A New Information System for Tracing Geolocations of Bovine Cattle

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ABSTRACT. The present paper describes the main idea of a new information system architecture dedicated to the animal geolocation acquisitions. It is applied to traceability of beefs in Brazil. In case of sanitary alerts, the system should be able to determine the animals which have been in contact with a diseased animal. This proposal is issued from studies undertaken in the project OTAG[1] supported by the European Union. OTAG focuses on improving methods and geotechnologies for recording reliable and accurate data on beef production. OTAG develops an operational geo-decisional system to track and trace the mobility, provenance, and state of beef cattle. The presented method enables the acquisition of animal geolocations at a large scale. It minimizes the quantity of devices equipped on animals, and consequently the global economical and energetic costs of the system.

KEY WORDS: AGRICULTURE, BOVINE TRACEABILITY, GPS, UHF

[1] Operational management and geo-decisional prototype to Track and trace AGricultural production - www.otag-project.org

1. Introduction

The main goal of this application paper is to sum up the first studies undertaken during a project supported by the European Community about geolocation and agricultural traceability.

The present paper introduces a first proposal of architecture for animal geolocation acquisitions at a large scale. It is applied to traceability of beefs in Brazil. This proposal is issued from the project OTAG (Operational management and geo-decisional prototype to Track and trace AGricultural production). The project is a specific support action of the 6th European Framework Programme. It concerns the bovine traceability in the context of Southern Cone Countries and EU policies. During the project, we proposed a new generation of methods to make the bovine traceability more reliable. The main idea of the solution is to use the last technologies of communication in order to memorize a precise history of animal geolocations. With the proposed system, deciders will have relatively exhaustive information about contacts between animals. In case of sanitary alerts (e.g. epidemic disease), they can deduce and delimitate very precisely the animals and the geographical areas (farms, pastures, etc.) having a potential risk. A goal of the solution presented in this paper is to minimize the economical and energetic costs of the geolocation acquisition.

In the last years Brazil has become the most important producer and exporter country of beefs in the world, with 2 millions tons in 2007. However, to maintain itself on this important economic position, Brazil needs constantly to improve its production systems as well to invest in aspects related to sanitary control. Brazil must fulfill the new requirements of markets such as the ones of European Community. The Brazilian beef production is developed all over the territory. It includes a population of 165 million of animals, and approximately 225 million hectares distributed in 2.20 million properties (IBGE, 2007).

The next section presents our analysis of existing traceability systems, and set the place of our proposal. Section 3 introduces the general architecture of our system and the main actors we consider; the possible use cases of the system has been studied for each actor. Section 4 describes our main idea for acquiring geolocations of animals. The presented method enables the acquisition of animal geolocations at a large scale. It minimizes the quantity of devices equipped on animals, and consequently the global economical and energetic costs of the system. Section 5 explains some models of databases that will be used to store animal geolocations.

2. Bovine traceability: existing systems and new needs

In Brazil there are two information systems related to beef cattle production. SISBOV (traceability service of beef cattle production chain) contains general information about the animal life inside the farm, from birth to death e.g. date of birth, vaccinations (SISBOV, 2008). The farms who intend to export their production must use this system. To control the animal movement, Brazilian Ministry of Agriculture, Food and Livestock (MAPA) uses GTA system (Animal Traffic Guide). GTA is used to record places of origin, as well as farm entry/exit dates of animals. The information managed by SISBOV and GTA systems are complementary.

In Quebec, the Ministry of Agriculture has entrusted Agri-Traçabilité Quebec (ATQ) with developing and managing livestock identification and traceability system (AGROTRACABILITE, 2008). Quebec's livestock identification and traceability system allow knowing the main locations of each animal, its history, its transit and the animals which have been in contact with it. There are 3 types of information stored in the national ATQ database:

- the animal identification (thanks to an RFID ear tag),
- the site identification (an unique seven-digit number for each site, like farm, slaughterhouse and so on),
- the recording of each animal movement (and some additional events).

In Europe the regulation for animal identification, which is the responsibility of the Ministry of Agriculture of each individual EU country, is based on 4 principles:

- allocation of an unique national number for each animal,
- recording of the information regarding to the identity of every bovine into a cattle register held (recording made by producers for each livestock),
- communication of this information to a national computerised database,
- production of an identity document (cattle passport) to accompany every bovine travel.

These rules are the same in all the EU countries with some local adaptation. There are official procedures to make the equivalence of the data from different country.

In France, the Ministry of Agriculture delegates the practical running of the identification process to an official regional body (Etablissement départemental de l'élevage). The database for the registration of bovine in France is the BDNI (Base de Données Nationale d’Identification). It was created in 1999 by the Ministry. In January 2008, there was around 19,900,000 bovines registered and 246,000 farms. In France, there is also a project named GIEA which is focused on the data management of the farm (GIEA, 2008; DUFY et al., 2006; BRUN et al., 2005; POYET et al., 2003). A goal of this project is to propose a standard data format to facilitate information exchanges between agricultural software and French information systems. Once implemented in the main software applications used by famers, this standard could be employed to encode data before their transmission between farms and national information systems. An UML modelling of the GIEA data format is available (PINET et al., 2009 ; BOOCH et al., 1999).

Traditional systems are able to memorize the main bovine movements (e.g. from a farm to another), or to capture the geolocation of an animal when a transporter scans its RFID tag with a specific device (see ATQ systems). Now it should be possible to envisage a new generation of bovine traceability systems in which the different locations are automatically recorded several times per day for each animal. Memorizing the precise history of animal geolocations will improve considerably the traceability especially for countries having very large pasture areas (such as Brazil). With these new systems, deciders will have relatively exhaustive information about contacts between animals. In case of sanitary alerts, they can deduce and delimitate very precisely the animals and the geographical areas (farms, pastures, etc.) having a potential risk.

An objective of OTAG is to propose a technological solution and a global architecture for a new generation of animal traceability systems. For measuring the animal geolocations in the pastures, the project proposed the use of electronic devices embedded in necklaces carried out by beefs. Then these data will be centralized in databases at different levels. These records will constitute a valuable information source for providing an efficient traceability of animals, and as a consequence, a better sanitary control and a reliable alimentary security.

3. OTAG solution: architecture layers and identified actors

The OTAG architecture is organized in four layers as schematized in Figure 1. The layer 1 concerns the acquisition of georeferenced data in the agricultural pastures; the data are captured thanks to embedded electronic devices carried out by the animals. The layer 2 is responsible for storing collected data at the farm level in using local information systems and databases. In the layer 3 the information of all the farms supporting our system are centralised in a same transactional database. The layer 4 is dedicated to the geo-decisional analysis; its main goal is to help public authorities make decisions (for instance in case of sanitary alerts). This last layer could be supported by different geo-decisional tools and a data warehouse that will integrate the database presented in layer 3 with several external sources of data e.g. information about ground, pastures, climate, etc.

We propose bellow the use cases of the possible protagonists involved in the system.

Government. Data about animal geolocations can be analysed by public authorities in order to make decisions in different situations when a sanitary alert occurs.

Consumers. The consumers are the domestic market of bovine meat. Our system could give information for those actors about production system practices and about the animal life and its origin. Those data contribute for increasing product quality.

Researchers. The researchers could get many information from the system, to compare the results of different production systems used in farms, to analyse data from different sources in order to study the real impact of grounds, pastures and climate in the bovine production systems and to analyse in a more realistic way the relation between animal movement and illness occurrence.

Farmers. Farmers are the most important actors in the system. The quality of information depends directly on the benefits that they could get by using the system.

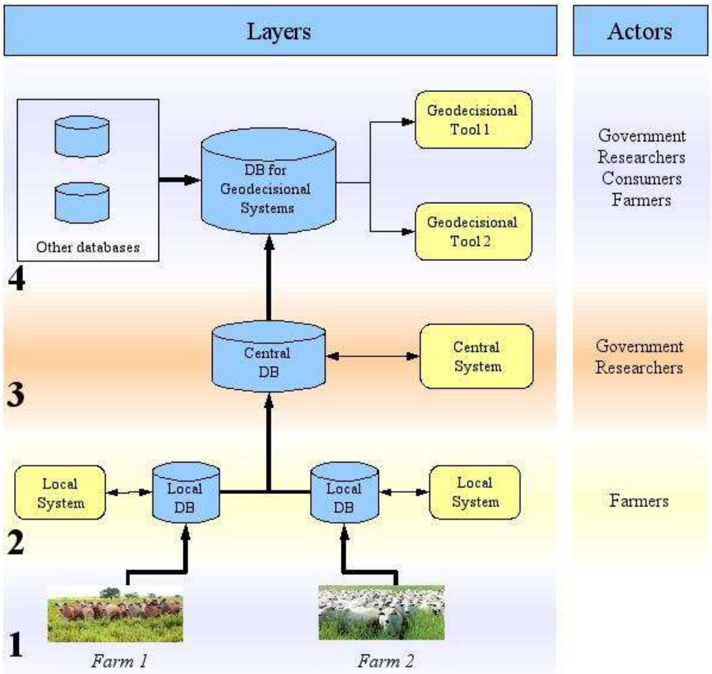

Figure 1: Layers of the traceability architecture

4. New principles of data acquisition

An innovative mechanism has been proposed to acquire geolocations of animals. In the proposed system, geolocations of animals will be measured periodically, by the use of specific electronic necklaces on the animals, and by considering the concept of "master" and "slave" animals.

In a herd, several animals follow the same leader animal. In fact, there are groups of animals and all the animals inside the group follow the same leader. In the proposed system the leader animal will have a specific “master” necklace and will capture periodically the identification of the “slave” necklaces of all animals close to it.

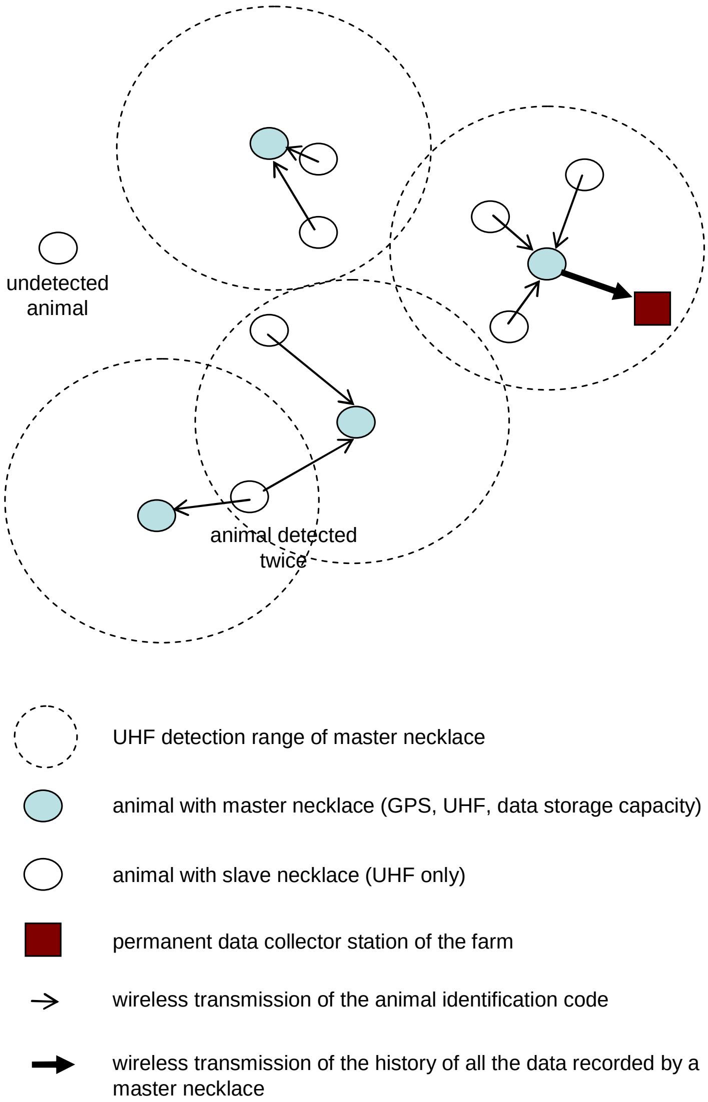

Figure 2. New principles for the acquisition of animal geolocations

The animals that are used to be leader must be beforehand identified in the herd by the farmer and they will be fitted out with a specific “master” necklace. This type of electronic necklace includes a GPS module, a data storage capacity, and a UHF (wireless) communication module. The other animals are equipped with a “slave” necklace that includes only a UHF system that is used to signal their presence to the master animal. The master animals are able to detect the presence of neighbours in using their UHF modules. The test of detection of presence is initiated every hour by the master necklace; indeed, every hour, it sends a wake up call to the slave necklaces close to it. Once they received this signal, the slave necklaces send their identification code the master necklace. At that moment, the master necklace records all the identification codes it received, as well as its GPS position and the current time. This method allow recording inside master necklaces, the rough geolocations of the slaves necklace. Only the position of the master necklace is acquired by the GPS module, but one can consider that the real positions of the slave necklaces are not very different from the one of the master. All the data recorded by master necklaces are transferred automatically to a permanent data collector station when the master animals pass it. With this new method, the majority of animals have only a UHF module. This technique enables the acquisition of animal geolocations, and minimizes the quantity of devices equipped on animals, and consequently the global economical and energetic costs of the system (including the maintenance costs). Figure 2 sums up the proposed architecture. As illustrated in the Figure, while some isolated animals can remain undetected, some others can be detected twice. The collected geolocation data will be centralized in a local database at the farm level, together with the traceability of different other information concerning the health of animals (weight, vaccination, body temperature, etc.).

5. Design of local systems

The model that describes data of local systems (layer 2 in Figure 1) has been formalized with UML. This type of representation is the better means to describe precisely data handled by local systems. The model has been built iteratively thanks to meetings and discussions between the different researchers involved in the project. Local systems are based on concepts like farm, farmer, cattle area, paddock, animal, sanitary event and geolocations. These concepts come from practices of Brazilian beef cattle production systems.

The diagrams of Figure 3 and 4 are subparts of the proposed conceptual model of the local database; they sum up the main data. The farm is an agricultural establishment that belongs to one owner. Each cattle area is under the responsibility of a farmer, that can be the owner or a leaseholder. Each cattle area corresponds to a geographical zone with one specific production system (extensive, semi-intensive and intensive), that can change periodically. This area is divided into paddocks; the paddock is associated with a feeding system, that can be modified throughout the time. A group of animals can be moved from a paddock to another one. The animals periodically receive vaccines. Their weight and their body temperatures are periodically observed. Moreover, different fundamental events are recorded: birth, death, entrance and exit of the farm. The positioning of the animals is measured periodically thanks to necklaces.

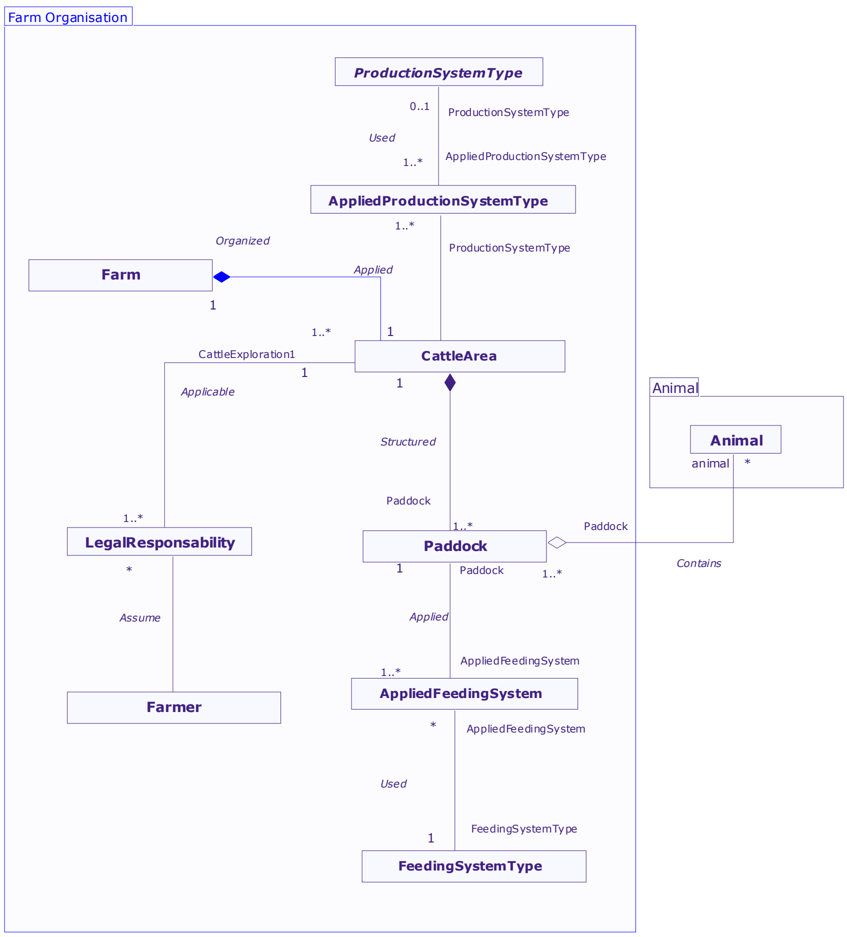

Figure 3. Main concepts of the local databases (Part 1)

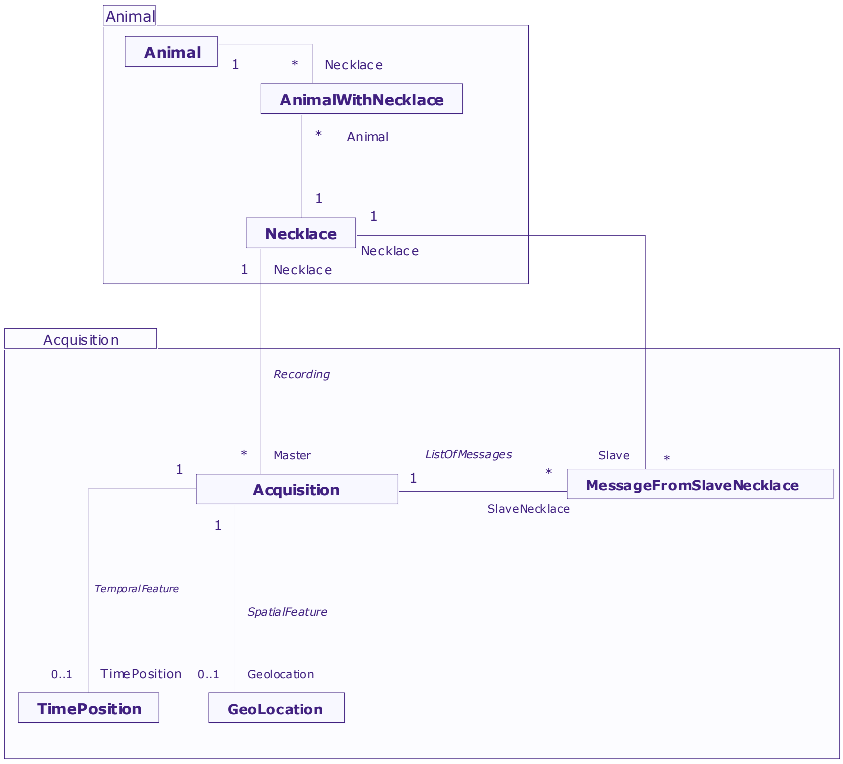

Figure 4. Main concepts of the local databases (Part 2)

6. Conclusion

OTAG focuses on an important target that involves a large number of actors around an proprietary subject for the human health. The development of the operational prototype is a very important requirement to move towards an efficient system for the bovine traceability. The system should be useful by governmental institutions in real situations.

Currently, the main architecture of the system has been proposed. The first version of the model of the database of local systems has been built, and an hardware prototype of necklace has been setting up (OTAG REPORT, 2008). A specific code has also been implemented to simulate the moving of groups of animals; it could be used to estimate the evolution of the number of non-detected animals depending on the number of animal fitted out with a master necklace. The next steps concern mainly the development of real experiments with several necklaces, and the specification of geo-decisional analyses.

At the level of layers 3-4 (Figure 1), in order to get an acceptable response time for answering user queries, it will be necessary to organize the great amount of collected data. The possibility of integration with external databases is studied. This can contribute for a better analysis aiming the decision making about the farm production. For instance, the integration of OTAG prototype with databases about ground, pastures and climate can increase the quality of information concerning to beef cattle production.

7. Bibliography

AGROTRACABILITE, 2008. Site Web Agi-traçabilité Québec, <**http://www.agri-tracabilite.qc.ca**>

BOOCH G., RUMBAUCH J., JACOBSON I., 1999. The Unified Modeling Language User Guide, Addison-Wesley.

BRUN T., POYET P., BOOP M., VIGIER F., 2005. Towards an agricultural ontology in France: Contributions of the farm Information Management Project (GIEA), EFITA/WCCA 2005 Joint Conference, Vila Real, Portugal, p. 1296-1302.

DUFY, L., ABT, V., POYET, P., 2006. GIEA : gestion des informations de l'exploitation agricole. Un projet au service de l'interopérabilité sémantique de la profession agricole. Ingénieries - Eau, Agriculture, Territoires n° 48, p. 27 – 36

GIEA, 2008. Site Web GIEA, <http://www.projetgiea.fr>

IBGE – Instituto Brasileiro de Geografia e Estatística, 2007. <www.ibge.gov.br>

OTAG REPORT, 2008. Traceability in beef production and crisis management in bovine sector: state of art. OTAG Project Report (WP2).

PINET F., ROUSSEY C., BRUN T. , VIGIER F., 2009. The Use of UML as a Tool for the Formalisation of Standards and the Design of Ontologies in Agriculture. Chapter in: Advances in Modeling Agricultural Systems, Springer.

POYET, P., BRUN, T., 2003. GIEA : gestion des informations de l`exploitation agricole - Vers des concepts et un langage communs pour les partenaires économiques et institutionnels de la profession agricole. Ingénieries - Eau, Agriculture, Territoires, n° spécial Technologies pour les agrosystèmes durables, p. 167 – 175

SISBOV, 2008, SISBOV web site, <http://www.localizaanimal.com.br/>