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EPCglobal Network Integrated Dynamic Carbon Footprints on Mobile Phones

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Abstract: Dynamic carbon footprint reflects potential differences between instances of the same product. To deliver dynamic carbon footprint to end consumers, we should adopt a new and innovative style as it cannot be implemented by common physical labels. This paper presents how EPCglobal network can be used to track carbon emissions, which then are the input of Sourcemap to create a lifecycle map. What's more, the lifecycle map is displayed on mobile phones to be a convincing persuasive technology.

Keywords: Dynamic carbon footprint, EPCglobal network, Sourcemap, Persuasive technology

1. INTRODUCTION

Facing the pressure from governments, national and international organizations, driving by constantly increasing customer demands, enterprises all around the world are now measuring and reporting their impacts on the environment. They have done much to or are planning to make efforts to monitor and manage the greenhouse gases(GHGs)emissions. They increase their supply chain efficiency and reduce energy and waste costs by assessing the life cycle environmental impacts of their products and services [1]. As a matter of fact, to better comply with all kinds of regulations and legislations, to better compete with rivals in the growing carbon market, to further optimize supply chain and quality management, enterprises are making supply chains sustainable and green supply chain becomes a frequently referred term and is considered to be critical for long-term profitability.

At the same time, information and communication technologies have reshaped our society a lot and the accelerating development of these technologies will continue doing so even more. Desktop computers, mobile phones, laptops and various smart appliances are widely distributed throughout the globe. Among of all these, mobile phones are no doubt the significant ones in changing the society because they are so widespread in the world that they are used everywhere, every time, by almost everybody. They can act as a pervasive concierge, coach and entertainer [2]. What's worth mentioning is that mobile phones have little impact on climate change. It is calculated that one year's average GSM subscriptions including all life stages (from mobile production to base stations energy use) is around 25kg CO2, which is just equivalent to driving an average car for one hour on a highway [3].

From the above analysis, this study attempts to design a system aimed at calculating dynamic carbon footprint via the EPCglobal network and communicating the result to consumers via mobile phones. By the EPCglobal network, real supply chain data is provided and thus we can deduce from it the required carbon emission related data to calculate dynamic carbon footprint. By mobile phones, the communication between back-end calculation and shop-floor consumers is built for consumers to make buying decisions, thus rewarding or publishing the company's environmental activities. In this context, a Guangdong manufacturer company is

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chosen to investigate the dynamic carbon footprint of their final product—manifeste bag, which is a simple but meaningful case.

This paper is organized as follows. In section 2 we present the concept and necessity of dynamic carbon footprint. In section 3 we focus on the EPCglobal network for tracking dynamic carbon footprint. In section 4 we propose a system which combines EPCglobal network with Fosstrak EPCIS to track products by capturing data and calculating carbon footprint. The application of this system through a case study is presented in section 5. Finally, in section 6, we present our main conclusions.

2. THE NECESSITY OF DYNAMIC CARBON FOOTPRINT

In this section, we'll elaborate what is dynamic carbon footprint, which is the paper trying to address. Before coming to the concept of dynamic carbon footprint, carbon footprint and its related life cycle assessment will be presented firstly. Then two ways of calculating carbon footprint and carbon labels, which are used to deliver product carbon footprint will be proposed. After that, the concept of dynamic carbon footprint comes with the dynamic nature of products.

2.1 Carbon footprint and life cycle assessment

In the context of high concern of climate change, there emerged a term called carbon footprint to quantify the environmental effect of GHG emissions. So that companies can take a necessary step towards managing complex carbon-related processes, and can make comparisons with previous year and with other companies. A carbon footprint is defined as the total greenhouse gas emissions caused directly and indirectly by a person, organization, event or product [4]. Exemplary causes of these emissions include electricity production in power plants, transport operations and other industrial and agricultural processes.

There are many national and international standards and tools existing to measure carbon footprint, on which companies can rely to take further supply-chain-wide eco-friendly activities. Many of these carbon footprinting standards comply with life cycle assessment (LCA), a technique to assess environmental impacts associated with all the stages of a product's life from-cradle-to-grave (i.e., from raw material extraction to materials processing, manufacturing, distribution, use, repair or maintenance, and disposal or recycling) [5]. LCA is a well-established field and exists as an international standard in the ISO 14040-14044 series. Actually, a carbon footprint is a life cycle assessment with the analysis limited to emissions that have an effect on climate change.

2.2 Carbon label and dynamic carbon footprint

Generally speaking, carbon footprinting can be achieved on two levels: enterprise level and product level, of which the latter one is with higher granularity. The total enterprise greenhouse gas emissions are unable to determine the carbon footprint of individual products because of two obvious reasons. First, all emissions are just added together to evaluate enterprise carbon footprints and the share of different products is not allocated accordingly. Second, the emissions due to activities of other supply chain partners are not considered [6] .On the other hand, product level carbon footprinting is evolved to satisfy some internal requirements, meanwhile to handle government pressure and customer demands. In order to deliver product carbon footprint to customers, and actually there is an increasing number of band owners intending to make the information available to their customers, a physical label is placed on the product providing the consumers with the calculated carbon footprint. Quite a few carbon labels have been designed and some of them are now applying in some pilot projects. Groupe Casino, the French retail together with ADEME (French Environment and Energy Management Agency) has launched a carbon label as shown in figure 1, on which the real carbon footprint value

and the carbon intensity are both recognizable.

Figure 1. The Casino carbon index

Nevertheless, there is a dynamic nature of carbon emissions of some products, which causes potential difference between instances of the same product. A physical label on the product isn't flexible enough to reflect the dynamic nature of carbon footprint. Some research is being done on using mobile phones to retrieve and display dynamic carbon footprint, which make the difference among items available to the end consumers at the point of sale. The usage scenario is: a consumer uses his or her mobile phone to touch the tagged product and then the carbon footprint information is displayed on the phone, so that multiple instances of the same product with different carbon footprints are correctly presented.

3. EPCGLOBAL NETWORK FOR TRACKING DYNAMIC CARBON FOOTPRINT

As the Electronic Product Code (EPC) is adopted worldwide, EPCglobal network is designed to share product data between trading partners, and basis for the information flow in the network is the EPC of each product which is stored on an RFID tag [7]. The network is primarily composed of three components: Object Naming Services (ONS), EPC Discovery Services (EPC DS) and EPC Information Services (EPC IS). Since EPC tags all components through the supply chain, carbon footprints of raw materials from suppliers are calculated by suppliers and are associated with EPCs. Both carbon footprint values and EPCs are stored in the respective EPC IS.

Manufacturers, according to their own internal process, account for the carbon footprints during production phase. What's important here is that manufacturers record an EPC aggregation event, specifying the parent-child relationship between the product and its raw materials. After products are manufactured, once again manufacturers must record the aggregation event of aggregating individual products into cases and cases into pallets, with parent-child relationships.

For the transportation part, manufacturers publish EPC events including pallet EPCs and the time of shipment to distributors. Upon the receipt, distributors record the reaching time, the type of transportation, and etc. Using the time difference between departing from manufacturers and arriving at distributors, and given the emission factor of the transportation, carbon footprint of the transportation part are quantified.

When products leave distributors for any retailer, an EPC event is triggered to record the leaving time. And the storage time in the distributors are attainable, thus together with the chilling condition, the corresponding amount of carbon footprint can be derived. Usually, products get disaggregated into cases to be shipped to different retailers, and distributors should also record the disaggregation event with parent-child relationships because these cases will account for different carbon footprints if they are transported over different distances.

From the above we can see, as long as all the supply chain processes, the aggregation and disaggregation events are recorded, carbon footprint can be deduced.

4. SYSTEM DESIGN

4.1 Determining dynamic carbon footprint by the EPCglobal network

The EPCglobal network inherently possesses the ability to track and trace products, as real time supply chain data can be easily collected. By use of this tracking infrastructure, together with product information database and life cycle assessment database, dynamic carbon footprint can be determined.

To integrate the EPCglobal network into our system, we need a software platform that implements this specification. Fosstrak is an open source RFID software platform that implements the EPCglobal Network specifications. It is intended to support application developers and integrators by providing core software components for track and trace applications [8]. Fosstrak provides core components for EPCglobal network based applications and can be used by application developers, system integrators and research groups in academy and industry. There are four fundamental modules in Fosstrak, which are EPCIS Repository, TDT Engine, ALE Middleware and LLRP Commander. In the paper, we'll adopt EPCIS Repository in our system as Fosstrak EPCIS is a complete implementation of the EPCIS standard specification and it is an EPCglobal-certified EPCIS Repository.

The architecture of Fosstrak EPCIS is shown in figure 2, from which we can see that Fosstrak EPCIS is composed of an EPCIS Repository implementation, an interactive EPCIS Capture Application and an interactive EPCIS Query Application.

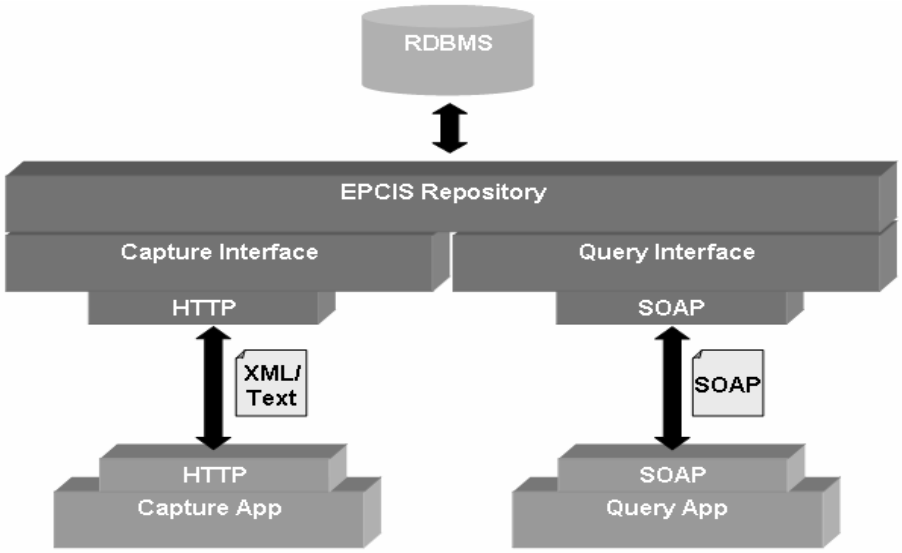

Figure 2. The architecture of Fosstrak EPCIS

4.2 Model of data capture and carbon footprint calculation

The whole picture of dynamic carbon footprint calculation is demonstrated as figure 3, in which a representative supply chain is used.

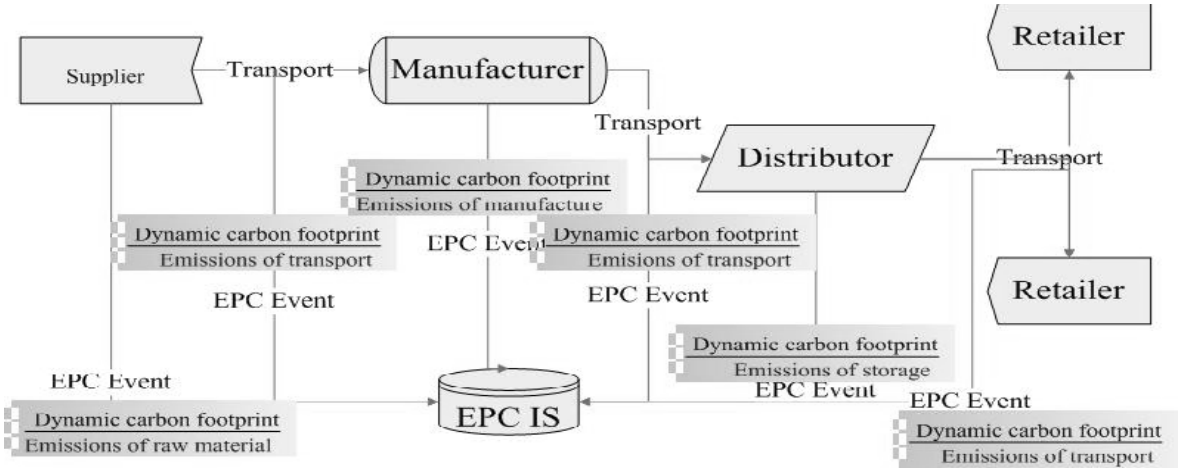

Figure 3. Complete dynamic carbon footprint calculation

As the calculation of carbon footprint is a LCA based process, the above figure involves all supply chain nodes from the supplier to any retailer. The EPCglobal network can only be applied to products which are previously RFID tagged, thus calculating the accurate product carbon footprint cannot only depend on the data captured by the EPCglobal network. For instance, wheat is a raw material to make bread and the carbon footprint emitted by wheat during its growth cannot be derived by the EPCglobal network. Also, the GHG emissions caused by usage of electricity during manufacture processes of products are beyond the control of the EPCglobal network. In the two situations here, GHG emissions should be available from the wheat supplier's and manufacturer's environmental management information systems (EMIS).

By incorporating with corresponding EMISs, emissions can be captured as parameters of EPC events when EPCs of products interact with the EPCglobal network. In this way, relative emissions are associated with EPCs. And combining the result from corresponding EMISs, we can have our accurate result of product carbon footprint, and then the information can be delivered to consumers.

To track necessary data for GHG emissions, EPC events have to capture additional information. For transport emissions, besides the information of EPC code and time, the additional information needed includes two end locations (start and end locations), vehicle types, travelling distance and the number of transported items. To integrate with Fosstrak EPCIS, EPC events should be compatible with Fosstrak EPCIS so that they can get recognized. We design an EPC event class, called TransportEPCISDocumentType by extending Fosstrak EPCIS's EPCISDocumentType class, which is the event object to be captured by Fosstrak EPCIS.

5. CASE STUDY

5.1 Overview

The case we choose to study is a simple yet meaningful one. The final product is a kind of bag called manifeste bag, which is produced by a company – the manufacturer in our case study, locating at Guangzhou, Guangdong, China. Manifeste bag is composed of three materials: lambskin leather, cotton chambray and zip. The manufacturer buys lambskin leather from a supplier located at Levroux, France, and the leather is transport to Guangzhou via van, 3.5tons. The supplier of cotton chambray is a local company, and cotton chambray is also transported via van, 3.5tons. For the material of zips, they are purchased from Mendrisio, Switzerland and are transported via air, freight. To make this manifeste bag, the amount of the three materials needed is 200 grams for lambskin leather, 200 grams for cotton chambray and 2 zips.

When it comes to estimate the dynamic carbon footprint of our final product – manifeste bag, the carbon

emissions of its three components are required according to the LCA approach. We assume that the three corresponding supplier have their EMISs, and these information is available when they are queried. Also, the carbon emissions of transportation are also partial of the entire product carbon footprint, and the data to calculate transportation carbon emission, such as transport type and travel distance, is provided by relative logistic providers.

5.2 Demonstration of Fosstrak as the EPCglobal network

The EPCglobal network connects all the supply chain nodes. In this subsection, we demonstrate how we utilize Fosstrak to connect the supply chain nodes of our case study – the manifeste bag product. More importantly, how Fosstrak plays the role of collecting necessary data to calculate dynamic carbon footprint.

For the supplier part, there is no need to collect data for carbon emission reason because carbon emissions should be provided directly by supplier's EMIS (but to be aware that supplier can utilize what we are going to demonstrate below to collect carbon emission related data, as supplier's material can be made of some other components that are purchased elsewhere). The EPC event that the supplier generates is Object Event, which is specified by the EPCglobal network specification. Object Event is to collect EPCs which are used to tag material of the supplier, usually in the format of RFID, so that manufacturer can make use of these EPCs to track the material of each individual product. Just as an illustration of how our system achieved this, figure 4 gives what we simulate to capture the supplier's Object Event.

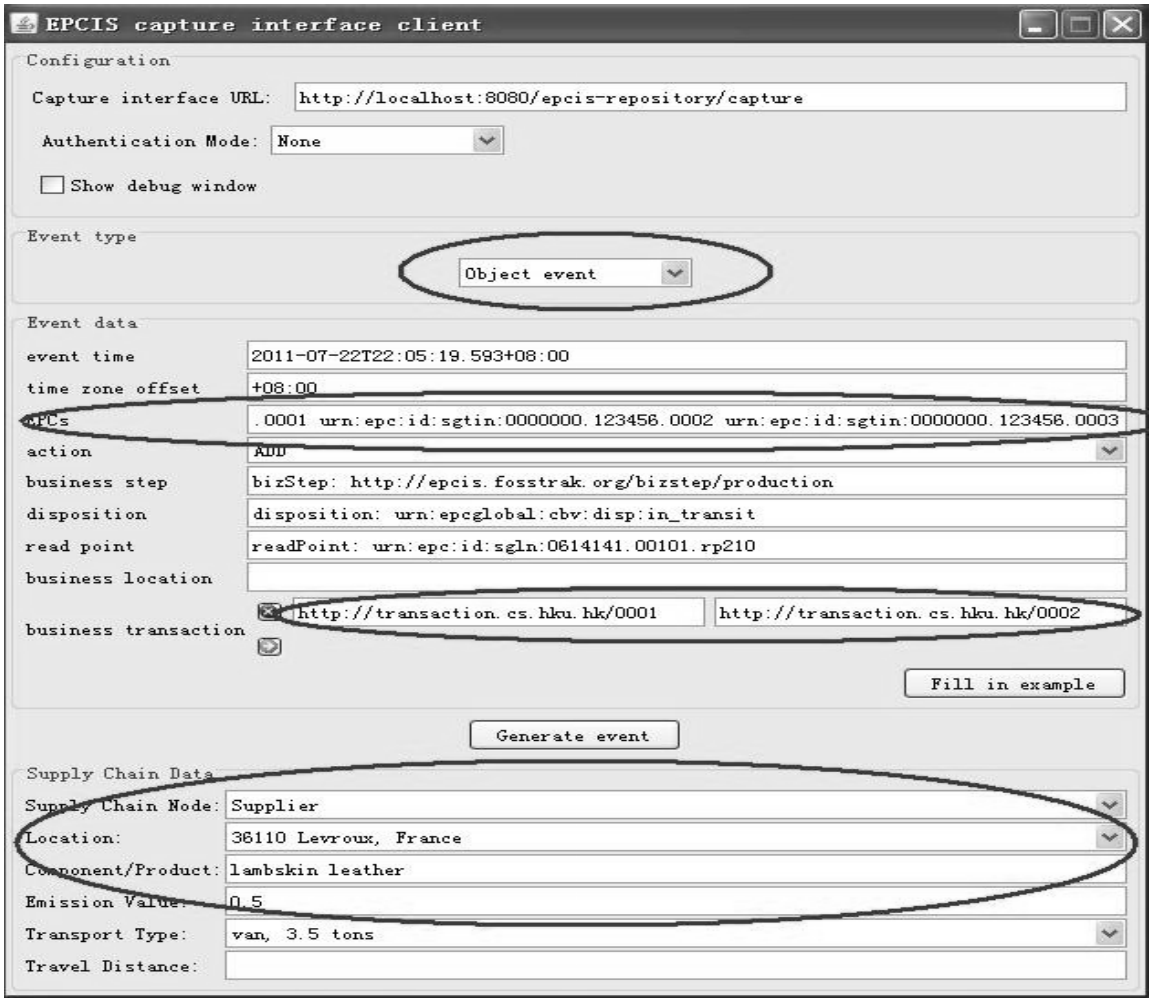

Figure 4. Simulation of a supplier's Object Event

The parts in ellipse shown are needed to generate a supplier's Object Event. First, we choose the event type to be Object Event, and then we must fill in the EPCs as they are used to identify the material of lambskin. We fill in the emission value of 0.5 to indicate the carbon emissions provided by the supplier's EMIS is 0.5, to be more specific, 0.5kg Co2e per gram of lambskin leather. Note that the business transaction part is very critical as the transactions are required by logistic service providers to calculate carbon emissions of the EPCs related material transportation.

Similar operations are done for logistic service providers, manufacturers and distributors. For logistic service provider part, the event type is the EPCglobal specified Transaction Event. The carbon emission related information is the transport type and the travel distance. While for manufacturer part, emissions value should be filled in the text field of emission value in previous figure, as this indicates that the carbon emitted during the manufacture of the product, which should be extracted from the manufacturer's EMIS in real business situation.

5.3 Sourcemap on mobile phones as visualizing carbon footprint and a persuasive technology

Just showing the dynamic carbon footprint value is not good enough. We are also going to show the origin locations of a product's components and every stage of the product's life cycle, which we believe is more powerful in making believe the dynamic carbon footprint we have derived.

We adopt Android operating system to implement some functions on mobile phones for the purpose of our demonstration. The scan of a RFID labeled on a product is simply simulated by the button click, and a query containing just a RFID is send to Sourcemap server. The figure 5 below shows the result of a RFID scanning:

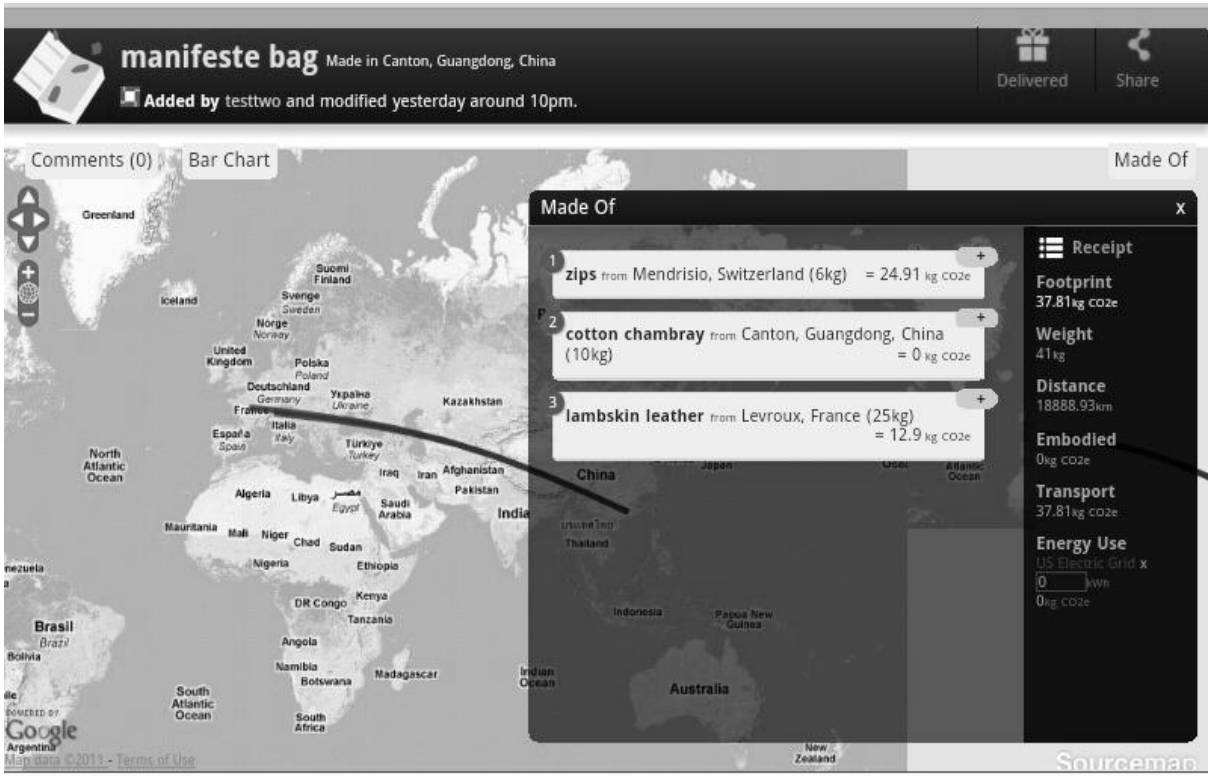

Figure 5. Sourcemap displayed on mobile phone

6. CONCLUSIONS

In this paper, we first talk about what is carbon footprint and the life cycle assessment approach is the standard way to derive carbon footprint of any product. As we have discussed, there is a dynamic nature of

product's carbon emissions, which shows that different carbon footprints can be among the same product. So, we have our notion of dynamic carbon footprint, and this dynamic value cannot be displayed appropriately on physical labels.

To sum up, in this paper we have made the contributions listed below:

- We analyze the necessity of dynamic carbon footprint, specifically from the perspective of being more competitive of a company.
- We analyze the feasibility of utilizing the EPCglobal network to estimate dynamic carbon footprint, in particular we implement our system based on Fosstrak EPCIS Repository.
- Persuasive technologies are applied to our system as the adoption of mobile phones and visualization of results.
- Fosstrak and Sourcemap are combined to bring together EPCglobal network and end consumers' perception of products' life cycles.
- The creation of a Sourcemap is automated due to the generation of EPC events, which simplifies the tedious and error-prone process of Sourcemap creation.

The system we have developed is only a prototype which demonstrates the basic processes of supply chain nodes and result presentations, and we believe that further improvements can be made:

- Complex supply chains have not been tested, some adjustments probably need be done to accommodate to them.
- The automation creation of a Sourcemap by EPC events is accomplished by plain HTTP request to Sourcemap server. Web services via SOAP maybe a better option between Fosstrak and Sourcemap servers.

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REFERENCES

[1] Carbon Trust. (2006). Carbon footprints in the supply chain: the next step for business.

[2] Fogg, B.J. (2003). Persuasive technologies, using computers to change what we think and do. Stanford University. Morgan Kaufmann Publishers.

[3] Informa Telecoms & Media. (2008). Online: http://www.informatm.com.

[4] UK Carbon Trust. (2008). Tesco and Carbon Trust join forces to drive forward carbon labeling.

[5] Wikipedia. (2011). Online: http://en.wikipedia.org/wiki/Life_cycle_assessment.

[6] Ali Dada, Thorsten Staake, Elgar Fleisch.(2010). The potential of the EPC network to monitor and manage the carbon footprint of products, part 1: Carbon Accounting.

[7] Wikipedia. (2011). Online: http://en.wikipedia.org/wiki/EPCglobal_Network.

[8] Auto-ID Labs. Online: http://www.fosstrak.org/.