Interest of new communicating material paradigm: An attempt in wood industry

J. Jover, A. Thomas, Jean-Michel Leban, D. Canet

Interest of new communicating material paradigm: An attempt in wood industry

Interest of new communicating material paradigm: An attempt in wood industry

J Jover[*], A Thomas[*], JM Leban[**], D Canet[***],
Research center for automatic control of Nancy, science faculty - BP 239
54506 Vandoeuvre les Nancy – France.
** Wood Quality department, national institute of agronomical research, Champenoux Center, Champenoux, France.
*** Departement of NMR metrology, Henry Poincare University, science faculty - BP 239, 54506 Vandoeuvre les Nancy – France.

E-mail: jeremy.jover@univ-lorraine.fr

Abstract. This paper present a new paradigm in which the wood material could become communicating. We decide to use Nuclear Quadrupole Resonance to mass marking the wood. We imagine a new method to create identification codes. At first, we examine the feasibility of this mass marking method by impregnating wood to obtain a specific marking signal. In parallel, we study the interest to abide information provided by this marker to control the supply chain. We model the supply chain (e.g. the information/decisional flow) to understand which information is important and how to use it.

1. Introduction

More and more, with a view to increase productivity or traceability, supply chain manager mark piece. The auto-ID technology, and in particular RFId, are more and more extended in the way to realize this product marking. Nowadays, advances in reading of these marks make possible to read many tag's names in the same times at long distance. In another way the storage capacity increases: on the one hand RFId chips have more memory, and in the other hand we know how associate chip names to a data base where they are reference. Some research projects showed the relevance of the communicating product concept and search for spread out in industry. So it's possible to increase the productivity of the workshop by using communicating products. For example tags are put on the kanban in order to become it active [1]: kanban label can "discuss" with the other labels to be better ordain.

But these products marking are discrete. That is to say one product is marked with only one tag. This is really practical for finished products but that means products could not be modified. May be we could imagine a new paradigm wherein it is the material that becomes communicating instead of the product. In this case we could cut the material and conserve the information associate with each element. Thus the material has its personal information like physical characteristic and origins with it. Under this new paradigm, our research group has studied the pertinence and the feasibility of this vision in wood industry and textile. This paper deals only on the wood mass marking. We look for how mass marking the wood and we project us in the exploitation of this marking for piloting the wood supply chain. To understand the effect of the information loss on the supply chain, we modelize all the wood supply chain and the information exchange. This paper will follow the present plan: first we will focus on the tractability techniques in wood industry. Secondly we will study the marking we want to experiment, using nuclear quadrupole resonance (NQR). Then we will modelize the information/decisional flow in order to study the interest of this information for piloting the production. Finally we will describe a first demonstrator which will confirm our concept.

2. The traceability in wood indutry

2.1. The importance of the tractability in the wood industry
Even though the wood was the oldest material used in the history, it was every time considered by people like an easy material in which the economic issue is weak. But today the mind change: wood industry has to be improved. Wood industry tries more and more to setup systems of material traceability. Many reasons are put forward: the increase of the outlaw wood exploitation [2], the need to improve the wood utilization [3] [4] and the important information loss all along the wood life cycle [4]. Some actions were realized by the manufacturers to increase wood traceability. For example:

- Certifications of the wood origins like PEFC (Pan European Forest Certification) or FSC (Forest Stewardship Council). These certifications give the proof that the woods come from forests which are durably managed and the supply chain respects specific rules of management.
- The European project Indisputable key [5] which search improvement ways for the wood traceability and methods for the information conservation width.

2.2. The information conservation in wood industry
The problems which are mentioned before have one common point: the wood industry can't conserve the information of the tree all along the supply chain. Finally the wood supply chain is sequence of information loss. A European project [5] shows that the leakage is between every important steps 'figure 1'. The solutions proposed by this project seek to solve the information loss between forest and log selection. Other papers like [3] look for solution between log selection and log sawing. Few publications deal with the information loss after sawing because the impact is less important, the information can be finding easily by measurement on the wood (humidity, class of quality, etc.).

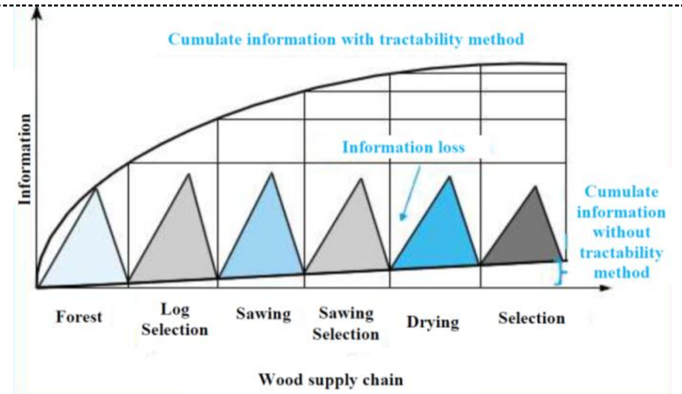


Figure 1. Schematization of information loss at each step during wood supply chain (source: the Indisputable Key).

The researchers try to put in place new identification and traceability methods for wood. The techniques used until today for marking logs are describe in publication [2]. The first markings put in place were paint mark or hammering, used by the log owners to recognize their own. While they are cheap these marks have a real big problem: you can reproduce it easily. The logs owner think to a new method that could be harder to reproduce: the bar code print on a plastics stamp which is hammering on the log. These stamps are unique and their reproductions are harder than the paint marking. But this marking can be easily removed from the log. To improve the security and reading possibility, the idea was to put in the log an RFId or magnetic tag which can be read in a dirty, dusty or damp environment. The project [5] submits an idea of RFId tag: this tag was cast in a resin wedge. Then the wedge is hammering at the end of the log. Another solution was to print a bar code directly at the end of the log.

But all these markings are discrete (i.e. one mark for one object). Furthermore they mark wood between forests and sawmill. The mark can be easily removed from the log by sawing the end of the log because it is not attach to the totality of the log. That's why other technics have been found. The use of the micro wave [6] allowed having a biometric code of the wood piece. An emission of micro wave goes through the piece of wood and gives a biometric mark of the wood. But this biometric mark changes in the time because wood could be manufactured or changed by the time. Another way to have a mark of the wood is the use of the X-ray: you obtain a picture of all the piece of wood. By the similitude you can recognize the piece. With this method the traceability can be possible by reconstruction of the log, and also the tree. But this technic repulse sawyer because the quantity of pictures to save is huge.

In the tree there is a unique code that could be used to identify it: the DNA [7]. This is the same technique than for human. It is used in the cooperage industry to identify the origins of the tree. But this method of identification is so complicated to integrate in an industrial process [2].

2.3. Issue

We understand that a mass marking is useful. However how marking the wood in the mass? If the code is unique for one tree, how to code the pieces cut in the tree? How to use this information to pilot the supply chain?

3. Utilization of the nuclear quadrupole resonance like a tag.

As one of the imperatives of this present project is the mass marking and as it will be probably (other while necessarily) a molecular marking, the non-destructive and non-invasive identification technique will use the radio frequency (not absorbed by the material). In addition this technique has to use a spectroscopies method which gives an ambiguous identification. We are obliged to use the nuclear magnetic resonance (NMR), the electron paramagnetic resonance (EPR) or the nuclear quadrupole resonance (NQR). NMR and EPR need a static magnetic field which complicates the equipment without given a specific determination. So we have to use the NQR which use a null field and the frequency response is characteristic to the molecule integrated to the material.

3.1. Principe of the NQR

The NQR result from nucleus quantum properties with a spin upper than ½. The nucleus is made up of protons and neutrons. The distribution of them in the core creates a distribution of the charge that could be spherical or with an axial symmetry 'figure2'. The spin is associated to the distribution: if the spin is ½ the distribution is spherical, if the spin is up than ½ the distribution has an axial symmetry. This symmetry allowed the apparition of a nuclear quadrupole moment. This moment can interact with the electric field gradient present in the nucleus environment and provoke a gap of the energy level. Between this energy level, transition could be induce by radio frequency as in our case.

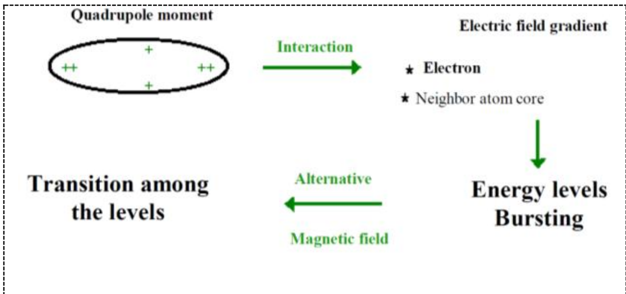


Figure 2. Scheme of the NQR Principe

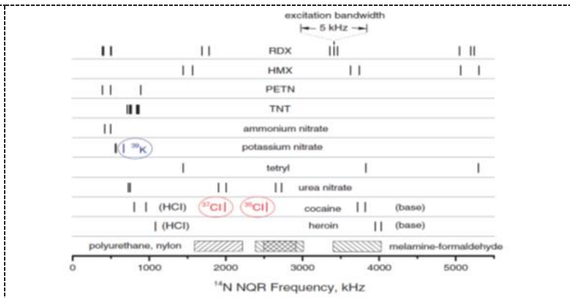


Figure 3. Representative RQN frequency for some explosives et narcotics. [8]

The frequency of this transition is a direct measure of the quadrupolaire interaction, and depends of the electronic distribution around the core. So it's possible to characterize the molecule. The land mine could be detected by this way [8]. A spectrum is established for explosive ‘figure 3’. This is like the molecule’s fingerprint.

3.2. Principe of the NQR

The objective is to create an identifying code that could be integrated in trees. So we imagine mixed some molecules you know the frequency responses. By using a transmitter/receiver and when the product is integrated in the tree, you have a code that is the identifying of the tree.

But NQR has a mediocre sensibility and temperature has a big influence on the frequency response [9]. As the NMR metrology laboratory of the henry Poincare University master the measurement of the sodium nitrite (NaNO2) we use it to see the effect of the wood on the NQR signal. We realize two experiences:

- NaNO2 and sawdust in order to be sure that wood doesn’t influence NQR signal
- A piece of wood impregnate with a solution of sodium nitrite so as to know if the nitrite signal is present after drying

3.3. Results and conclusion

We test two different ratios during the first test: firstly, we put fifty percent of wood and NaNO2, secondly we reduce the quantity of NaNO2 to twenty five percent. We note that the sodium nitrite’s signal is present in the both cases so wood doesn’t affect NQR signal ‘figure4’. Some parasitic signals appear come from the preparation on the nitrite but disrepair little by little (piezoelectric effects).

The second experience shows us that one part of the nitrite has been correctly crystallized because we see the sodium nitrite ray. But an abnormal ray appears in the two spectrums ‘figure5’. If we made the parallel with the explosive detection [10] which show that the ray width is more important than the crystal lattice have defects, this ray is a part of the sodium nitrite which is more amorphous or interacts with the wood.

We can conclude that it will be possible to mark wood using NQR response like code but nowadays the technique isn’t efficient.

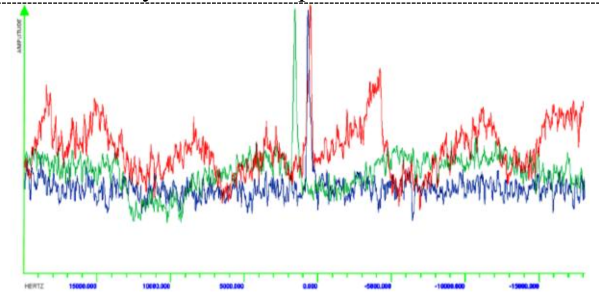


Figure 4. Sodium Nitrite response Spectrum at 4,64MHz. Blue Spectrum: 100% de $NaNO_2$ (powder), reference (8 scans). Red spectrum: 50% $NaNO_2$, 50% sawdust (32 scans). Green spectrum: 25% $NaNO_2$, 75% sawdust (128 scans).

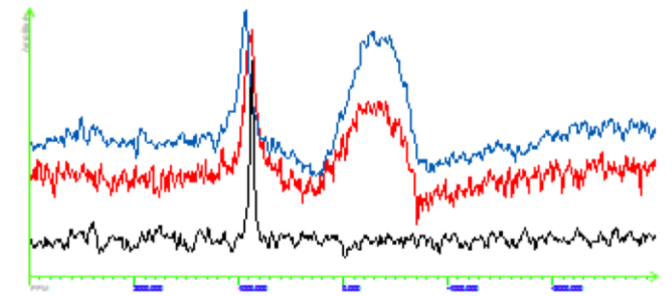


Figure 5. Sodium Nitrite response Spectrum at 4,64MHz. Black spectrums: 100% de NaNO2, reference (8 scans). Red and blue spectrum: impregnate wood with two different NaNO2.(40 000 scans)

4. Modeling the flow of information

In order to see the interest of the information in the wood supply chain, we model them. Like this we can understand the utility of the information at each activity.

4.1. Information flow Model in the wood supply chain.

Few models describing all the wood supply chain exist; often it is part of this supply chain. Some projects show the information’s loss [5] or the exchange between the activity sectors [11]. These

Journal of Physics: Conference Series **416** (2013) 012031 doi:10.1088/1742-6596/416/1/012031

projects show the most important information is at the beginning of the supply chain (from forestry to end of sawing). So we decided to break up this part of the supply chain.
The forest inventories give us all the information relative to the forestry or the logging industry [12] and some paper explain the utility of this information [13]. We have used the books of FCBA [14] to find the information used to pilot sawmills. When the data was gathering and the supply chain modeled, we have studied all activity to identify the information at the input and the output (A1).

4.2. Study of the model: the output information of the forestry and logging industry.
All the data use in the forestry and the logging industry are data which refer to the growth of the tree. There are two industrial utilities for that data: first, with that data you can know the tree's origin. Secondly, they could be used by the sawyer in order to determine the potential of a plot. Rules exist between the tree's growth and the quality of the tree. So sawyer can use an electronic data exchange, like a database, to know the plots and have ratios. With them he can determine if the plots will be good for him or not. (I.e. if the sawyer cut wood for pallet, he has to choose plot with a good ratio in pour quality wood).

4.3. Study of the model: the output information of sawmill.
In sawmill, the information has another utility. This information enables the sawyer to tune his materiel. When you have a hardwood you know the stress on the blade is bigger so you tune your saw cut at lower speed. So if you could find the information relative to the tree you can tune the machine in real time. But there is a big problem with the unique code: how to identify the pieces cut in the log if they have all the same code? This is our future research: we would like to study which way is the best to have a code for the "children" (pieces of wood cut in the log)? If it was possible to code the "children", we can imagine that the sawyer have a data base where he can look all his storage. When a customer wants a product, he describes the destination of the product and the sawyer can deliver the product which is the closest from his need.

4.4. Future researches
As we said just before, our future researches are to find the best way to code the "children". It looks easy to create a code, but what is the best one to include in an industrial process?

5. The demonstrator
While the NQR marking is not ready, we would like to continue the research on the generation of the code for the "children" pieces. So we decide to simulate the mass marking material. So we decide to build a demonstrator which simulates a log mass marking. Another utility of this demonstrator is to show the benefit of marking the tree in the mass. You can simulate a log's storage and when you scan the storage, you can find which log is the most appropriate to cut function of the orders: you know the information relative to the logs and the orders and the computer find which log is the best one for the situation. So we made a requirement for our demonstrator.

As we want to simulate a log which must be cut and mass mark, the demonstrator have to be easy to disassemble and have all the parts marked by RFId. We have decided to use piece of wood with little magnets on it to make the assembly easiest. On each piece of wood we have to put an RFId tag 'figure6'. If all the RFId tags have the same code, we can simulate mass marking wood. This wood is not marked itself but we don't want to cut piece of wood, just disassemble our tree. For the second utility we have just to change the RFId tags with other ones that have many different codes.

At the same times, we made some model of an informatics program and we asked to an informatics engineer to program the software 'figure7'.

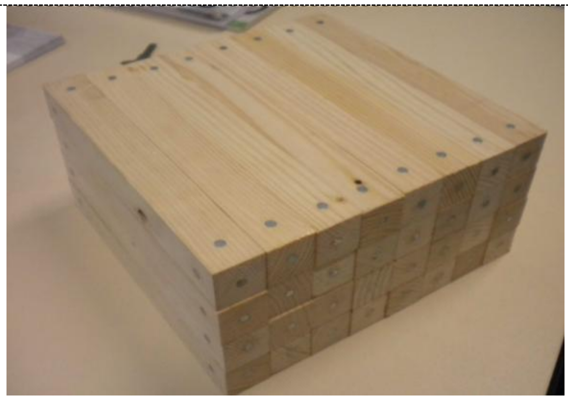


Figure 6. Piece of wood composing our tree without the RFId tags

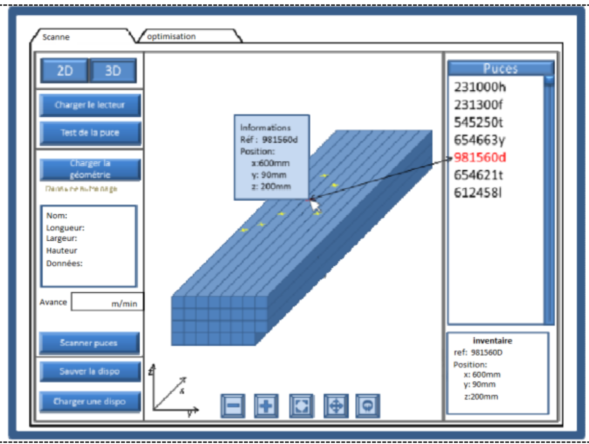


Figure 7. Model of the software

6. Conclusion

Finally the wood mass marking stays a futurist project. But with this project we show that it's not impossible to mark the wood. NQR marking could offer possibilities: with other products, best research on the NQR stability... so researches must be done on this subject.

Concerning the model, it enables us to understand the utility of each data present in the wood supply chain. We understand the benefit from this marking. The next research that our research group has to do is the generation of the "children" piece code with a reflection on the best way to obtain it.

For this we have to finish our demonstrator. Perhaps, the mass marking will be efficient in wood. For the moment the textile mass marking is more concrete than the wood mass marking and researches are bring to light better results.

7. Thanks

The authors gratefully acknowledge the financial support of the CPER 2007-2013 "Structuration du Pôle de Compétitivité Fibres Grand'Est" (Competitiveness Fibre Cluster), through local (Conseil Général des Vosges), regional (Région Lorraine), national (DRRT and FNADT) and European (FEDER) funds. The authors want to thank the INRA (National Institute in Agronomical Research) and, particularly, Jean-Michel LEBAN and Charline FREYBURGER for the use of their X rays scanner.

8. References

[1] Klein, T. (2008). Le kanban actif pour assurer l'interopérabilité décisionnelle centralisé/distribué. Application à un industriel de l'ameublement. Thesis of the university Henry Poincare.

[2] Dykstra, D.P., Kuru, G., Taylor, R., Nussbaum, R., Magrath, W., and Story, J. (2002). Technologies for wood tracking: Verifying and Monitoring the Chain of Custody and Legal Compliance in the Timber Industry, World Bank / WWF Alliance for Forest Conservation and Sustainable Use.

[3] Chiorescu, S., and Grönlund, A. (2004). The Fingerprint Method: Using Over-bark and Underbark Log Measurement Data Generated by Three-dimensional Log Scanners in Combination with Radiofrequency Identification Tags to Achieve Traceability in the Log Yard at the Sawmill, Scandinavian Journal of Forest Research, 19: 4, 374 — 383

[4] Ginet, C., and Golja, R. (2007). Traçabilité et échanges électroniques pour la filière forêt bois papier. Fiche information–forêt n°750 d'Afocel

[5] The Indisputable Key. (2009). www.indisputablekey.com, European project.

[6] Charpentier, P. and Choffel, D. (2003). The feasibility of intrinsic signature identification for the traceability of pieces of wood, Forest Products Journal, 53(9) : 40-46

[7] Deguilloux, M.F., Pemonge, M.H., and Petit, R. J. (2003) DNA-based control of oak wood geographic origin in the context of the cooperage industry, Annals of Forest Science 61 (2004) 97–104

[8] Garroway, A.N. (1994). Explosives detection by Nuclear Quadrupole Resonance, Cargo Inspection Technologies, San Diego.

[9] Ferrari, M. (2006). Temperature effects on 14N Nuclear Quadrupole Resonance (NQR) parameters, Poster.

[10] Buess, M.L. and Caulder, S.M. (2004) Appl. Magn. Reson. 25, 383.

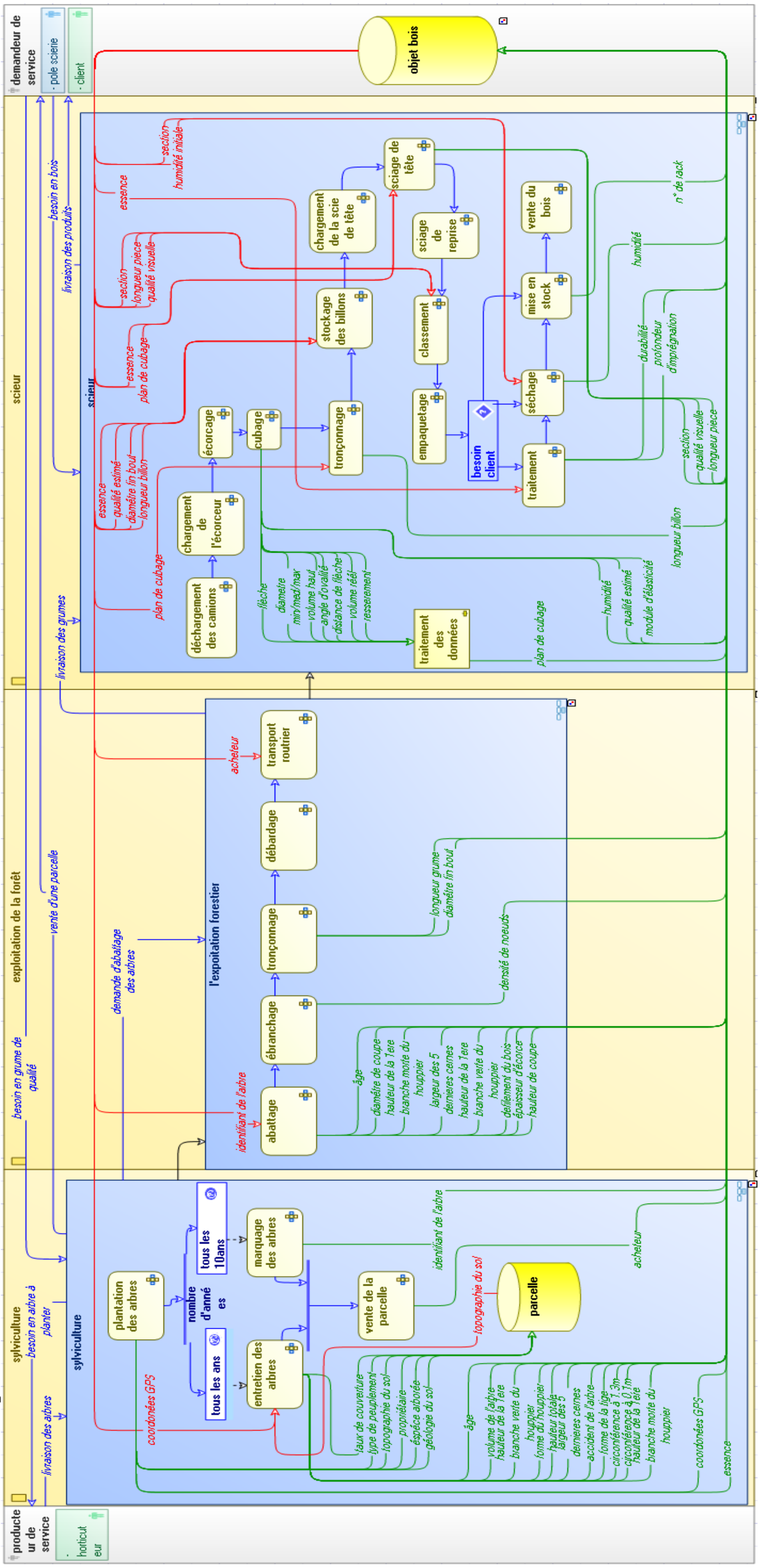
[11] Jover, J. ; (2010). Le bois communicant sur pied, rapport de projet de fin d’étude pour le diplôme d’ingénieur ENSTIB.

[12] Inventaire Forestier National. (2010). Documentation relative aux données brutes « arbre », Campagne 2008.

[13] Pignard, G. (1993). La base de données dendrométriques de l’inventaire forestier national. Revue forestière française, XLV, n° spécial.

[14] FCBA (Institut technologique Forêt, Cellulose, Bois, Ameublement) (2001). Manuel de scierie: techniques et matériels. (Paris: FCBA).

9. Apendice A



A1. Model of the information exchange in the wood supply chain using the wood object data base