Worksheet OM-5

Checklist for the feasibility decision.

Organization Model	Checklist for Feasibility Decision Document: Worksheet OM-5
BUSINESS FEASIBILITY	1. What are the expected benefits for the organization from the considered solution? Both tangible economic and intangible business benefits should be identified here. 133782320. How large is this expected added value? *The number of cured animals will increase, disease patterns will be broken by proactive intervention. The survival of these animals is very important for the economical state of the farmers.* 133782408. What are the expected costs for the considered solution? *Less than the old treatment. The use of the system will be costless for farmers. The intervention of a veterinarian will be held in time, preventing unnecessary high costs (due to surgery or medication).* 133782496. How does this compare to possible alternative solutions? *The current solution is that farmers wait too long before going to the veterinarian, which often results in death. The morbidity and mortality percentage of animals will hopefully decrease.* 133782584. Are organizational changes required? *Yes, the veterinarians will have to cooperate with the system. The farmers will need a one day introductory workshop to be able to use the system.* 133782672. To what extent are economic and business risks and uncertainties involved regarding the considered solution direction? *The highest risks are in the distribution of knowledge. Once the system is used, it should contain knowledge that is up-to-date, useful and valid.*
TECHNICAL FEASIBILITY	For a given problem/opportunity area and a suggested solution, the following questions have to be answered: 1. How complex, in terms of knowledge stored and reasoning processes to be carried out, is the task to be performed by the considered knowledge system solution? Are state-of-the-art methods and techniques available and adequate? 133782760. Are there critical aspects involved, relating to time, quality, needed resources, or otherwise? If so, how to go about them? *There are critical aspects involved relating to quality and needed resources. The cooperation of local veterinarians as well as local developers is needed in the future. If new knowledge is to be implemented in the system, this should be done by the local developers in order to guarantee the quality of the system. The used resources, namely the hardware, should be robust, sustainable and inexpensive, in order to meet the environmental and economical requirements requirements of the local area. The system should be easily replaceable and easy to use/implement.* 133782848. Is it clear what the success measures are and how to test for validity, quality and satisfactory performance? *Yes, by measuring the morbidity and mortality rate of animals before and after implementation in the given area.* 133782936. How complex is the required interaction with end users (user interfaces)? Are state-of-the-art methods and techniques available and adequate? *State-of-the-art techniques are available and adequate in order to meet the educational level and technical background of the end users. They are often illiterate and do not have prior experience to these kinds of technologies, requiring them to be easy to use.* 133783024. How complex is the interaction with other information systems and possible other resources (interoperability, systems integration)? Are state-of-the-art methods and techniques available and adequate? *The current information goes through word to mouth communication, meaning that knowledge and information travel through generations of farmers. The mentality of going to the veterinarian too late, being due to costs or lack of knowledge, should be broken, which can be complex to realize.* 133783112. Are there further technological risks and uncertainties? *The environment is dusty and hot, which means that the hardware should be well adjusted. This can be achieved by creating a custom made case with ventilation. Lack of electricity means that we will need a solar based charger, powerful enough to handle the Raspberry Pi. The service should be developed in a language that is universally used, and can be taken over by local developers in the future.*
PROJECT FEASIBILITY	For a given problem/opportunity area and a suggested solution, the following questions have to be answered: 1. Is there adequate *commitment* from the actors and stakeholders (managers, experts, users, customers, project team members) for further project steps? 133783200. Can the needed *resources* in terms of time, budget, equipment, staffing be made available? *Yes, a team of researchers of the VU goes to the target area on a regular basis. They will help with the needed input for the prototype as well as the feedback*

	provided by the local population. Regarding the time, we will probably need more time than was scheduled in this course to develop a robust and valid system. 133783288. Are the required *knowledg*e and other *competencies* available? *The knowledge we use is coming from a Dutch veterinarian that has experience in Upper-East Ghana, as well as a Senegalese veterinarian and a Ghanaian veterinary researcher of the University of Development Studies (UDS), Ghana. These experts will be sufficient in order to provide us with the knowledge needed for our prototype. Before implementation, we will need second opinions that will test the knowledge put in the system.* 133783376. Are the {\em expectations} regarding the project and its results realistic? *Yes, although the use of the system of course depends on the end users. If they feel that the system is unusable or inadequate, they will not use it. Due to the word-to-mouth culture, one opinion can destroy the further use of the whole population. This is why the implemented knowledge should be submitted to several experts before distribution.* 133783464. Is the {\em project organization} and its internal as well as external {\em communication} adequate? *No, there is little to no communication between experts (veterinarians) and laymen (farmers), which is why there is a need for this system.* 133760376. Are there further project risks and uncertainties? *No.*
PROPOSED ACTIONS	This is the part of the feasibility decision document that is directly subject to managerial commitment and decision making. It weighs and integrates the previous analysis results into recommended concrete steps for action: ● *Focus:* what is the recommended focus in the identified problem-opportunity areas? *The veterinary knowledge to be implemented regarding symptoms and disease patterns. The educational level and technical background of the end users. And the socio-economic constraints and requirements of the local context.* ● *Target solution*: what is the recommended solution direction for this focus area? *Animals are treated before further spreading of the disease.* ● What are expected *results and benefits*? *Decreased morbidity and mortality rates of animals.* ● What *project actions* are required to get there? *Identify symptoms and disease patterns that are locally occurring. Develop a working prototype that is easy to understand. Use voice-based technologies in order to deploy the knowledge. Find veterinarians who are willing to participate in this project. Find local organizations who are willing to finance the project.* ● If circumstances inside or outside the organization change, under what *conditions* is it wise to reconsider the proposed actions? *We already changed the purpose of our system. The interview with the Dutch veterinarian taught us that we should think of a system that will tell a farmer when to go to a veterinarian, instead of diagnosing sick animals.*

1.4. Worksheet TM-1

Refined description of the tasks within the target process.

Task Model	**Task Analysis Worksheet TM-1**	
Task	Urgency identification	Task ID = 1
Organization	Task of our system. The farmer needs to use the system in order to find out what the urgency is.	The village of the farmer
Goal and Value		Deciding on the urgency of veterinarian intervention, based on a set of symptoms.
Dependency and Flow	Preceding Tasks	The farmer should use the system when observing that an animal is sick and give the specific symptoms found in his sick animal as input.
	Follow-up Tasks	Contact the veterinarian if necessary and make sure that the animal is treated appropriately.
Objects handled	Input Objects	Set of symptoms
	Output Objects	Final decision whether or not the animal should be taken to the veterinarian, as well as a short list of tips that the farmer could follow in order to prevent or overcome the disease.
	Internal Objects	Veterinary knowledge regarding the specific animal.
Time and Control	Frequency, Duration	The system should be available during the time that the guardian is available. If the guardian is not available, the job should temporarily be handed over to the assistant-guardian.
	Control	The outcome of the system is checked by the local veterinarian.
	Constraints & Conditions	*Preconditions*: information about the sick animal *Postconditions:* animal is cured either by intervention of the veterinarian or not. C*onstraints*: The system should be available on a constant basis, to enable farmers to use it. The system knowledge should be up-to-date and relevant.
Agents		The farmers.
Knowledge and Competence		There is knowledge needed of various domains, for example medical knowledge coming from vets, animal knowledge, knowledge about the local context and knowledge about the current communication between vets and farmers.
Resources		Vets, hardware (Raspberry Pi + dongle), a safe location for the system (guardian).
Quality and Performance		Percentage of decreased morbidity and mortality of sick animals thanks to the system.

1.5. Worksheet TM-2

Specification of the knowledge employed for a task, and possible bottlenecks and areas for improvement. For this worksheet, we select one significant knowledge which is used in TM-1, which is the task of using the system by the farmers.

Task Model	**Knowledge Item Worksheet TM-2**	
Name Possessed by Used in Domain	Identifying the urgency of animal disease by the farmer The system Urgency identification, ID = 1 Categorization of situation urgent or not	
Nature of the knowledge		**Bottleneck/to be improved**
formal, rigorous		
empirical, quantitative		
heuristic, rules of thumb		
highly specialized, don specific	X	
experience-based	X	
action-based	X	
incomplete	X	
uncertain, may be incorrect	X	X
quickly changing		
hard to verify	X	
tacit, hard o transfer	X	X
Form of the knowledge		**Bottleneck/to be improved**
Mind		
Paper		
Electronic	X	
Action skill		
Other		
Availability of knowledge		**Bottleneck/to be improved**
Limitations in time	X	
Limitations in space	X	
Limitations in access	X	X
Limitations in quality	X	X
Limitations in form	X	X

1.6. Worksheet AM-1

Agent specification according to the CommonKADS agent model. An agent specialisation is made for a veterinarian, a farmer and a guardian.

Agent Model	**Agent Worksheet AM-1**
Name	Veterinarian
Organization	The veterinarian is one of the users of the system.
Involved in	Urgency Identification (task ID = 1)
Communicates with	System, farmer
Knowledge	Retrieving calls from farmers Decides whether or not to see the animal Diagnoses the animal, tries to cure the animal Provides feedback, knowledge to the system
Other competencies	Social, communication and medical skills. And the ability to handle efficiently and under pressure.
Responsibilities and Constraints	Make sure that farmers are treated equally. Do not make subjective choices, but instead make choices that are based on a protocol to improve the process of diagnosing and curing animals.

Agent Model	**Agent Worksheet AM-1**
Name	Farmer
Organization	The farmer is the main user of the system.
Involved in	Urgency Identification (task ID = 1)
Communicates with	System, guardian, veterinarian
Knowledge	Low level knowledge about the animal working with the system
Other competencies	Able to use the system and to make a phone call to a veterinarian
Responsibilities and Constraints	Working properly with the system, not destroying it.

Agent Model	**Agent Worksheet AM-1**
Name	Guardian
Organization	The guardian veterinarian is one of the users of the system.
Involved in	Urgency Identification (task ID = 1)
Communicates with	System, farmer
Knowledge	Works with the system Protecting the system from other people and the environment (dust and temperature)
Other competencies	Social, communication skills. And the ability to be honest.
Responsibilities and Constraints	Make sure that farmers are treated equally and that the system is used in a good way.

2. Knowledge Model

As described in section 1, the system consists of two parts. First, the system has the function to provide general information to the farmer. The farmer selects an animal and a topic of interest to obtain information about. Example topics are: hygiene and pregnancy. Second, the system provides a diagnosing task which tries to determine what the possible causes of the symptoms can be, and then gives an advice to the farmer whether or not to go see a veterinarian. Since providing general information is not a task, but just a representation of available information, this report focuses on the diagnosing task which will be further described in this chapter.

2.1. Task Knowledge

2.1.1. Task template

For this part of the assignment, we choose the main task of our system, and analyse it further. The task that we selected is: *"Deciding whether or not an animal should be taken to the veterinarian based on a set of symptoms."*

This is an analytic task, with diagnosis as task type. Although the system does not diagnose what the specific disease of the animal is, it still generates a specific output given a set of symptoms as input. The knowledge in this case is the habits and behaviors of animals in case of health and illness.

General characterization

Goal - Find out whether or not an animal should be taken to the veterinarian
Input - Symptoms of the animal
Output - Decision of the system whether or not an intervention of a veterinarian is necessary

2.1.2. Task Decomposition Diagram

The task decomposition diagram of the diagnose task can be found in figure 3.

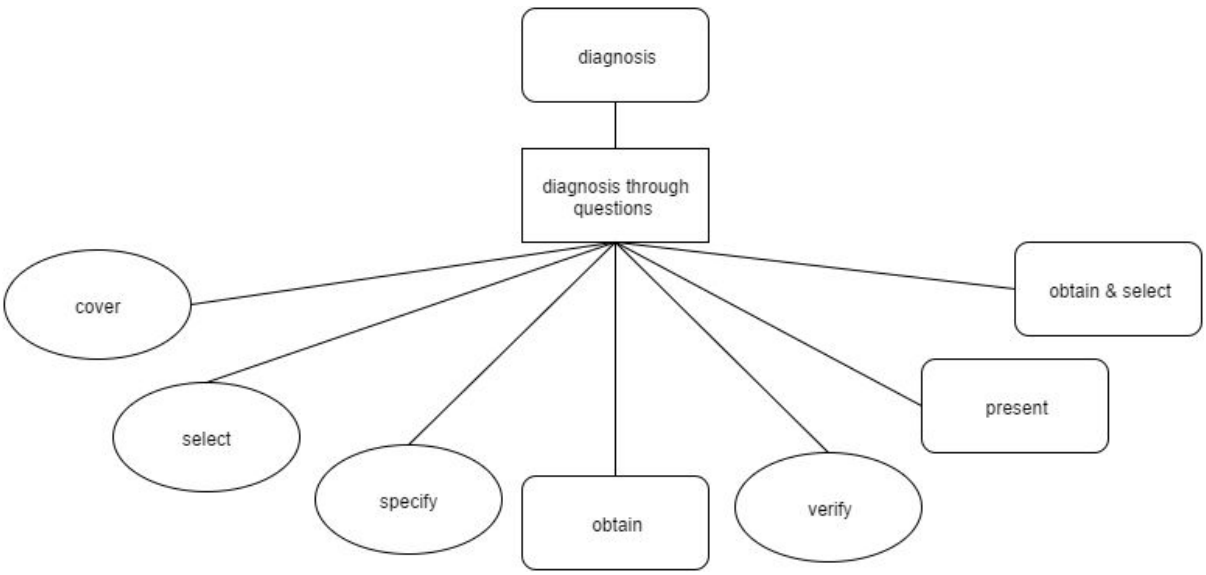

Figure 3. Task decomposition of the diagnosing task.

2.1.3. Task and Task Method Description

```
TASK diagnosis;
      GOAL:
            “Determine if a farmer needs to go to a veterinarian.”
      ROLES:
         INPUT:
            complaint: “Finding that initiates the diagnostic process.”;
         OUTPUT:
            advise: “advise whether or not to go to a veterinarian”;
            evidence: “the evidence obtained during diagnosis.”;
END TASK diagnosis;

TASK-METHOD diagnose-situation-method;
      REALIZES: diagnose-situation;
      DECOMPOSITION:
            INFERENCES: cover, select, specify, verify, select;
            TRANSFER-FUNCTIONS: obtain, obtain;
      ROLES:
            INTERMEDIATE:
                  hypothesis: “List of possible causes and illnesses.”;
                  observable: “An observation provided by the farmer.”;
                  finding: “A degree to what the situation is applicable.”;
                  result: “Possible cause of the situation.”;
                  options: “Options representing the possible causes.”;
                  decision: “Choice of going to a veterinarian.”;
      CONTROL STRUCTURE:
            hypotheses := all-hypotheses;
            FORALL hypotheses AS hypotheses:
                  select(hypothesis -> hypothesis);
                  specify(hypothesis -> observable);
                  obtain(observable -> finding);
                  verify(finding -> result);
                  present(result -> options);
                  obtain&select(options -> decision);
            END-FORALL;
END TASK-METHOD diagnose-situation-method;
```

2.2. Inference Knowledge

Figure 4 shows the inference model which is based on to the diagnosis task template. The prototype makes use of a database which stores all the information. This includes all the entities described in the domain model (section 2.3.1). KB indicates the four types of Knowledge banks used, each KB stands for a table in the database.

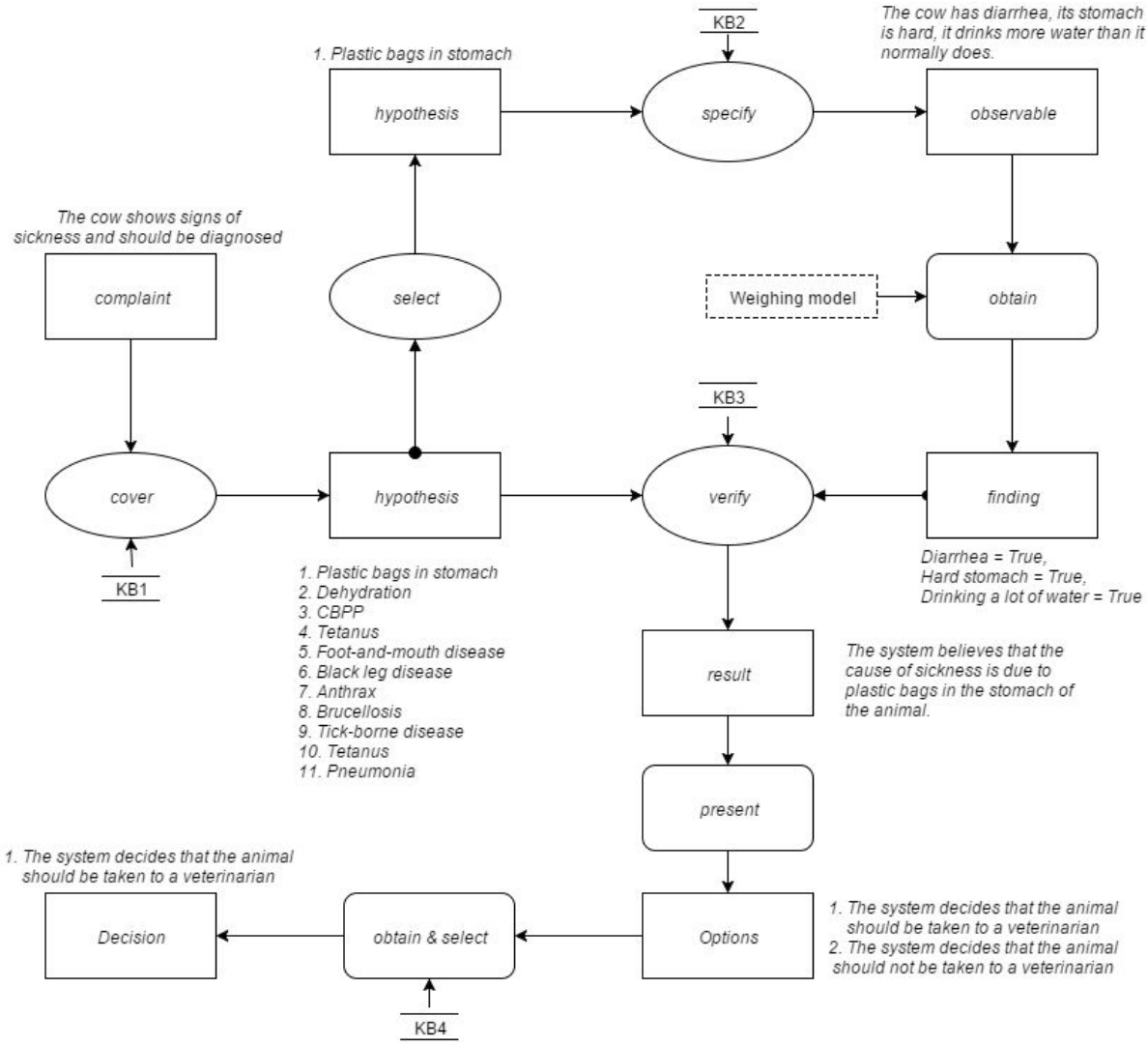

Figure 4: Annotated inference structure - diagnosis

The inferences of the model for diagnosing are described in the table 1 below.

Inference	Input	Output	Static	Specification
Cover	Complaint by a farmer regarding an animal type	List of possible hypotheses based on animal type	KB1: Animals-Influence-rule	The candidate hypotheses are created here
Select	Hypotheses about possible diseases	One specific hypothesis that fits the severity of the disease		Select one hypothesis that is best fitting
Specify	One specific hypothesis about the severity of the disease	The observed symptoms that led to the selected hypothesis	KB2: AnimalDisease-Influence-rule	Describe the severity of the disease by the observed symptoms of the animal
Obtain	Observable	Finding of observable symptoms	Weighing model	Weigh the severity of the symptoms by performing the treatment and reporting it
Verify	Report of the found symptoms	Verification of the chosen hypothesis	KB3: Symptoms-Influence-rule	Verification whether the system has selected the right output given the symptoms
Present	Verification of the chosen hypothesis	The options that the system outputs regarding the final decision		Conclusion about the situation by the system is presented
Obtain & select	Options provided by the system	The final decision based on the input	KB4: LevelUrgency-Influence-rule	Decision whether or not the farmer goes to a veterinarian

Table 1. Inferences of the diagnosis model.

The knowledge roles are in the table 2 below.

Knowledge role	Type	Domain mapping
Complaint	Dynamic	Requested by farmer
Hypotheses	Static	The issues translated to possible hypotheses (KB1)
Hypothesis	Dynamic	The chosen hypothesis based on the most likely outcome
Observable	Static	Observables in sick animal (KB2)
Finding	Dynamic	The conducted treatment
Result	Static	Report of the chosen treatment (KB3)
Options	Static	Options provided by the system to visit a veterinarian
Decision	Static	Decision made by the system (KB4)

Table 2. Knowledge roles of the diagnosis model.

2.3. Domain Knowledge

As described in section 1, this system provides animal health information to a farmer and helps him in the decision whether to go see a veterinarian or not. This project is discussed and has been further elaborated through interviews with experts, both in the Netherlands and in Ghana (see Appendix B). Once the farmer decides to contact a veterinarian, the latter receives a SMS with the details about the situation of the animal obtained by the system. Subsequently, the system shows the telephone number of the veterinarian to the farmer, so that he can call the veterinarian to discuss the situation. This last step is not necessary, as the farmer can also opt to use the system solely as a consulting tool.

2.3.1. Domain Schema

The domain schema used in our application can be found in figure 5.

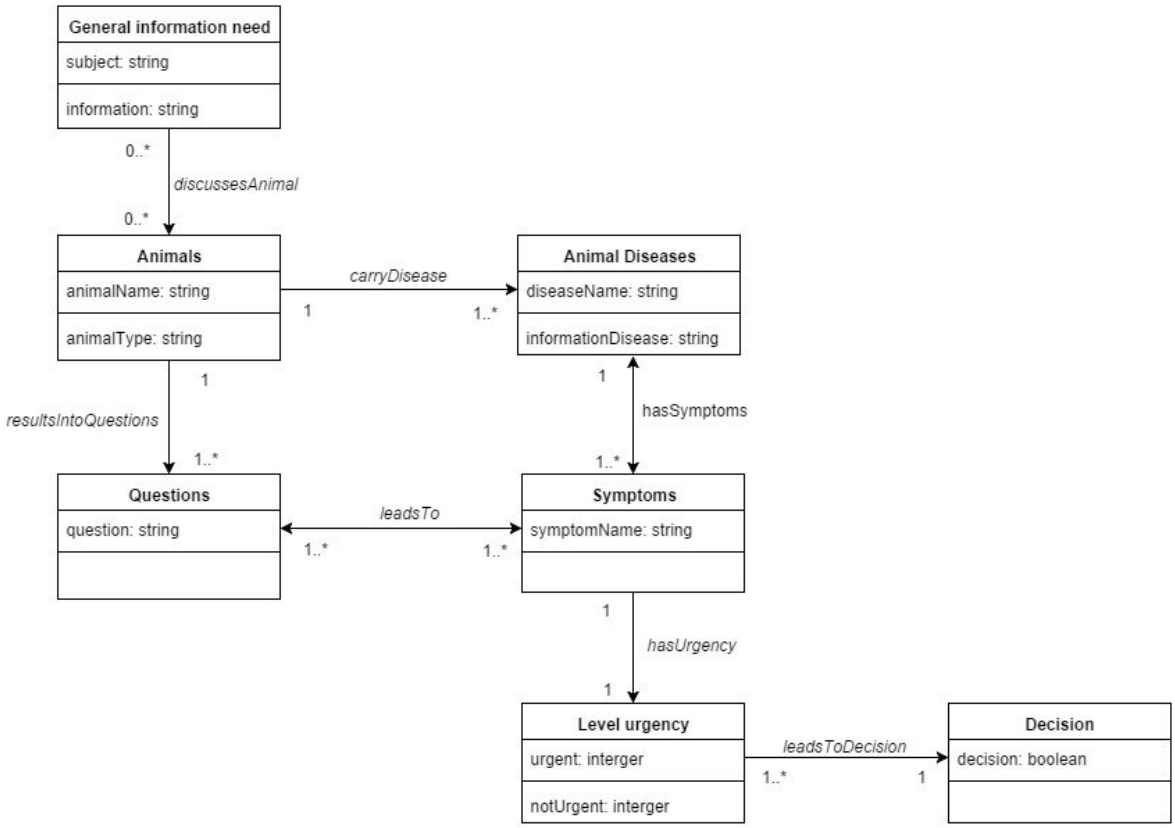

Figure 5. Domain schema.

2.3.2. Rule Types

Figure 6 shows the rule types. Note that the AnimalDisease-influence-rule is reversed compared to the Symptoms-influence-rule. In other words, symptoms can lead to a disease and a disease has certain symptoms, for this reason, both rule-types are given.

Figure 6. Rule types.

```
RULE-TYPE Animals-Influence-rule;
      DESCRIPTION: “Rule stating the relation between Animals and Animal
Diseases.”;
            ANTECEDENT: Animals;
                  CARDINALITY: 1+;
            CONSEQUENT: Animal Disease;
                  CARDINALITY: 1+;
            CONNECTION-SYMBOL: carries;
END RULE-TYPE;
```

```
RULE-TYPE AimalDisease-Influence-rule;
      DESCRIPTION: “Rule stating the relation between the Animal Disease and
Symptoms.”;
            ANTECEDENT: Animal Disease;
                  CARDINALITY: 1+;
            CONSEQUENT: Symptoms;
                  CARDINALITY: 1+;
            CONNECTION-SYMBOL: influences;
END RULE-TYPE;

RULE-TYPE Symptoms-Influence-rule;
      DESCRIPTION: “Rule stating the relation between the Symptoms and the
Level of Urgency and Animal Disease”;
            ANTECEDENT: Symptoms;
                  CARDINALITY: 1+;
            CONSEQUENT: Level Urgency && Animal Disease;
                  CARDINALITY: 1+;
            CONNECTION-SYMBOL: causes;
END RULE-TYPE;

RULE-TYPE LevelUrgency-Influence-rule;
      DESCRIPTION: “Rule stating the relation between the Level of Urgency
and the Decision whether or not to go see a veterinarian.”;
            ANTECEDENT: Level Urgency;
                  CARDINALITY: 1+;
            CONSEQUENT: Decision;
                  CARDINALITY: 1+;
            CONNECTION-SYMBOL: leadsto;
END RULE-TYPE;
```

2.3.3. Knowledge base

First the relations between symptoms and corresponding diseases are discussed. The system makes use of a counting. Whenever a symptom occurs in the animal, the corresponding disease receives one point. After all the necessary questions, the disease(s) with the most points have to most chance of being true. Second, the symptoms are categorized in urgent or not urgent. Again, a counting is used to determine the level of urgency. Note that the questions are not described as rules here, although in the system there is a connection as described in section 2.3.1.

Diseases occur in animals

Rule type: Animals-influence-rule

```
sheep.animal = TRUE OR
goat.animal = TRUE
       CARRIES
PPR.disease = TRUE;

dog.animal = TRUE
       CARRIES
rabies.disease = TRUE;
```

```
cow.animal = TRUE OR
sheep.animal = TRUE OR
goat.animal = TRUE
       CARRIES
plasticBags.disease = TRUE;

cow.animal = TRUE OR
sheep.animal = TRUE OR
goat.animal = TRUE OR
pig.animal = TRUE OR
dog.animal = TRUE
       CARRIES
tetanus.disease = TRUE;

cow.animal = TRUE OR
sheep.animal = TRUE OR
goat.animal = TRUE OR
pig.animal = TRUE OR
dog.animal = TRUE
       CARRIES
tickBorne.disease = TRUE;

cow.animal = TRUE OR
sheep.animal = TRUE OR
goat.animal = TRUE OR
pig.animal = TRUE OR
dog.animal = TRUE
       CARRIES
brucellosis.disease = TRUE;

cow.animal = TRUE OR
sheep.animal = TRUE OR
pig.animal = TRUE
       CARRIES
anthrax.disease = TRUE;

cow.animal = TRUE
       CARRIES
CBPP.disease = TRUE;

cow.animal = TRUE OR
sheep.animal = TRUE
       CARRIES
blackLegDisease.disease = TRUE;

cow.animal = TRUE OR
sheep.animal = TRUE OR
goat.animal = TRUE OR
pig.animal = TRUE
       CARRIES
footAnMouthDisease.disease = TRUE;

dog.animal = TRUE
       CARRIES
rabies.disease = TRUE;

cow.animal = TRUE OR
sheep.animal = TRUE OR
goat.animal = TRUE OR
pig.animal = TRUE OR
dog.animal = TRUE OR
```

```
       CARRIES
dehydration.disease = TRUE;
cow.animal = TRUE OR
sheep.animal = TRUE OR
goat.animal = TRUE OR
pig.animal = TRUE OR
dog.animal = TRUE OR
       CARRIES
bovineTuberculosis.disease = TRUE;

cow.animal = TRUE OR
sheep.animal = TRUE OR
goat.animal = TRUE OR
pig.animal = TRUE OR
dog.animal = TRUE OR
       CARRIES
pneumonia.disease = TRUE;
```

Symptoms and corresponding diseases

Rule types: Symptoms-influence-rule & AnimalDisease-influence-rule

```
fever.symptom = TRUE
       CAUSES
footAndMouthDisease.disease += 1 AND
blackLegDisease.disease += 1 AND
tickBorneDisease.disease +=1 AND
brucellosis.disease +=1 AND
CBPP.disesase +=1 AND
PPR.disease += 1 AND
bovineTuberculosis.disease += 1;

blistersMouth.symptom = TRUE
       CAUSES
footAndMouthDisease.disease += 1 AND
PPR.disease += 1;

blistersFeet.symptom = TRUE
       CAUSES
footAndMouthDisease.disease += 1;

dropMilkProduction.symptom = TRUE
       CAUSES
footAndMouthDisease.disease += 1 AND
rabies.disease += 1;

weightLoss.symptom = TRUE
       CAUSES
footAndMouthDisease.disease += 1 AND
plasticBags.disease += 1 AND
dehydration.disease += 1;

appetiteLoss.symptom = TRUE
       CAUSES
footAndMouthDisease.disease += 1 AND
blackLegDisease.disease += 1 AND
CBPP.disease += 1 AND
tickBorneDisease.disease += 1 AND
rabies.disease += 1 AND
bovineTuberculosis.disease += 1 AND
pneumonia.disease += 1;

quiveringLipsAndFrothingMouth.symptom = TRUE
```

```
        CAUSES
footAndMouthDisease.disease += 1;

blistersTeats.symptom = TRUE
        CAUSES
footAndMouthDisease.disease += 1;

lameness.symptom = TRUE
        CAUSES
footAndMouthDisease.disease += 1 AND
blackLegDisease.disease += 1;

swellingThigh.symptom = TRUE
        CAUSES
blackLegDisease.disease += 1

rapidBreathing.symptom = TRUE
        CAUSES
blackLegDisease.disease += 1 AND
pneumonia.disease +=1;

isolateFromHerd.symptom = TRUE
        CAUSES
CBPP.disease += 1;

unwillingnessToMove.symptom = TRUE
        CAUSES
CBPP.disease += 1 AND
blackLegDisease.disease += 1;


lossCondition.symptom = TRUE
        CAUSES
CBPP.disease += 1 AND
plasticBags.disease += 1;

difficultBreathing.symptom = TRUE
        CAUSES
CBPP.desease += 1 AND
anthrax.disease += 1;

suddenDeath.symptom = TRUE
        CAUSES
anthrax.disease += 1 AND
PPR.disease += 1;

bloodFromOpeningsAfterDeath.symptom = TRUE
        CAUSES
anthrax.disease += 1;

trembling.symptom = TRUE
        CAUSES
anthrax.disease += 1;

highTemperature.symptom = TRUE
        CAUSES
anthrax.disease += 1;

collapse.symptom = TRUE
        CAUSES
anthrax.disease += 1 AND
tetanus.disease += 1;
```

```
convulsions.symptom = TRUE
        CAUSES
anthrax.disease += 1;

abortion.symptom = TRUE
        CAUSES
brucellosis.disease += 1 AND
tickBorne.diseas += 1;

stillborn.symptom = TRUE
        CAUSES
brucellosis.disease += 1;

weakCalfBorn.symptom = TRUE
        CAUSES
brucellosis.disease += 1;

retentionMembranes.symptom = TRUE
        CAUSES
brucellosis.disease += 1;

nervousness.symptom = TRUE
        CAUSES
brucellosis.disease += 1;

infectionMembranes.symptom = TRUE
        CAUSES
brucellosis.disease += 1;

swollenTesticles.symptom = TRUE
        CAUSES
brucellosis.disease += 1;

fatigue.symptom = TRUE
        CAUSES
tickBorneDisease.disease +=1 AND

wound.symptom = TRUE
        CAUSES
tetanus.disease += 1;

stiffness.symptom = TRUE
        CAUSES
tetanus.disease += 1;


twitchingMuscles.symptom = TRUE
        CAUSES
tetanus.disease += 1;

protrudingEyelid.symptom = TRUE
        CAUSES
tetanus.disease += 1;

anxiousAndEasilyExcited.symptom = TRUE
        CAUSES
tetanus.disease += 1;

bloat.symptom = TRUE
        CAUSES
tetanus.disease += 1 AND
```

```
plasticBags.disease += 1;

spasm.symptom.symptom = TRUE
        CAUSES
tetanus.disease += 1;

hardBallInStomach.symptom = TRUE
        CAUSES
plasticBags.disease += 1;

eyesInOrbit.symptom = TRUE
        CAUSES
dehydration.disease += 1;

diarrhea.symptom = TRUE
        CAUSES
plasticBags.disease += 1;
PPR.disease += 1
dehydration.disease += 1;

drinkingLotsOfWater = TRUE
        CAUSES
plasticBags.disease += 1;

drinksLittle = TRUE
        CAUSES
dehydration.disease += 1;

notEnoughFood.symptom = TRUE
        CAUSES
weightLoss.symptom = TRUE;

cough.symptom = TRUE;
        CAUSES
pneumonia.disease += 1 AND
PPR.disease += 1;
bovineTuberculosis.disease += 1;

snot.symptom = TRUE
        CAUSES
pneumonia.disease += 1 AND
PPR.disease += 1;

dropHead.symptom = TRUE
        CAUSES
pneumonia.disease += 1

difficultSwallowing.symptom = TRUE
        CAUSES
rabies.disease += 1;

alteredVocalisation.symptom = TRUE
        CAUSES
rabies.disease += 1;

seizures.symptom = TRUE
        CAUSES
rabies.disease += 1;

aggressive.symptom = TRUE
        CAUSES
rabies.disease += 1;
```

```
exaggeratedMovements.symptom = TRUE
        CAUSES
rabies.disease += 1;

increaseSexualActivity.symptom = TRUE
        CAUSES
rabies.disease += 1;

depression.symptom = TRUE
        CAUSES
PPR.disease += 1;

extremelyThin.symptom = TRUE
        CAUSES
bovineTuberculosis.disease += 1;

swollenLymphNodes.symptom = TRUE
        CAUSES
bovineTuberculosis.disease +=1 1;
```

Urgent or not urgent symptoms

Rule type: Symptoms-influence-rule

```
wound.symptom = TRUE OR
dropMilkProduction = TRUE OR
rapidBreathing.symptom = TRUE OR
lossCondition.symptom = TRUE OR
trembling.symptom = TRUE OR
swellingThigh.symptom = TRUE OR
convulsions.symptom = TRUE OR
abortion.symptom = TRUE OR
stillborn.symptom = TRUE OR
weakCalfBorn.symptom = TRUE OR
retentionMembranes.symptom = TRUE OR
fatigue.symptom = TRUE OR
twitchingMuscles.symptom = TRUE OR
anxiousAndEasilyExcited.symptom = TRUE OR
bloat.symptom = TRUE OR
diarrhea.symptom = TRUE OR
drinkingLotsOfWater.symptom = TRUE OR
insects.symptom = TRUE OR
notEnoughfood.symptom = TRUE OR
drinksLittle.symptom = TRUE OR
swollenLymphNodes.symptom = TRUE OR
alteredVocalisation.symptom = TRUE OR
exaggeratedMovements.symptom = TRUE OR
increaseSexualActivity.symptom = TRUE OR
depression.symptom = TRUE
        INFLUENCES
notUrgent.levelUrgency += 1;

fever.symptom = TRUE OR
highTemperature.symptom = TRUE OR
eyesInOrbid.symptom = TRUE OR
pinkMassEye.symptom = TRUE OR
extremelyThin.symptom = TRUE OR
dropHead.symptom
isolateFromHerd.symptom = TRUE OR
weightLoss.symptom = TRUE OR
```

```
unwillingnessToMove.symptom = TRUE OR
appetiteLoss.symptom = TRUE OR
quiveringLipsAndFrothingMouth.symptom = TRUE OR
blistersTeath.symptom = TRUE OR
lameness.symptom = TRUE OR
difficultBreathing.symptom = TRUE OR
suddenDeath.symptom = TRUE OR
bloodFromOpeningsAfterDeath.symptom = TRUE OR
collapse.symptom = TRUE OR
infectionMembranes = TRUE OR
swollenTesticles = TRUE OR
protrudingEyelid.symptom = TRUE OR
spasm.symptom = TRUE OR
hardBallInStomach.symptom = TRUE OR
cough.symptom = TRUE OR
snot.symptom = TRUE OR
aggressive.symptom = TRUE OR
weirdNoises.symptom = TRUE OR
limping.symptom = TRUE OR
bleeding.symptom = TRUE OR
difficultSwallowing.symptom = TRUE OR
blistersMouth.symptom = TRUE OR
blistersFeet.symptom = TRUE OR
seizures.symptom = TRUE
       INFLUENCES
urgent.levelUrgency += 1;
```

Decision

Rule type: (levelUrgency-influence-rule)

```
notUrgent.levelUrgency > 3
        LEADSTO
toVeterinaian.decision = TRUEwater

notUrgent.levelUrgency < 3
        LEADSTO
toVeterinaian.decision = FALSE

urgent.levelUrgency >= 1
        LEADSTO
toVeterinaian.decision = TRUE

urgent.levelUrgency = 0
        LEADSTO
toVeterinaian.decision = FALSE
```

2.3.4. Weighting model

Based on the scenario's described in section 2.4, here two examples are given.

Plastics bags

```
cow.animal = TRUE;
footAnMouthDisease.disease = TRUE;
blackLegDisease.disease = TRUE;
CBPP.disease = TRUE;
anthrax.disease = TRUE;
brucellosis.disease = TRUE;
tickBorn.disease = TRUE;
tetanus.disease = TRUE;
plasticBags.disease = TRUE;
diarrhea.symptom = TRUE;
hardBallInStomach.symptom = TRUE;
drinkingLotsOfWater = TRUE;
urgent.levelUrgency = 1;
notUrgent.levelUrgency = 2;
plasticBags.disease = 3;
toVeterinaian.decision = TRUE
```

Dehydration

```
cow.animal = TRUE;
footAnMouthDisease.disease = TRUE;
blackLegDisease.disease = TRUE;
CBPP.disease = TRUE;
anthrax.disease = TRUE;
brucellosis.disease = TRUE;
tickBorne.disease = TRUE;
tetanus.disease = TRUE;
plasticBags.disease = TRUE;
drinksLittle.symptom = TRUE
diarrhea.symptom = TRUE;
notUrgent.levelUrgency = 2;
dehydration.disease = 2;
toVeterinaian.decision = FALSE
```

2.4. Scenario's

2.4.1. Plastic bags

Domain	Input	Output	Model	Explanation
Farmer starts application.	The cow shows signs of sickness and should be diagnosed.	Animal type cow is selected.	The farmer is welcomed and selects a cow.	The farmer has an animal that shows signs of sickness. He selects the type of his sick animal.
All possible disease patterns are covered as hypotheses.	Animal type is cow.	Possible hypotheses based on knowledge bank (=KB)1.	Cover: Plastic bags in stomach, Dehydration, CBPP, Tetanus, Foot-and-mouth disease, Black leg disease, Anthrax, Brucellosis, Tick-borne disease, Tetanus, Pneumonia	The hypotheses are selected.
The farmer selects symptoms that fit a specific hypothesis.	Farmer selects a hypothesis.	One hypothesis.	Select: plastic bags in stomach.	A candidate hypothesis is selected based on the questions asked.
We expect that the symptoms will be noticeable on the animal.	One hypothesis.	The cow has diarrhea, its stomach is hard and it drinks more water than it normally does. Based on KB2.	Specify: Minimum of one symptom is noticed in the animal.	One or more symptoms that relate to the selected hypothesis is specified.
System: Obtain symptoms from farmer.	The observables.	Symptoms based on the weighing model.	Obtain: The cow is drinking a lot of water, has diarrhea and farmer feels a hard ball in the stomach of the cow.	The symptoms are processed.
The results are true.	Symptoms.	Possible cause for disease and level of urgency, based on KB3.	Verify: Diarrhea = True, hardBallInStomach = True, drinkingLotsOfWa	Verifying whether one or more symptoms that relate to the hypothesis has

			ter = True.	been found in the animal.
Action execution options.	Result is a possible disease.	Action execution options.	Present: 1. The animal should be taken to the veterinarian. 2. The animal does not have to be taken to the veterinarian.	The system has to decide whether or not the animal should be taken to the veterinarian.
One of the execution options is selected as a final decision.	Action execution options.	Decision made by the system, based on KB4.	Obtain&select: The animal should be taken to the veterinarian.	The system decides, based on the symptoms, that the animal should be taken to the veterinarian.

As can be seen in the scenario above, based on the symptoms, the possible hypotheses is reduced to one. This hypothesis leads to a specific decision made by the system.

Output:
The three symptoms observed in the cow are:

- diarrhea
- hard ball in stomach
- drinks a lot of water

The system believes, based on these symptoms, that the cow has plastic bags in her stomach.

Best practice is:
The cow should be taken to the veterinarian.

2.4.2. Dehydration

Domain	Input	Output	Model	Explanation
Farmer starts application.	The cow shows signs of sickness and should be diagnosed.	Animal type cow is selected.	The farmer is welcomed and selects a cow.	The farmer has an animal that shows signs of sickness. He selects the type of his sick animal.
All possible disease patterns are covered as hypotheses.	Animal type is cow.	Possible hypotheses based on knowledge bank (=KB)1.	Cover: Plastic bags in stomach, Dehydration, CBPP, Tetanus, Foot-and-mouth disease, Black leg disease, Anthrax, Brucellosis, Tick-borne disease, Tetanus, Pneumonia	The hypotheses are selected.
The farmer selects symptoms that fit a specific hypothesis.	Farmer selects a hypothesis.	One hypothesis.	Select: dehydration	A candidate hypothesis is selected based on the questions asked.
We expect that the symptoms will be noticeable on the animal.	One hypothesis.	The cow has diarrhea and drinks less than it normally does. Based on KB2.	Specify: Minimum of one symptom is noticed in the animal.	One or more symptoms that relate to the selected hypothesis is specified.
System: Obtain symptoms from farmer.	The observables.	Symptoms based on the weighing model.	Obtain: The cow has diarrhea and drinks less than normal.	The symptoms are processed.
The results are true.	Symptoms.	Possible cause for disease and level of urgency, based on KB3.	Verify: Diarrhea = True, drinksLittle = True.	Verifying whether one or more symptoms that relate to the hypothesis has been found in the animal.
Action execution options.	Result is a possible disease.	Action execution options.	Present: 1. The animal should be taken to the veterinarian.	The system has to decide whether or not the animal should be taken

			2. The animal does not have to be taken to the veterinarian.	to the veterinarian.
One of the execution options is selected as a final decision.	Action execution options.	Decision made by the system, based on KB4.	Obtain&select: The animal should not be taken to the veterinarian.	The system decides, based on the symptoms, that the animal should be taken to the veterinarian.

As can be seen in the scenario above, based on the symptoms, the possible hypotheses is reduced to one. This hypothesis leads to a specific decision made by the system.

Output:
The two symptoms observed in the cow are:

- diarrhea
- drinks little

The system believes, based on these symptoms, that the cow suffers from dehydration.
Best practice is:
The cow does not have to be taken to the veterinarian.

3. Communication Model

This chapter describes the CommonKADS communication model, which describes the agent-agent transactions and how the knowledge is transferred.

3.1. Communication Plan

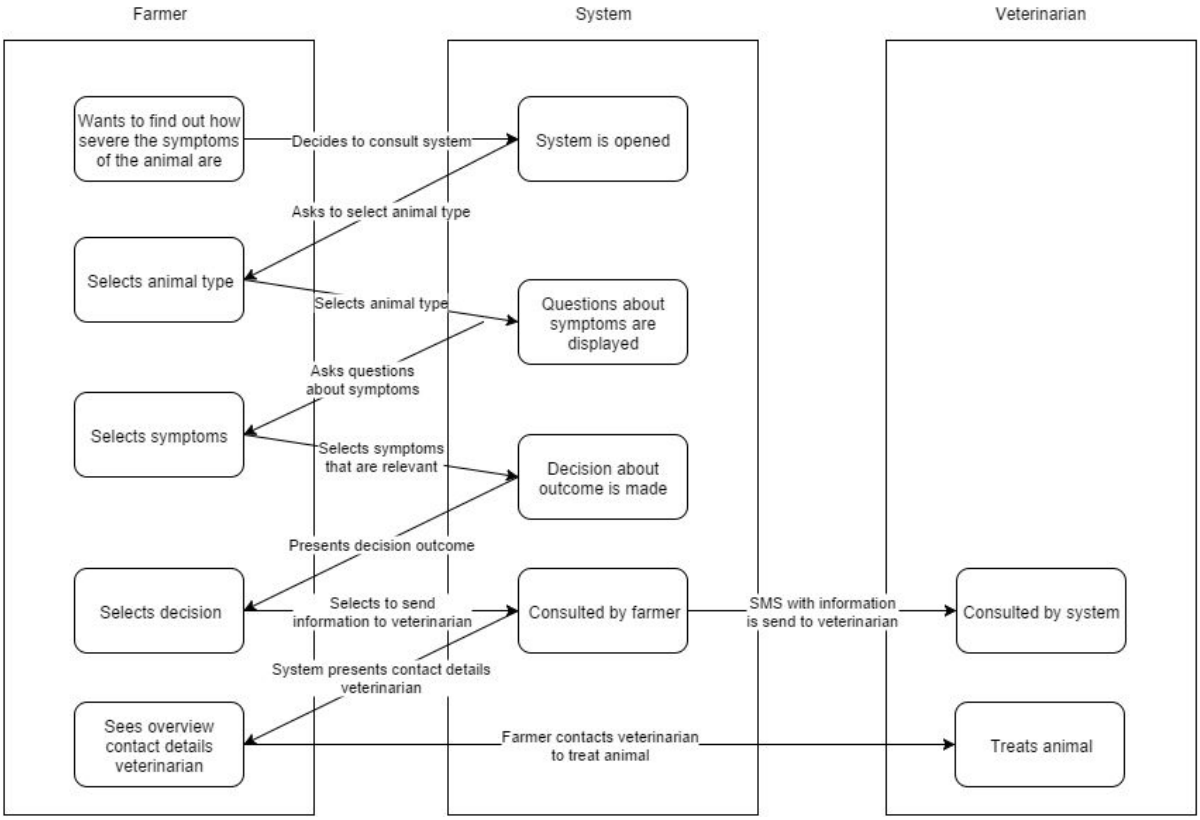

Figure 7. Communication plan.

3.2. Transactions

Communication model	**Transaction Description Worksheet CM-1**
Transaction Identifier/Name	Decides to consult system.
Information Object	Start transaction between the farmer and system.
Agents Involved	Farmer and system
Communication Plan	P1
Constraints	Pre-condition: Farmer is able to use and reach the system. Post-condition: System should have enough energy (solar).
Information Exchange Specification	-

Communication model	**Transaction Description Worksheet CM-1**
Transaction Identifier/Name	Asks to select animal type.

Information Object	System presents the possible animal types to the farmer.
Agents Involved	System and farmer
Communication Plan	P1
Constraints	Pre-condition: - Post-condition: An animal type should be selected.
Information Exchange Specification	-

Communication model	**Transaction Description Worksheet CM-1**
Transaction Identifier/Name	Selects animal type.
Information Object	Farmer selects animal type: transaction between farmer and system.
Agents Involved	Farmer and system
Communication Plan	P1
Constraints	Pre-condition: - Post-condition: System prepares questions based on the animal type.
Information Exchange Specification	-

Communication model	**Transaction Description Worksheet CM-1**
Transaction Identifier/Name	Asks questions about system.
Information Object	Transaction between farmer and system about the presentation of animal specific questions.
Agents Involved	System and farmer
Communication Plan	P1
Constraints	Pre-condition: - Animal specific questions should be presented. Post-condition: Farmers has to answer the question.
Information Exchange Specification	-

Communication model	**Transaction Description Worksheet CM-1**
Transaction Identifier/Name	Selects symptoms that are relevant.
Information Object	Farmer selects relevant symptoms: transaction between farmer and system.
Agents Involved	Farmer and system
Communication Plan	P1
Constraints	Pre-condition: Farmer has to remember symptoms of animal. Post-condition: -
Information Exchange Specification	-

Communication model	**Transaction Description Worksheet CM-1**
Transaction Identifier/Name	Presents decision outcome.
Information Object	Specific outcome is presented by system to farmer.
Agents Involved	System and farmer

Communication Plan	P1
Constraints	Pre-condition: Outcome summary should be given to farmer. Post-condition: Farmer makes a decision.
Information Exchange Specification	-

Communication model	**Transaction Description Worksheet CM-1**
Transaction Identifier/Name	Selects to send information to veterinarian.
Information Object	Farmer indicates decision to consult veterinarian by SMS to system.
Agents Involved	Farmer and system
Communication Plan	P1
Constraints	Pre-condition: - Post-condition: -
Information Exchange Specification	-

Communication model	**Transaction Description Worksheet CM-1**
Transaction Identifier/Name	SMS with information is send to veterinarian.
Information Object	System sends SMS with information about animal to veterinarian.
Agents Involved	System and veterinarian
Communication Plan	P1
Constraints	Pre-condition: System provides a summary of the symptoms and outcome. Phone has mobile reach. Post-condition: Veterinarian knows how to interpret the SMS.
Information Exchange Specification	Transaction is based on a SMS that will be send by the system.

Communication model	**Transaction Description Worksheet CM-1**
Transaction Identifier/Name	System presents contact details veterinarian.
Information Object	Contact details veterinarian presented to farmer by system.
Agents Involved	System and farmer
Communication Plan	P1
Constraints	Pre-condition: System has contact information of all possible veterinarians and is able to provide this in speech. Post-condition: Farmer is able to interpret veterinarian contact details and

	has means to contact the veterinarian.
Information Exchange Specification	-

Communication model	**Transaction Description Worksheet CM-1**
Transaction Identifier/Name	Farmer contacts veterinarian to treat animal.
Information Object	Transaction between farmer and veterinarian regarding the consultation of the animal.
Agents Involved	Farmer and veterinarian
Communication Plan	P1
Constraints	Pre-condition: Farmer possesses a mobile phone. Post-condition: Veterinarian answers the call.
Information Exchange Specification	A telecom connection between the farmer and the veterinarian is used.

3.3. Information Exchange Specification

Communication model	**Information Exchange Specification Worksheet CM-2**
Transaction	Decides to consult system.
Agents involved	1. **Sender:** Farmer 2. **Receiver:** System
Information items	1. **Role:** Core 2. **Form:** Boolean question 3. **Medium:** Any medium used for human communication.
Message specifications	1. **Communication type:** Request/Order 2. **Content:** Decision to consult system. 3. **Reference:** -
Control over messages	-

Communication model	**Information Exchange Specification Worksheet CM-2**
Transaction	Asks to select animal type.
Agents involved	1. **Sender:** System 2. **Receiver:** Farmer
Information items	1. **Role:** Core 2. **Form:** A screen with listed options. 3. **Medium:** Via the GUI.
Message specifications	1. **Communication type:** Ask/Reply 2. **Content:** A screen with optional animals listed as images. 3. **Reference:** -

Control over messages	-

Communication model	**Information Exchange Specification Worksheet CM-2**
Transaction	Selects animal type.
Agents involved	1. **Sender:** Farmer 2. **Receiver:** System
Information items	1. **Role:** Core 2. **Form:** The specific animal selected by the user. 3. **Medium:** Via the GUI.
Message specifications	1. **Communication type:** Ask/Reply 2. **Content:** The farmer selection regarding the sick animal. 3. **Reference:** -
Control over messages	-

Communication model	**Information Exchange Specification Worksheet CM-2**
Transaction	Asks questions about symptoms.
Agents involved	1. **Sender:** System 2. **Receiver:** Farmer
Information items	1. **Role:** Core 2. **Form:** A question. 3. **Medium:** Via the GUI.
Message specifications	1. **Communication type:** Ask/Reply 2. **Content:** A question regarding the type of animal selected. 3. **Reference:** -
Control over messages	-

Communication model	**Information Exchange Specification Worksheet CM-2**
Transaction	Selects symptoms that are relevant.
Agents involved	1. **Sender:** Farmer 2. **Receiver:** System
Information items	1. **Role:** Core 2. **Form:** Boolean option. 3. **Medium:** Via the GUI.
Message specifications	1. **Communication type:** Ask/Reply 2. **Content:** List of symptom that have been selected. 3. **Reference:** -
Control over messages	-

Communication model	**Information Exchange Specification Worksheet CM-2**
Transaction	Presents decision outcome.
Agents involved	1. **Sender:** System 2. **Receiver:** Farmer
Information items	1. **Role:** Core 2. **Form:** Boolean decision. 3. **Medium:** Via the GUI.
Message specifications	1. **Communication type:** Inform

	2. **Content:** Outcome whether or not to go to the veterinarian and short description of the outcome. 3. **Reference:** -
Control over messages	-

Communication model	**Information Exchange Specification Worksheet CM-2**
Transaction	Selects to send information to veterinarian.
Agents involved	1. **Sender:** Farmer 2. **Receiver:** System
Information items	1. **Role:** - 2. **Form:** Data gathered in selection process about outcome. 3. **Medium:** Via the GUI.
Message specifications	1. **Communication type:** Order/Agree 2. **Content:** Data gathered in selection process about outcome. 3. **Reference:** -
Control over messages	-

Communication model	**Information Exchange Specification Worksheet CM-2**
Transaction	SMS with information is send to veterinarian.
Agents involved	1. **Sender:** System 2. **Receiver:** Veterinarian
Information items	1. **Role:** - 2. **Form:** SMS with list of most relevant details outcome. 3. **Medium:** Via SMS through the system's USB 3G dongle.
Message specifications	1. **Communication type:** Inform 2. **Content:** List of most relevant details outcome. 3. **Reference:** -
Control over messages	-

Communication model	**Information Exchange Specification Worksheet CM-2**
Transaction	System presents contact details veterinarian.
Agents involved	1. **Sender:** System 2. **Receiver:** Farmer
Information items	1. **Role:** Core 2. **Form:** List of contact details veterinarian. 3. **Medium:** Via the GUI.
Message specifications	1. **Communication type:** Inform

	2. **Content:** Listed contact details veterinarian. 3. **Reference:** -
Control over messages	-

Communication model	**Information Exchange Specification Worksheet CM-2**
Transaction	Farmer contacts veterinarian to treat animal.
Agents involved	1. **Sender:** Farmer 2. **Receiver:** Veterinarian
Information items	1. **Role:** - 2. **Form:** Cellphone conversation. 3. **Medium:** Mobile phone
Message specifications	1. **Communication type:** Inform 2. **Content:** Conversation on plan of treatment. 3. **Reference:** -
Control over messages	-

4. Design Model

This chapter describes the design of the model, its architecture and the developed prototype. The hardware is displayed, as well as the software used and the programming language(s) used. This design follows the structure of the annotated inference structure as mentioned in section 2.2.

4.1. Worksheet DM-1: System Architecture

Architecture Decision	Format
Subsystem architecture	The architecture of our system can be found in figure x.
Control model	Centralized control for the unit which handles the input.
Subsystem decomposition	The subsystem “application model” is decomposed into models. This decomposition follows object-oriented principles. See figure x.

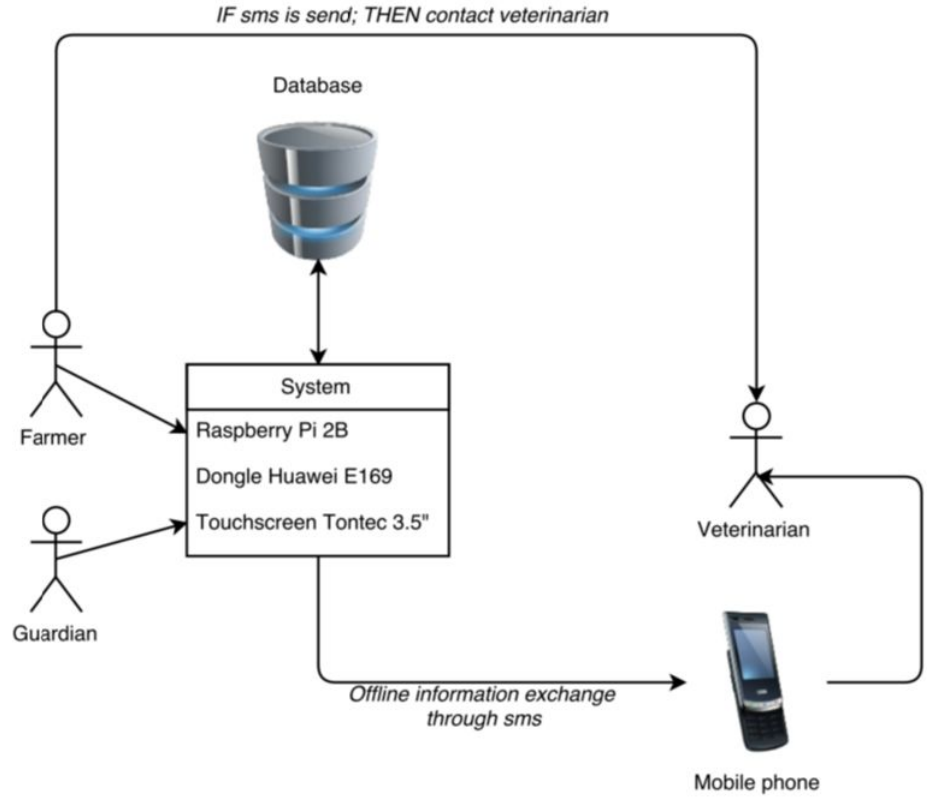

Figure 8. System architecture.

4.2. Worksheet DM-2: Target Implementation Platform

Design Model	
Software package	PHPmyAdmin
Potential hardware	Linux based operating systems
Target hardware	Raspberry Pi 2B [1], Touchscreen Tontec 3.5 inch [2], Huawei E169 dongle [3]
Visualization library	None
Language typing	HTML, CSS, JavaScript, PHP, SQL
Knowledge representation	Procedural
Interaction protocols	-
Control flow	Not needed
CommonKADS support	No

4.3. Implementation

The prototype is developed in such a way that it can be used on a Raspberry Pi. However, due to lack of hardware, the prototype is tested on Windows computers. The prototype contains a README file in which the installation instruction can be found.

The screenshots used in this section will show the overall system. Note that the prototype provides information through text, but also through audio fragments (which are stored in the database) because most of the users are illiterate. This application is dynamic, meaning that every question is requested from a database and then placed into the same page. Advantages of this method is that there is only one page necessary for displaying the questions When questions are changed in the database, this is immediately visible in the application.

To categorize the questions corresponding to the possible disease, a database has been made which stores all the different questions. Since we wanted to prevent the user from having to go through all of the 55 questions, the questions have been categorized. There is a table which contains general questions (which is adapted based on the kind of animal the user has selected), each question here represents a corresponding symptom which is unique or crucial within a certain disease. This means that once a farmer indicates that his animal suffers from this specific symptom, all of the other diseases can be eliminated at that moment. When the farmer clicks yes, it receives questions which correspond to this disease. If no conclusion can be drawn after going through these specific questions, the system will show the second general question, until all of the questions have been asked. If the threshold value is reached, a final outcome in the form of a decision is given. This threshold value is reached once three not urgent and one urgent question is answered by the farmer with yes, or if one or more urgent questions is answered with yes.

Figure 8 shows the start screen. Following the selection made by the farmer to diagnose his animal, the animal screen is displayed (figure 9) in which he selects the animal type. In section 4.3.1, an example of the prototype are given based on the used scenario about dehydration. The system displays the decision whether or not to go to a veterinarian, after which the farmer has the choice to contact a veterinarian or not. Figure 10 shows how the contact details are displayed when a farmer wants to contact a veterinarian. Figure 11 displays the screen when the farmer does not want to contact a veterinarian.

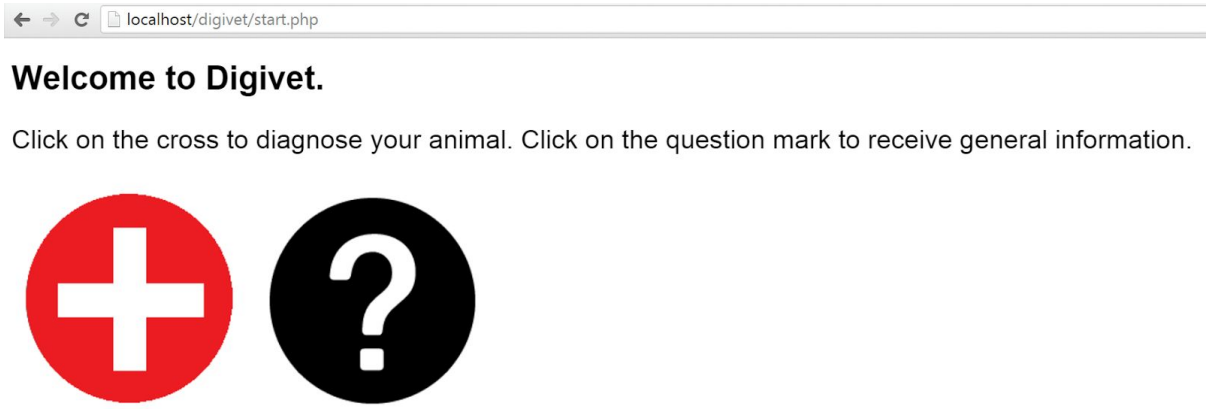

FIgure 8. Start screen

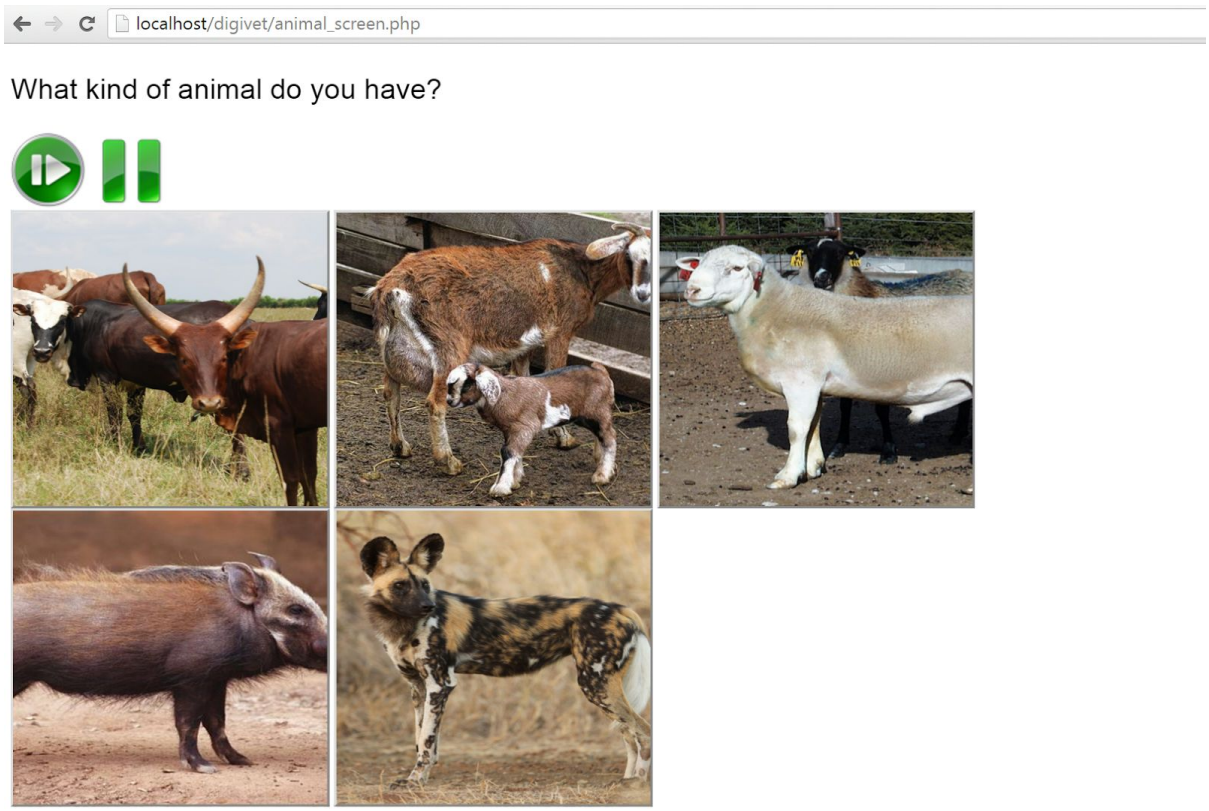

Figure 9. Animal screen.

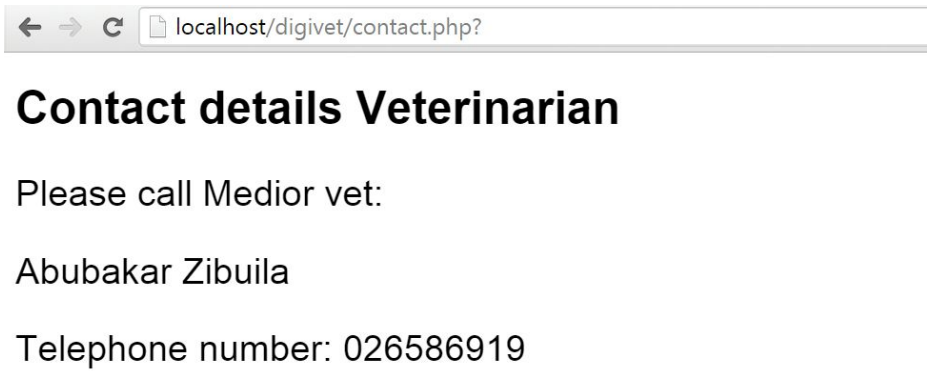

Figure 10. Contact screen.

Figure 11. Final screen.

4.3.1. Prototype scenario Dehydration

After the farmer starts the application, the farmer will be answering yes on the general question showed in figure 12. The question displayed in figure 12 is the general and question that leads to the specific questions about dehydration.

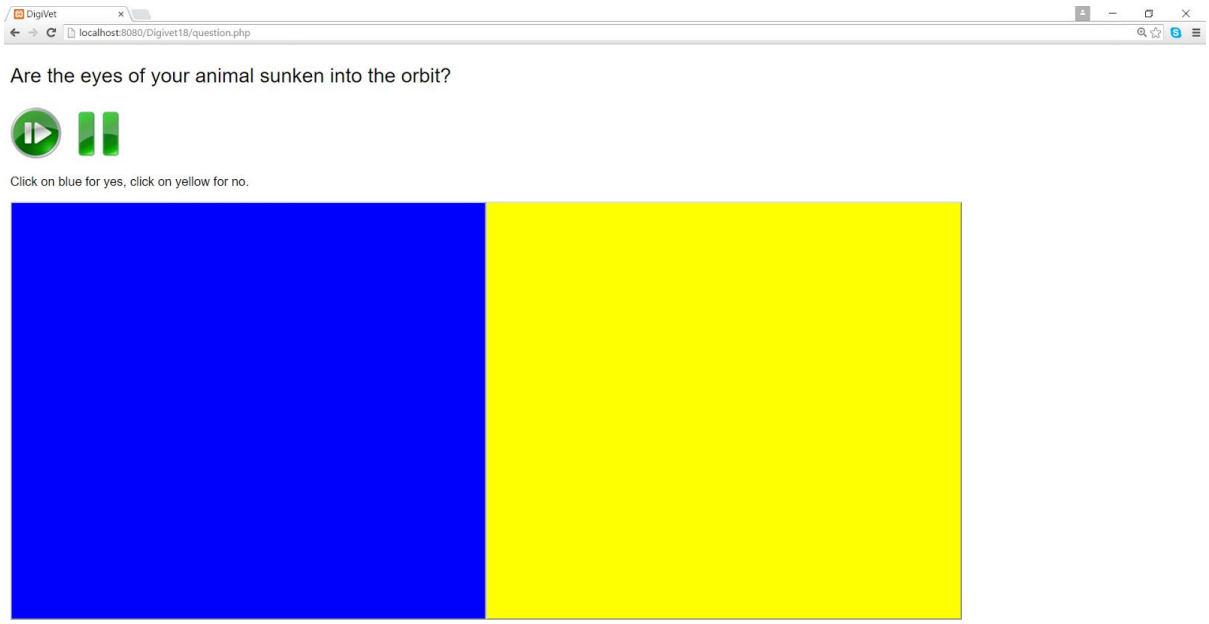

Figure 12: General question dehydration.

5. Reflection

In this chapter we reflect on the overall project, the decisions we made, and we discuss points of improvements/ discussion.

5.1. Reflection on results

The prototype allows to diagnose five kind of animals, which can be affected by a number of possible diseases. Based on the classification of the symptoms as described in chapter 2 (urgent or not urgent and in accordance with specific diseases), corresponding questions and tables have been stored in the database. Thanks to the experts, we gained a lot of information regarding different disease patterns and the structure and purpose of our prototypical system. One of the veterinarians we contacted is located in Senegal, but unfortunately we did not hear back from him. This was probably due to the distance and his busy schedule. Fortunately, the input of the other experts turned out to be enough to complete our prototype.
It would have been nice if one of the experts could verify the questions and our classification. Due to the time limits, this has not been done yet. However, in the interviews with the veterinarians, they indicated that they would be more than willing to test the prototype in their area. This exciting next step will probably provide us with feedback that is required to distribute a fully functioning product in the future.

In order to improve the system, we would like to mention some future goals:

- Sending a SMS to the local veterinarian with all the details retrieved by the system when a farmer decides to contact a veterinarian (possibly using compressed Semantic Data).
- Adding more languages (by creating more audio fragments in different languages).
- Adapting the prototype such that more types of animals and diseases can be processed.
- Providing general information about animals in subjects such as diet and pregnancy.

Concluding, we are very pleased with the progress we made during the project and the final results that were processed in the prototype. The prototype as introduced in the demo transcended our expectations and we are looking forward working on new versions of the prototype in the future. We would like to thank W4RA for their help in obtaining the interviews with the Ghanaian farmers, as well as Ilse Roeker for her honest feedback and necessary background information about Tamale, Ghana and her veterinary experience in this area.

5.2. Discussion and reflection on the process

Looking back at this project and the corresponding process, we are very satisfied with the delivered work. However, we have some points of discussion and possible improvements.

First of all, this system makes use of a lot of information (appendix C). This information is currently based on the interviews with veterinarians and a veterinary information website. Due to the time limits of this project, it was not possible to verify this information by an expert after conducting the interviews. However, this would be necessary once we opt to further

develop the prototypical system. The same applies to the distinction between urgent and not urgent symptoms. Distributing the system on a small scale will reveal to what extent this distinction is correct. Within the framework of this project, the assumption was made that three or more ‘not urgent’ or low priority symptoms would, combined with one ‘urgent’ or high priority symptom, lead to the system’s decision to visit a veterinarian. However, this threshold has not been tested yet and should be revised by the veterinarians in the target area.

We made the decision to focus solely on four-legged animals. However, as indicated by the veterinarians in Ghana (appendix B), there are more animals that require veterinary aid, such as birds and even snakes. These animals should therefore be added in the next developmental cycle of the DigiVet prototype.

An assumption is made that all the other symptoms which were not linked to diseases in this project, can occur in all types of animals. When expanding the distribution scale of the system to other areas than Ghana, context-specific information should be added, which complies to the diseases that occur in those specific regions.

References

1. Raspberry Pi B2. https://www.raspberrypi.org/products/raspberry-pi-2-model-b/. Accessed: 2015-11-17.
2. Touchscreen Tontec. http://www.itontec.com/product-detail/product-name-9/. Accessed: 2015-11-17.
3. Dongle Huawei. http://www.amazon.de/Huawei-E169-Datenstick-farblich-sortiert/dp/B004DEJEMY. Accessed: 2015-11-17.
4. SID NL. http://sidnl.org/. Accessed: 2015-12-10.
5. Frugal Innovation. http://www.ascleiden.nl/research/projects/frugal-innovations-africa. Accessed: 2015-12-10.
6. Frugal Innovation Wiki. https://en.wikipedia.org/wiki/Frugal_innovation. Accessed: 2015-12-10.
7. CFIA. http://www.cfia.nl/. Accessed: 2015-12-10.
8. The Cattle Site. www.thecattlesite.com. Accessed: 2016-01-08.
9. Chabeuf, N. (1983). Trypanotolerant cattle in West and Central Africa. *Journal of the South African Veterinary Association*, *54*(3), 165-170..
10. Audevard Piroplasmosis page. www.audevard.com/en/pages/piroplasmosis.htm.l Accessed: 2016-01-09.
11.Daily nations. http://www.nation.co.ke/business/seedsofgold/Livestock-Animals-Plastic-Bags/-/2301238/2832862/-/el92da/-/index.html. Accessed: 2016-01-09.

Appendix A: Log

Date	Action
16-11-2015	Brainstorming about the project.
23-11-2015	Project Presentation.
25-11-2015	Preparing SID and questions for Dutch veterinarian.
30-11-2015	Preparing SID.
01-12-2015	SID.
03-12-2015	Meeting Dutch veterinarian.
05-12-2015	Working on the first draft of the context analysis.
06-12-2015	Working on the first draft of the context analysis.
07-12-2015	First appointment.
10-12-2015	Processing SID and interview with Dutch veterinarian.
12-12-2015	Mail contact with Dr. SOW.
13-12-2015	Working on the knowledge model.
14-12-2015	First version meeting, improving the context analysis and working on the knowledge model.
18-12-2015	Mailing with Dr. SOW (questionnaire), contact with VU group in Ghana
28-12-2015	Working on changes of the inference and domain model. Viewing and summarizing the data from Ghana.
05-01-2016	Elaborating interviews from Ghana.
06-01-2016	Elaborating interviews from Ghana.
08-01-2016	Working on prototype.
09-01-2016	Working on prototype.
13-01-2016	Communication plan.
14-01-2016	Finishing knowledge model and communication model.
17-01-2016	Finalizing report.
18-01-2016	Working on prototype and finalizing the report for feedback.
22-01-2016	Working on prototype.
23-01-2016	Working on prototype.
24-01-2016	Working on prototype.
25-01-2016	Working on prototype.
26-01-2016	Working on the report and prototype.
27-01-2016	Working on prototype an making final presentation.
28-01-2016	Final presentation.
29-01-2016	Writing a README file for the prototype and finishing the report.

Appendix B: Expert Conversations

Meeting 1: SID

At Tuesday 1 December we went to a SID NL [4] member event, called 'Connect, Consult and Cooperate'. SID stands for Society for International Development. SID NL is a platform for any organisation and individual working on global issues, international cooperation and sustainable development. The event contained two parts. During the first part, several in-depth sessions were organized, where we visited the session from the African Studies Centre [5] about Frugal Innovation. Frugal innovation can be defined as: 'Frugal innovation or frugal engineering is the process of reducing the complexity and cost of a good and its production. Usually this refers to removing nonessential features from a durable good, such as a car or phone, in order to sell it in developing countries.' [6] An example is a small, affordable weather station [7], but also our system is an example of a frugal innovation.

The second part of the event was The World Café which consisted of 2 rounds of 15 minutes in which 8 small sessions took place simultaneously. We participated by being one of the 8 groups which discussed their ideas. In both rounds we shortly introduced ourselves and explained our project idea, which was followed by a discussion with the audience (about 5 persons).

In the first round the audience could share their ideas in the discussion and can write these ideas down on a big paper on the table. In the next round of 15 minutes the audience changes and you will do the same (introduction, question, discussion). But besides having a different discussion due to a different audience, we could use the input of the first round in this discussion as well. The audience could add their ideas on the paper on the table, like the first group did, as well. Within this format, thoughts were shared easily and quick, we gained a lot of new ideas and insights about our project.

Based on the discussion in the two session, the following points and ideas were addressed:

1. Ideas to expand and improve the system
    - Saving old data, this can be used to monitor diseases in a particular area.
    - Possibility to send photo's to a veterinarian to give him/her more information about the current state of the animal.
    - Possibility to send a message from a veterinarian to the community. For example, when a disease is very common, the way how farmers can prevent this disease by their animals can be spread by a message from the veterinarian through the system.
2. Existing projects to look at
    - Crop system from the University of Wageningen
    - www.pharmaccess.org (improving access to quality basic health care including HIV/AIDS treatment and care in sub-saharan Africa).
3. Defined challenges for our project
    - Challenge 1: the system
    - Challenge 2: business model
        - service fee
        - owner
        - publicity

- co-optimizing the vet
- business case of the organisation

5.. Other ideas

- how to use technology in the local context
- Ghana has a lot of spare parts, can you use that in this project
- the question: raspberry vs. smartphone

In conclusion, this was a nice way to hear opinions about our project idea, and gave us a lot information about what we should taken into account when building such a system. Overall, the reactions were positive, and our system, is a system that 'fits in' the current state of the art in Ghana.

Meeting 2: Dutch Veterinarian

At Thursday 3 December we had a meeting with Dr. van Roekel. Dr. van Roekel worked three years ago for a couple of months in Ghana. The meeting was informal, and can be summarized to this extend:

What was the situation in Ghana during your period there?

Farmers from small villages around Tamale all go to one veterinary clinic. Her colleagues were all Ghanaian. There were three veterinarians, there level is hard to determine, some learn by experience, and if they went to college, the study material can be old. This is hard to say.

Often, when a sick animal is coming, one 'golden recipe' is used, which is a mix of antibiotics, multivitamins and corticos. A diagnosis is not that important, the people just want that the animal gets better. Second reason is that a diagnosis costs to much money for the people.

Animals are also a status symbol, the more animals, the richer someone looks.

How does a day as a veterinarian look like in Ghana?

There is nothing like making appointments, people just come by. If it is raining, no one is coming. In the morning the operations are done. Animals do not receive painkillers, people see them as a 'thing'.

Which animals did you see with what kind of problems?

Some cats, 1 monkey, dogs, a couple of donkeys, peacocks and cows. Sheep and Goats were most common.

Rabius, or so called rabies is a disease that often occurs. There is no remedy for rabies, so a local veterinarian just locks up the animal (often a dog) to see if it is rabius. If it is, the animal will die within one week.

Another problem are inflammations of the balls, often by dogs, sheep and goats. The remedy here is to remove the balls through an operation.

One of the biggest problem are the plastic bags which lie everywhere. Animals eat it, but can not digest it. As a result, they stay in the stomach of the animal and eventually the animal will die because of that.

Other common issues are births and abscesses (often by sheeps and goats).

Current situation and problem
Veterinary medicine knowledge from the Netherlands can be used for this system, however the short-sighted reasoning in West-Africa is the biggest problem. Too often, the ‘golden recipe’ is used. In the Netherlands, antibiotics is used against infections and corticos is used for inflammation. When antibiotics is always used, the biggest problem in the future is that the animals will become resident to the golden combi, if this happens, the animals cannot be cured anymore.

The goal is to reduce the amount of antibiotics that is used, however this problem lies with the local veterinarian.

Another problem is that people do not often go to a veterinarian, because this is expensive. However, this results in the fact that it is often too late for a vet to help the animal which has huge consequences such as the dead of an animal.

What do you think of our system?
Diagnosing is really hard, there are multiple symptoms that lead to a disease and vice versa. Another way is to motivate the people to think earlier about their animals to prevent that they take an animal too late to a vet.

The people will probably already have interest in the system due to the device itself. However, you have to prevent that it is used as it is meant to be used, and not misused. An idea is to have a guard for the device, which is someone ‘important’ in the village.

Nevertheless, it is important that the device is firm and is resistant against dust, the hot weather and water.

The system will probably not form a thread for the local veterinarians because if it is working, it will lead to more clients (which are now coming earlier, and probably won’t have seen otherwise because the animal died) and important, more happy clients.

The goal of the system should be to decide if a farmer needs to go to the veterinarian or not.

What are alarm symptoms and corresponding questions?
- Is the animal limping?
- Is the animal bleeding?
- Has the animal a fever (if a temperature measurement is possible)?
- Does the animal fall over?
- Does the animal make weird noises?
- Is the animal still able to walk?

- Is there weight loss?
- Is the animal aggressive?
- Has the animal a cough? Has the animal snot? (this can be a pneumonia)

Less alarming, but if the farmer sees small insects (like fleas), a vet should also be visited, but has less hurry.

Ideas to improve the system

Providing general information about animals and possible diseases to farmers:

- How does a childbirth go by a certain animal?
- What should and shouldn't a specific animal eat?

And, so increasing the general knowledge of farmers which is done through the questions the systems has to ask. For example, for how long is the sheep not eating? How long has the animal diarrhea? For how long is the animal not drinking? These question can perhaps lead to a greater awareness of the farmers.

Another idea is to use the system the other way around, a message from the veterinarian to the people in the village. An example: ‘Clean up the plastic bags, animals should not eat these.’ But also when fast spreading disease do occur, like the pest.

What are things we should take into account?

Every region speaks another language, English is the shared language but not everyone speaks it. Perhaps a kind of interpreter should be available for the farmers. For this reason, now children bring often the animals instead of their parents.

Dr. van Roekel was there during the rain period, but it might be interesting to know if there are other common diseases in the dry period.

We should be careful with making diagnosis. If the system is wrong (a couple of times), the people will not believe in the system and not use in anymore. Therefore it is perhaps better to make a distinguish if the farmer needs to go to the veterinarian or not. And, it is better to say more often to go, than not to go because people now do not go most of the times.

Interviews Tamale

Medior vet:
Abubakar Zibuila,
Technical officer
Tamale Metro Veterinary Clinic
026586919

Junior vet:
Dr. Amoro Nelson Ajanga
Tamale Metro Veterinary Clinic

Interview Hans, Anna and Chris with vets in Tamale:

What is a veterinarian’s working day like in Ghana?

Cattle. If a farmer has a problem, he calls you. Then you go there, to the community. Most of the time it has to do with difficulty in giving birth. This can be done from mondays to saturdays, I'm visiting all the villages.

How many veterinarians does each region have on average?
There are around 14 veterinarians in Tamale. Tamale Metro has 11 vets and Zanleru has 3. They are divided over the region.

Which types of animals are taken to the veterinarian?
All the species that you can think of. Cows, goats, sheep, dogs, birds (fowls, guinea fowls), donkeys, horses?, cats, some people even have snakes as animals.

What are the most common diseases that farmers bring their animals in for?
They are not that varied. In the food, Foot and mouth disease is attacking the cattle. A bacteria takes charge of the system. Farmers sometimes do not have money to treat them. Three streaks: SAT I to III. SAT I can be okay, will sometimes heal by itself, others will suffer and die. If you treat your animal with antibiotics, it will survive. But others who refuse to treat their animals (because of lack of money) will return and they will become carriers. In three or four months, the disease will return. SAT III does not really occur in Ghana. If the animal is sick, it cannot eat, because the mouth is full of sores the feet is full of sores. If it is rainy season, it can spread fast, because of the water.

Black leg is a bacterial disease, the upper thigh, the hymen. In a shorter period, per acute. It happens really fast, in the morning you can become sick, and if you don't take care of it, by the evening, you will lose the animal. You might think that it is bitten by a snake or a scorpion, and by the time you have it checked out, it dies.

The third disease is CBPP, it is very common in the Northern region. There is no vaccination for CBPP.
The fourth one is Anthrax, but that occurs more in other regions. The last time it occurred in Tamale was in 2001/2002. Due to vaccination, this occurs less.
When veterinary care was first introduced in the Northern region in Ghana, it was given for free. So the current people heard from their parents and grandparents that the care was free, which is no longer the case. Before, it was founded by the government. Due to economical hardships, this is no longer the case.

How are these diseases treated in general?
How much does a veterinary consult/ surgery cost on average?
The cost of the vaccination of one cow for Anthrax is 2 Ghanaian cedis.
CBPP is 4 cedis.
Black leg is 2 cedis.
Foot and mouth disease we don't have vaccin for it right now. It spreads by contact. The treatment with antibiotics depends on the weight of the cow and on the antibiotics used. It can range between 5 - 20 cedis.

What are the diseases that are characteristic of the rainy season/the dry season?

Most of the diseases happen in the rainy season, for example the foot and mouth disease. Ticks occur in the rainy season and they bring diseases into the system of the animal, parasites. Breaking down their system.
Anthrax and foot and mouth are very contagious, they can affect other four legged animals. Dry season, mostly in the time when we are in the peak of the heat, we have Anthrax and Blackleg. Tetanus happens during the dry season, they graze closer to the ground, and bacteria can live there for 20-30 years. The animals graze closer to the ground, and get the bacteria in their systems. We vaccinate these animals for all these diseases, except for Foot and Mouth disease. We do not have a vaccination for that disease. The animals are thus protected.

Do you use ICTs, such as computers or cell phones, in order to complete your daily tasks?
We use them on our mobile phones to get particular information, for example pictures. You can snap the picture with your phone. There is a need to get pictures from animals. Our system is so porous, even providing notebooks by the state is difficult. Farmers don't use the devices to snap pictures, they can only call. They call to ask the veterinarian to take a look at their sick animal. "Can you come, my animal is dead, it died suddenly.". They want you to drop everything you're doing and come fly to them immediately.

Do you use the internet for consulting about veterinary information?
When I use the net, I go on it for my own personal issues. It is not used for professional purposes.

People have a lot of goats here, do they also vaccinate them?
They vaccinate goats and sheep here. Groups can get infected by similar diseases, so the most common disease that affects them is PPR. There are other diseases, such as black leg or foot rot.

Is it easy to recognize the disease?
No, we have certain meetings and workshops. A serious farmer is one who is concerned about his animal, and that when there is a need for him to call a vet, he will do it. %serious farmers is the whole community.

Do the farmers keep the cattle for meat or to sell it?
They keep them for economical benefit. They do not slaughter themselves. All the cattle farmers keep them for business, the whole year, to get medium size animals, to get some small money out of them. They also keep them to carry heavy things or to plow to get maximum results of their yields. Now, the illiterate and literate farmers know why they keep their animals. The housing might be a problem, the hygienic aspect, some of them know, but not all of them. They can take a workshop for two or three hours, to learn this stuff, so then they know.

What kind of things do you teach farmers?

How to identify diseases, typical diseases for their particular animals. You let them know when a particular animal is healthy. Some diseases are due to nutritional factors.

So there are also some diseases that the animals can get, because they don't get the good food. What kind of symptoms do cows have when they do not get good food?
During the rainy season, the weight of the cow will change. We ask the farmers to give the cows supplementary feeding. It does not eat, and it walks in a wobbly way. There are certain situations where we have to give calcium, dextro(...) or put them on multivitamin. We need to tell them that where they live is a problem. So we tell them to take them off that particular place, and they heal automatically. Cause sometimes this disease is due to bacteria that are in the place where they eat.

Is that expensive for the farmers?
All things are expensive to the farmers. They always say that they do not have the money. They live in poverty. The rain has reduced. It comes somewhere may/june, sometimes june/july. Before it would sometimes come in march, but this is no longer so, sometimes it arrives beginning of august.

Do you also give advice on cropping or harvest?
We do, we go to the communities and tell them that because of certain techniques, their animals are suffering. We call it a training, we train them.

How often do you go to the village and give training?
You want to give a vaccination, so you go there. You try to talk to them, cause you see this or that. We have to come together.

So you make advantage of the fact that they have called you for a vaccination to give training?
Yes, exactly.

Did you experience any difficulties while using ICTs in your job?
We are developing a knowledge based system to enable farmers in rural Ghana to obtain veterinary information. Through the system, they can indicate what the symptoms of their sick animal are, and the system will output whether or not the farmer should visit a veterinarian. In this way, we hope to reduce the time farmers take to find a cure for their sick animals. In case of a disease, we hope to establish communication between the vet and the farmer.

What do you think of our system?
Yes that is useful, it might give them a push. If you give them the tablet, and let them physically diagnose the disease, and tell them this is how it's supposed to be done, then tomorrow, they will go beyond. Farmers often come to us and tell us what the condition of their sick animal is, and they will not even tell you the truth. If they don't tell you the right condition, you will never fight it. So most of the times you even have to go there specifically. There should be veterinary officer around.

It would be difficult to diagnose for them, but it would be nice to repeat what we have told in the training/meeting. There are some communities or members that could test it out.

Before they distribute it, we should talk to the students about the diseases, the signs. Then, prior to that, the very day that the tablet will be issued at, this should be repeated.

It would be made for illiterates as well, such that everything would be in pictures, and they can see what they do. It is a gradual process, if you say that we should change it, we will change it.
The illiterates will not even be able to tell you what the signs are. If you don't have a proper explanation, then it will not go well.

Do they keep their animals in their own field, or combine them?
Some do, they release them to graze. Some lock them up inside and don't allow them to go outside. They are protected from bad water and weather.
They supplement them in the morning. Put water with it. Then they go out until the evening.

Do they buy the food or do they take it from their fields?
Almost all buy food for their animals now, almost all the animals within Tamale. Virtually nothing is free when it comes to animal feeding.

Do they milk the cows and sell the milk?
Yes they do, and sell it as well. They do not do that for the goats or sheep. They produce cheese from the milk in the cattles. Those who know how to make cheese will do that.

Appendix C: Overview diseases and symptoms
Based on the interviews, animals and diseases for our prototype are here discussed. Next, the corresponding symptoms are explained. To gain more detailed data, such as symptoms and treatment, the website 'The Cattle Site' [8] is mostly used which lists a lot of information about diseases in cattle.

The following type of animals do occur: cows, goats, sheep, dogs, birds (fowls, guinea fowls), donkeys, horses, cats, snakes and pigs. For our prototype, we focus on the following animals:

- cows
- goats
- sheep
- pigs
- dogs

The following diseases are used in the prototype:
The symptoms that are unique for a specific disease are displayed in bold. These were used to narrow the search tree when a farmer uses the system.
Foot-and-mouth disease
Summary: A severe, highly contagious, viral disease of cattle and swine. It can also affect sheep and goats. Occurs in the rainy season.

Animals affected: cows, sheep, goats, pigs

Cause: This disease is caused by a virus, of which there exist seven types. They all lead to the same pattern of symptoms, and are only distinguishable by doing laboratory research. The symptoms can appear as early as 24 hours after infection, but can also show after ten days or longer. The average time for symptoms to appear is three to six days.

Depending on the temperature and the pH-value in the environment, the virus can survive in contaminated fodder for up to one month.

The virus spreads among animals by direct contact with an infected animal or contact with the contaminated fodder or other things that have been contaminated by the infected animal. It can also be spread by people and vehicles that have been in touch with infected animals.

Symptoms:

- Fever
- Blisters in the mouth
- **Blister on the feet**
- Drop in milk production
- Weight loss
- Loss of appetite
- Quivering lips and frothing of mouth
- Cows may develop blisters on teats
- Lameness

Treatment: The animal is treated with antibiotics. Often, farmers do not take their sick cattle to the veterinarian (because they lack money), which causes the disease to spread among the other animals. The disease will then return in three or four months. If the mouth of the sick animals full of blisters, it has difficulty to eat properly. In the rainy season, the disease spreads fast, because of the large amount of water.

Black leg disease

Summary: A highly fatal, bacterial disease that affects young cattle. Most of the cases occur in young animals between 10 months and two years of age. Occurs in the dry season.

Animals affected: cows and sheep

Cause: This disease is caused by bacteria (Clostridium chauvoei).

Symptoms:

- Lameness
- **Swelling on the thigh**
- Loss of appetite
- Rapid Breathing
- Fever
- Unwillingness to move

Treatment: In most cases the affected animal is found dead before its owner could suspect that something was wrong. The animal can fall ill in the morning and die in the evening. It might look as if the animal is bitten by a snake or a scorpion.

Animals are vaccinated and these animals are thus protected.

Prevention: Vaccination is available.

CBPP (Contagious Bovine Pleuropneumonia)

Summary: An infectious and highly contagious disease of cattle. It is considered to be one of the most important infectious diseases. All ages are susceptible, but whereas old cattle lung infections, young cattle suffer from joint swellings.

Animals affected: cows

Cause: Caused by bacteria (Mycoplasma mycoides var. mycoides). It spreads through contact with an affected animal. This occurs when animals have direct, close or repeated contact, for example in their accommodation, in their drinking/eating areas, when they graze together. The bacteria are present in the breath and urine of infected animals. The bacteria are killed in hot and dry environments, but can still transmit over 200 metres through the air. The spreading of this disease is more common when a group of animals is being transported, when they are housed together, or when they are trekking.

Symptoms:

- **Cow isolates itself from the herd**
- Difficulty in breathing
- Loss of condition
- Fever
- Snot coming out of the nose
- Loss of appetite
- Cow is unwilling to move

Treatment: Treatment is rarely used, as the emphasis is usually on prevention in the form of vaccination. However, in Northern Ghana, treatment is often given by means of antibiotics. Prevention: The prevention of CBPP can be achieved by eliminating the whole group of cattle, if af case has been detected. However, this is not realistic, and it is often opted to single out the infected animal, put it in quarantine, and vaccinating it. This vaccination is only 100% effective if all the cattle in the area are vaccinated.This vaccination should then be repeated every year or every couple of years.

The veterinarians that were interviewed for this project indicated that there currently is no vaccination available in their region.

Anthrax

Summary: Highly contagious, bacterial disease. Occurs in the dry season.

Animals affected: Cows, sheep, pigs

Cause: Infection is often caused by ingestion of contaminated soil, fodder or compound feed. In wet weather, Anthrax spores can surface. These spores can cause Anthrax even years after the outbreak.

Symptoms:

- Sudden death (often within two or three hours of being completely normal)
- Very occasionally before death (over 24 hours):
    - **Convulsions**
    - Trembling
    - Blood coming out of the animal after its death
    - A high temperature
    - Difficulty breathing
    - Collapse
    - Animal is unwilling to move
- After death:
    - Blood may not clot (small amounts of blood from the nose, mouth and other openings)

Treatment: Due to the fact that the disease occurs so rapidly, treatment is often out of the question. In some cases, high doses of penicillin may be effective in the later stages.

Prevention: The animals should be vaccinated against Anthrax.

Whenever the animal dies of Anthrax, its carcase should be removed immediately, once the bacteria comes into contact with oxygen, it will form spores. The accommodation should be quarantined until all the susceptible animals have been vaccinated.

Brucellosis
Summary: This infectious disease can occur by cattle, goats, dogs and pigs. It spreads easy as the calf, membranes and the uterine fluids contain the bacteria. Diagnosis has to be done in a laboratory by testing for example blood or milk samples [9].

Animals affected: cows, sheep, goats, pigs, dogs

Cause: This disease is caused by Brucella bacteria.

Symptoms:
- Abortion
- Stillborn
- Weak calf born
- Nervousness
- Retention of fetal membranes
- Signs of infection in the membranes
- **Swollen testicles in bulls**
- Fever

Note that this disease is manifested differently in males than females. This is why we decided to use two unique questions in our system. The bold question above focuses on male animals, whereas the more general question 'Did your animal give birth recently?' focuses on the females.

Treatment: No treatment is available.

Prevention: Vaccination of the animals, however this is not a guarantee but it can increase resistance to an infection. Animals with the disease should be kept in quarantine to prevent spreading of the disease.

Tick-borne diseases (piroplasmosis, rickettsiosis, streptothricosis)
Summary: The parasite invades the animal and destroys red blood cells. The disease develops at different rates, symptoms appear one to four weeks after the infection. Ticks occur in the rainy season [10].

Animals affected: cows, sheep, goats, pigs, dogs

Cause: Stung by a tick (parasite).

Symptoms:

- Lack of appetite
- **Fatigue**
- Recent abortion
- Fever

Treatment: Removing the tick.

Prevention: Cleaning pastures to remove areas where ticks like to live, for example, heaps of death leaves and undergrowth. Removing ticks as soon as possible and preferably apply insecticides to the animal's body.

Tetanus

Summary: Common disease in many types of animals. Tetanus is a disease which occures during the dry season, animals the graze closer to the ground where the bacteria (Clostridium tetani) can survive for 20 till 30 years.It is rare in cattle, but outbreaks of this disease can cause many losses.

Animals affected: cows, sheep, goats, pigs, dogs

Cause: This disease is caused by a bacteria which enters the body of an animal through a wound or through the mouth while grazing which leads to an infection. The time between the infections and the disease can be short (two or three days) or longer (four weeks or more). This disease can cause death of the animal.

Symptoms:

- **Spasms**
- The animal has a wound
- Stiffness causing difficulty in moving and a held out tail
- Twitching of the muscles
- Protruding third eyelid
- Cattle can be anxious and easily excited by sudden actions (movement)
- Urgent symptoms: collapse, lying with legs held stiffly out, spasm

Treatment: not worth it when the disease is already fully developed. Otherwise, sedatives and relaxants can be used as a possibility for recovery. Animals in early stages have the most chance of survival with a treatment.

Prevention: Undertaking surgical procedures (like castration) in a clean environment. A vaccine can be used to protect the animals.

Plastic bags in stomach

Summary: Due to the fact that there are a lot of plastic bags wander around the areas, animal eat these which can causes the death of an animal [11].

Animals affected: cows, sheep, goats

Cause: Wandering of plastic bags.

Symptoms:
- **Hard ball in stomach**
- Diarrhea
- Loss of condition
- Fatigue
- Bloat
- Drinking a lot of water
- Loss of weight

Treatment: Operation which removes the plastic bags from the stomach of the animal.

Prevention: Removing plastic bags from the environment and give cattle enough food.

Rabies
Summary: Rabies is a disease which attacks the nervous system (brain and spinal cord) which can result in the death of an animal. This virus is common, among others, in Africa.

Animals affected: dogs

Cause: Infection in cattle is often caused by a bite from an infected wild animal.Possible entrance points for the virus are open wounds, mucous membranes, eyes and the mouth.

Symptoms:
- Drop of milk production
- Lack of appetite
- Difficulties swallowing
- Altered vocalisation
- **Seizures**
- Aggressive
- Excitable or exaggerated movements
- Increase sexual activity

Treatment: There is no treatment available. Place the animal in quarantaine.

Prevention: Vaccination of the animals. Identify and control source, and education.

PPR (Peste des Petits Ruminants)
Summary: a severe, fast-spreading viral disease which mainly affects domestic small ruminants.

Animals affected: sheep and goats

Cause: A viral disease which spreads through discharges from eyes, nose and mouth, as well as the loose faeces of infected livestock. The virus can spread through water and feed troughs and by close contact between the animals.

Symptoms:

- **Sudden onset of depression**
- Discharges from the eyes and nose
- Sores in the mouth
- Disturbed breathing and cough
- Foul-smelling diarrhea
- Sudden death

Treatment: There is no treatment available, but prevention in the form of vaccination should take place.

Prevention: Vaccination of the sheep and goats.

Some diseases and disease patterns can be treated without the intervention of a veterinarian. These will be classified as non-urgent. However, the farmer will still be able to contact a veterinarian.

Dehydration

Summary: Cattle will use body reserves or drink water in order to maintain homeostasis. When this homeostasis is disturbed, it can result in dehydration.

Animals affected: cows, sheep, goats, pigs and dogs

Cause: Drinking too little water, spending too much time in the sun.

Symptoms:

- Does your animal drink less water than usual?
- Does your animal suffer from weight loss?
- **Are the eyes of your animals sunken into the orbit?**
- Does your animal suffer from diarrhea?

Treatment: Restoring the body fluid needs to a level of homeostasis, this can be reached by drinking a lot of water.

Bovine tuberculosis

Summary: Although this disease first and foremost affects cattle, it is highly contagious and can be transmitted to other warm blooded animals, even to humans. It is caused by a bacterium, which is killed by sunlight.

Animals affected: cows, sheep, goats, pigs and dogs

Cause: This disease is caused by a bacterium. These bacteria affect the lymph nodes of the animal and is highly contagious.

Symptoms:
- **Is your animal extremely thin?**
- Does your animal have a fever?
- Does your animal have loss of appetite?
- Does your animal have swollen lymph nodes?
- Does your animal cough?

Treatment: Treatment is rarely attempted because of the high costs.

Prevention: Isolate or even slaughter the affected animal.

Pneumonia
Summary: A multifactorial disease which spreads in high humidity environments.

Animals affected: cows, sheep, goats, pigs and dogs

Cause: This disease is a major problem in livestock and is very complex and multifactorial.

Symptoms:
- Does your animal cough?
- **Does your animal drop its head?**
- Is there snot coming out of the nose of your animal?
- Is your animal breathing more rapidly than usual?
- Does your animal have loss of appetite?

Treatment: Antibiotics can be used to treat the affected animal, however, it is not a guarantee that the animal will be cured.

Other symptoms and diseases
Besides the serious diseases as described above, there are also ‘less’ urgent diseases or conditions of animals. The system takes into account the following:
- Dehydration, symptom: animal drinks not enough.
- Urgent symptom: animal is limping, can because of broken bones for example.
- Urgent symptom: if the animal is bleeding
- Urgent symptom: if the animal makes weird noises
- Urgent symptom: if the animal is aggressive
- Urgent symptom: if the animal has a cough and snot (can be pneumonia)
- If there are small insects on the animal. Not urgent, but a farmer should be visited.
- Weight loss due to too little food.