Requirements Analysis for a Traceability System for Management Wood Supply Chain on Amazon Forest

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ABSTRACT: *The wood production is an activity of fundamental importance for Brazilian economy. Studies show that the illegality in wood production is around 80% of the total production. This illegal wood becomes legalized in its supply chain due to the failures in controlling and monitoring systems. This paper analyzes some computational problems existing in managing and monitoring the production process in Amazon Forest and identifies new requirements to create a traceability system more efficient and appropriate to the region's characteristics.*

1. Introduction

The world's tropical forests are being reduced at a rate of approximately 5% per decade, due to the lack of supplying the national and international wood markets and besides the use of their areas for the agricultural production, livestock and, recently, biofuels [1]. This deforestation is also responsible for the emission of approximately 2 billion tons of carbon gas into the atmosphere per year. In Brazilian Amazon only, the deforestation released in this decade, an average of 200 million tons of carbon gas per year, which represents 55% of the total emission in the country [20].

Despite the forest products have an important role in the Brazilian´s economy, it is estimated that the illegality in this activity is around 80% of the total produced. This illegal wood becomes legalized in its supply chain due to the failures in controlling and monitoring computer systems of these activities [19], [11].

These failures contribute to increase the illegal deforestation and the Amazon Forest destruction, because of the industries that follow the productive good practices are obligated to race into market with the same conditions of illegal industries that do not pay taxes, have low operational cost and simply extract native wood without any concern about the environment.

This context supports the writing of this paper, which shows the computational problems existing in forest products traceability coming from Amazon Forest and, based on this information, identifies the requirements to develop a computational system

that can solve these problems, allowing the monitoring of all steps in this chain, enabling either the interoperability between the productive system, the government control systems and the system which proves the origin of these products for the final consumers.

2. Forestry Wood Supply Chain

The wood supply chain corresponds all activities in the productive process of a forest product, since the extraction of the forest raw material and its transportation, until its sale to the final consumer, going through all the steps in the product transformation and manufacture [17].

In Figure 1, it is showed an example of wood supply chain. The first step consists in raw material extraction from the forest and its transportation in logs to sawmill. In the sawmills, the logs are sawn and transported to the furniture factory. In the factory, the several models of furniture are set up, finished and transported to the retail which conducts the sale to the final consumers. How it is a raw material controlled by laws and environmental standard, the Brazilian Institute of Environment and Renewable Natural Resource (IBAMA) and the States Secretaries of Environment (SEMA) from each state, execute the control and the supervision in some steps of this supply chain.

3. Evaluation Systems of Forestry Controlling and Monitoring

In Brazil, there are computer systems which perform the control of the Manage Plan of Sustainable Forest (PMFS), the license to forest deforest and the transportation of products and raw materials [1]. In Table 1, there are listed the systems used in each Brazilian state of Amazon.

The PMFSs and the authorizations for the forest deforestation are the unique lawful modalities of wood exploration provided by the tropical Brazilian forests.
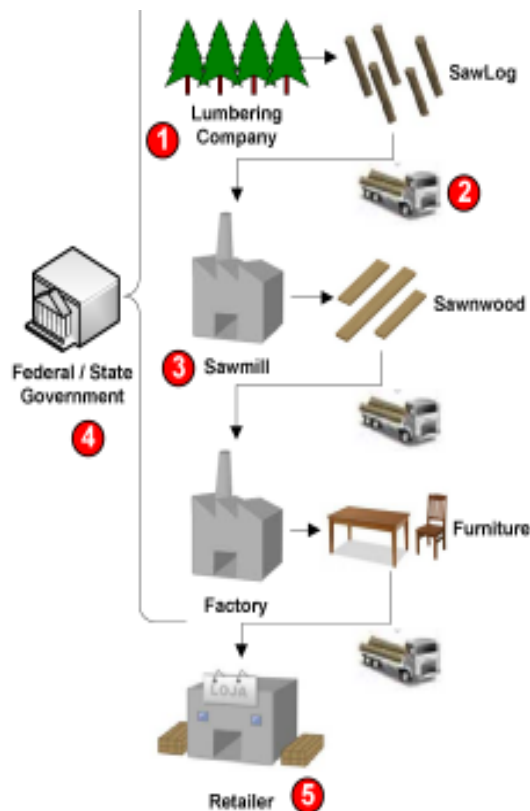

Figure 1. Furniture Supply Chain and the
steps with a higher incidence of frauds

The PMFS is created from a project. It is produced based on technical standards of low environmental impact, where studies are carried out to define how they will conduct the exploration of the defined area. This activity is regulated by laws, decrees and normative instructions.

The license to deforest the forest is released by the environmental organizations in areas for crops or pastures, and in areas outside the lawful reserve property, which represents 80% of its total area.

	States of Brazilian Amazon		
States	**PMFS**	**Deforest**	**Transport.**
Mato Grosso	CEPROF	CEPROF	SISFLORA
Acre	SISPROF	Own System	DOF
Amapá	SISPROF	SISPROF	DOF
Amazonas	-	-	DOF
Maranhão	-	-	SISFLORA
Pará	CEPROF	CEPROF	SISFLORA
Rondônia	CEPROF	CEPROF	SISFLORA
Roraima	SISPROF	SISPROF	DOF
Tocantins	Own System	Own System	DOF

Table 1. Amazon State and Forestry Control Systems in Service

Contemplate these authorizations the Forest Harvest Authorization (ACOF) and the Exploration Authorization (AUTEX), which are created from the inventory of trees existing in areas that will be wield or deforested. These documents will be responsible for the generation of initial virtual stock in the company (storage) in the transportation systems (Document of Forestry Source - DOF and the System of Registration, Trade and Transport of Forest Products - SISFLORA). In these systems, just the species of trees with available quantity in their virtual stock will be commercialized and transported by the company during a period of determined time.

The Monitoring Integrated System and Controlling of Resources and Forestry Products (SISPROF) and the Consumer Registration System of Forestry Products (CEPROF) are responsible for the registration of companies, forestry projects and release licenses of forest management plans and deforestation.

The DOF System [15] and the SISFLORA System [23] are systems responsible for monitoring the transportation of wood and its derivatives. Mandatorily, any forestry products controlled under the country environmental laws must have their transportation monitored by these systems.

The lawful wood supply chain is initiated with the approval of a PMFS or an authorization to deforest the forest in a determined area. Together with this authorization it is found the AUTEX/ACOF which informs what can be extracted from the forest. For the use of the transport control system, the companies should be properly legalized and registered in the responsible government organizations in the respective state.

From this point, all transported wood and their derivatives, provided by the all commercial relations between the participative companies in the chain, should be accomplished by the transportation systems.

This process begins with an on-line negotiation between the seller company and the buyer, until the approval of the business in the system. With the negotiation approved it is possible the generation of a transport authorization document, called DOF in DOF System and Forest Guide (GF) in SISFLORA System. This document follows the merchandise in the route between

both companies, and contains information about the carried products, the transaction invoice, the means of transportation and the path from origin to its destination.

In arrival of the merchandise on its destiny, the buyer company performs the registration of the merchandise arrival and the system does the transfer of virtual stock from the seller's storage to the buyer's storage.

In cases where the companies perform the transformation and improvement in the raw material, as instance, in the sawmills which transform logs in sawn wood or laminated wood, the transportation control system performs a conversion of the raw material stock used to the new product created, which allows that company to do its commercialization.

The creation of DOF and SISFLORA was considered a major evolution compared to the old transportation control system of forestry products. This system is no longer used since 2006 and it was called Authorization to Transport of Forestry Products (ATPF). Unlike the DOF and SISFLORA systems that are based on electronic documents, this system was based on paper and filled out manually, making it very vulnerable to fraud, corruption and forgery [15].

However, there are still problems to be solved also in these new systems, to enable an effective control of these activities.

3.1. Process Issues
During the wood supply chain, there are steps where problems and frauds occur more frequently. In Figure 1, these steps were numbered and are described as follows.

1. **In the design of projects to PMFS's approval or the license to forestry deforest.** Some fraudulent data are used to obtain the authorization to explore in prohibited areas or for the acquisition of nonexistent virtual stock for lawful marketing of woods harvested in others illegal areas [16], [9], [7].

2. **In the transportation of wood and its derivatives.** The highest numbers of frauds occurs during the transportation activities. Creation of transport authorization documents using fraudulent data, falsification of documents, use of the same invoice to transport different goods. This is only a part of the existing frauds.

3. **In the implementation of transformation processes from raw materials to new products.** Due to the transformation coefficients are often outdated and generic in the transportation systems, companies are benefiting from these failures to generate higher stocks in these systems [2], [9].

4. **During the field inspection.** Government organizations of supervision have a small number of supervisors and weak infrastructure to carry out checks on companies and multiple distribution channels of the wood, thus facilitating the criminal actions [2] [6].

5. **In the forestry product marketing on the market.** Due to the lack of resources for the consumer to find out the real origin of products offered in the market, people generally buy products from illegal activities, because they usually have cheaper prices [8].

3.2. Computational issues
Considering the computational systems used to control and monitoring of wood supply chain, the following issues were identified and their influence in the operation of process.

1. **Lack of integration and standardization of entries and rules considered in wood transportation control systems.** Due to the lack of integration and standardization of transportation control systems, products that are sold to states that use a different controlling system, lose their traceability and hinder their monitoring [9].

2. **Lack of integration with support from government systems, as the financial state systems and the transport department systems.** Due to the lack of integration with these systems, some frauds that could be avoided at information input step in the system can only be discovered by audits in the field [6].

3. **Lack of standards for electronic identification for wood and its derivatives during the chain (barcodes, Radio Frequency

Identification - RFID, etc.). Due to the lack of standards, the identification of these products in each of the production stages is performed manually, allowing differences between the physical products and virtual registered in the systems [12].

4. **Security information problems.** According to a technical report published about SISFLORA system, it is not considered a secure system in accordance with ISO/IEC 15408:2005, ISO/IEC 17799:2005, and ISO/IEC 27001:2005 [12]. In addition, the DOF system has logged invasions by hackers. They had changed the virtual stock quantity of 107 lumbering company for allowing the illegal marketing [10].

4. Traceability System Proposed

Traceability can be defined as the ability to preserve the product identity and its origin, and its main characteristics are [13]:

1. To ensure that only quality components are present in the final product.

2. Efficiency in the allocation of responsibilities.

3. To identify products those are distinct but may be confused.

4. To enable the return of defective or suspects products.

5. To find the failure causes and take actions to repair them at the lowest possible cost.

Applied to supply chain, traceability can be defined as a process of systematic practice of physical segregation and information exchange among different actors in the chain, responsible for the implementation and enforcement of a specific target, in order to preserve the identity and attributes of products traded in accordance with their specifications [18].

Based on these concepts, the proposed system seeks to solve the problems currently existing in the information management of the wood supply chain.

The system requirements, based on this research, are presented below.

4.1. Requirements for the Proposed System
1. **Efficient acquisition of data**. The data input in the system should be checked immediately to prevent the registration of incorrect data. The proposed strategy is the validation of information at the time of entry, through integration with expert systems related.

2. **Electronic identification of product.** Raw materials and products should be identified to enable traceability and record their information throughout its lifecycle. The proposed strategy is the definition of standards for identification of products and raw materials. This identification will be used throughout the life cycle. Standards as defined by the GS1 system [14], recognized internationally, ensure the unique identification of products anywhere in the world. These identifiers may be associated with the products through the use of technologies such as RFID and barcodes [4], [3].

3. **Interoperability among systems.** The interoperability among heterogeneous systems involved in the process is necessary to provide transparency and security in the process. The proposed strategy is modeling a service-oriented architecture (SOA) [22], [5] based on open technologies, which enables the integration of these systems. Also to define metadata standards, such as e-Forestry Industry Data Standards (eFIPS) [21] for the exchange of information. A representation of the proposed system is shown in Figure 2, where the systems involved in the process are integrated with the proposed architecture, allowing the information exchanges between these systems throughout the product life cycle.

4. **Availability of product information throughout the supply chain.** Providing reliable information about traceability of products throughout the supply chain, including end users that can prove the product's origin before their purchase. The proposed strategy makes available web services to query the forestry product's origin. These services use the database traceability system, and can be accessed by applications available on web portals and embedded on mobile devices, like cell phones and palmtops. The forestry products can be tracked through a unique identifier (serial number) associated with the product.

5. **Use of mobile devices for monitoring the process.** Use of mobile devices to enable the validation of the documents of

authorization to exploration and transport. The proposed strategy is the use of mobile devices with embedded applications that work in online and offline modes. For online access, the embedded software performs the query of pieces of information by the Internet, but if there is no such feature, the system can perform the query in its local database, which can be synchronized at any time with the traceability system.
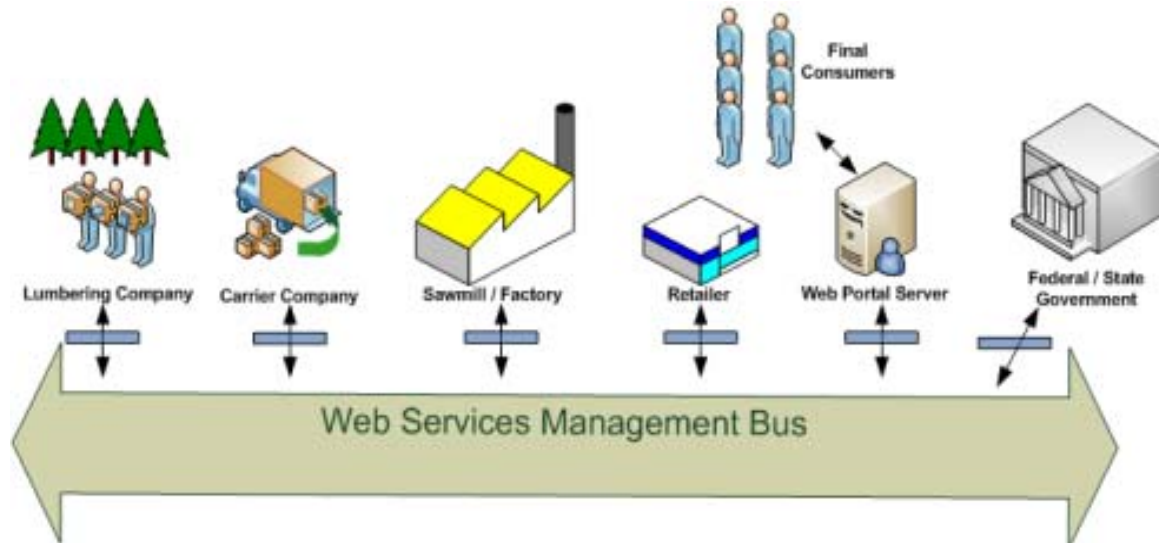

Figure 2. Proposed system and its integrations with the supply chain

5. Model of the Proposed System

Based on the problems and requirements presented in this research, was performed an initial modeling of a service-oriented architecture to develop a computational system able to ensure the traceability and origin of products and raw materials of wood from the Amazon Forest.

The system modeling process was based on the method presented in Endrei et al [5], which defines good practices for implementing solutions using this paradigm. It has two approaches to specification of services and integration requirements: The top-down approach to discovery services based on the application domain and the bottom-up approach which extract the services considering the legacy systems, databases or software packages.

Through process specification and identification of participants and systems that compose the wood supply chain, the decomposition of this domain was performed in its value chain, identifying the functional areas and their respective business processes relevant to the maintenance of traceability information of these products.

For each functional area was identified business use cases that will become services in the proposed model.

Through the services identification and their input and output information were defined the components that will compose this architecture, besides the identification of metadata standards for the communication standardization between the systems involved.

5.1. Enterprise Service Bus (ESB)
The main role of ESB in this architecture is to provide interoperability. Due the integrating heterogeneous platforms, a primary function of this approach is the data transformation. Furthermore, the ESB is responsible for managing the services and their routing, by the data tracking and logging and the security transactions.

5.2. Metadata Standards
An analysis was performed in the metadata standard Electronic Forestry Industry Data Standard (eFIPS) to be used in the model proposed. The eFIPS was created to facilitate the electronic exchange of information in the forestry industry. Its schema provides an XML structure that allows the representation of a variety of business documents used in forest production processes [21].

The analysis result showed that the eFIPS, due the data set that represents, could be used in communication between enterprises that are part of the wood supply chain and the transportation control systems. In the remaining value chain will be identified or created metadata standards that are more appropriate to the characteristics of their information. The Figure 3 shows the proposed architecture and its components distribution.

Due the managing of the traceability information and the integration of the several systems participating in the process, it will be possible to maintain these informations and their connections throughout the product lifecycle, from the cutting of tree until the sale of the final product at retail, including all stages of production. These informations will support the legality validation of these processes and can be used for many purposes for the participants of the wood supply chain, such as:

1. Companies can ensure that the raw materials purchased from suppliers have a legal origin and may use these traceability informations to improve of its local processes. Furthermore, these informations facilitate the deployment of product certifications and chain of custody certifications.

2. Government agencies will have access to more detailed information of the entire production process of wood, allowing greater control and effective monitoring of these companies in their commercial and extractive activities.

3. Before buying, the final consumer can query informations about which region that wood was extracted, if this region has a PMFS or deforestation authorization, if the companies that participated in the production process are legalized and are certified, including other relevant information. These informations could add value to products produced in a legal way, in addition to allow the opening to new consumer markets that require these environmental requirements.

6. Conclusion

Due to the continuing search for better control of production processes and higher product quality, research on applying the concepts of traceability is being conducted in several areas. These studies are aimed at the development of efficient traceability models that concern the specific features of each product.
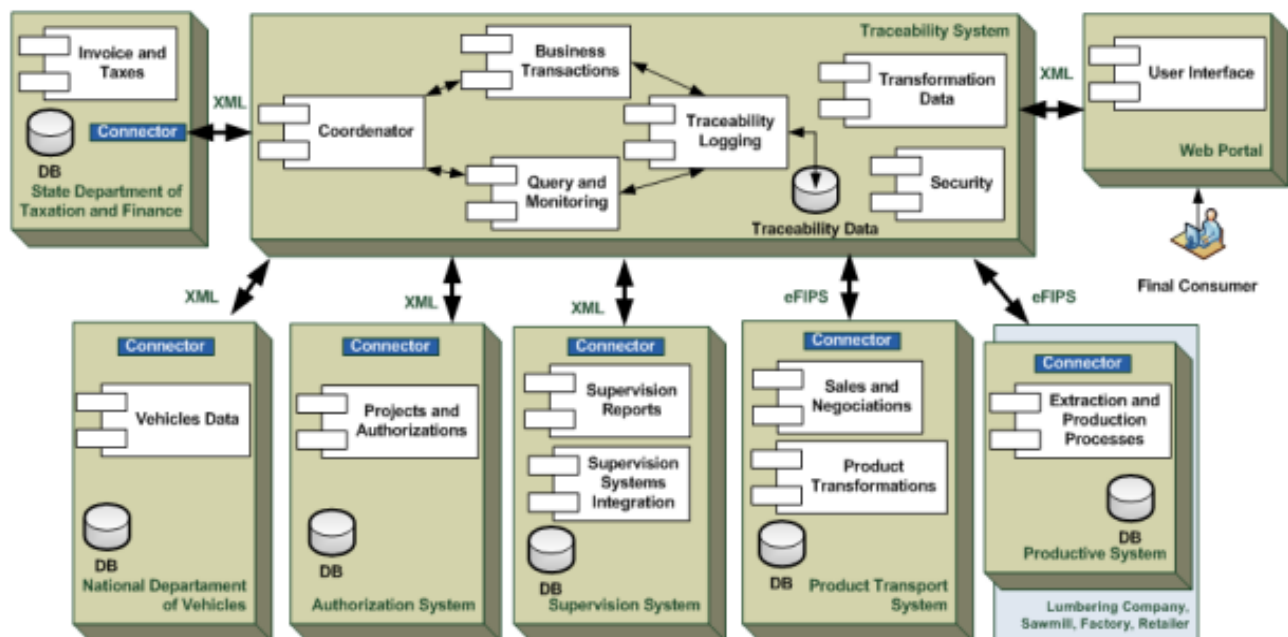

Figure 3. Proposed Wood Traceability System Architecture

For forestry products, their production process traceability goes beyond the pursuit of quality and performance, since it is directly related to the deforestation controlling of tropical forests and ensuring of this activity sustainability.

This paper presented the wood supply chain from the Amazon Forest, its problems and requirements for developing a system that helps to solve the computational problems that currently exist in this process.

From this research was proposed a serviceoriented architecture for information management of wood traceability in its supply chain, in order to establish a reference model for interoperability among wood transportation systems, production systems and monitoring systems.

Subsequently, will be refined the modeling of proposed architecture and a prototype will be developed to validate this architecture.

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