IMPACT INDICATORS RELATING TO VERY HIGH SPEED COMMUNICATION NETWORKS.

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Abstract

Brittany (France) starts a deployment program of a fiber-optic based communications network at very high speed, Fiber To The Home (FTTH). The purpose of our work is to investigate the regional and social impacts of the uses that will result from the establishment of such a network (environmental impacts, etc.). Among the existing impact indicators for the implementation of eco-responsible information systems, few concern the communication infrastructure. In this paper, we propose new indicators focused on the communication infrastructure to allow a comparison between alternatives (wired networks, fiber-optic, or wireless). These indicators are composed following the early stages of the X development method. Interactions, targeted performance and environmental constraints are then quantified and a dimensional analysis is performed to forge dimensionless numbers. Some of these are directly related to the impact of the system on its environment, from its design until its end of life, and even after. We find the existing dimensionless Green IT indicators, and we show how to make the others dimensionless. At the end of this work, we present the new indicators proposed from our analysis.

Keywords

eco-IT, impact indicators, methodology, territories, land planning

1. INTRODUCTION

The interdisciplinary Infraweb project investigates the way a FTTH network impacts territories and local communities in Brittany. Structuring effects of networks have been studied before [1][2][3][4][5]. However the Web, with its ability to redefine proximities very shortly [6], offers new perspectives to study territorial mutations [7]. Our method relies on an analysis of the relationships between websites held by specific types of stakeholders (local authorities, businesses and associations) in some areas (Finistère, Morbihan, etc.). Using different web crawling tools, we aim at highlighting the general structure of the Breton territorial Web and identifying singular places and links. Results of this investigation could serve the building of new sustainable development indicators, which until now often ignore distances, scales and territorial structures [8]. Within a super-system approach designed to follow a product along

its life cycle [9], we consider impacts of the FTTH, from measurable to much less certain and quantifiable ones. Qualitative surveys among producers of digital information are foreseen to understand to which point social relationships and cultural activities can be developed without the need of physical proximity and dedicated places. The second section of this paper is dedicated to related works. In the third section we present the X-development method. The fourth and the fifth sections deal respectively with our analysis for the definition of indicators, and their presentation. This papers ends by a conclusion.

2. RELATED WORKS

For some past years, several organizations have structured their recommendations in evaluation domains. The Global Reporting Initiative (GRI), an international organization, covering the fields of environment, economy and society. Transverse indicators and protocols are proposed and are organized through thematic booklets (Environment, Human rights, Society, etc.). The French Association for Standardization (AFNOR) provides, among other, white papers on information and communication systems [10]. In the GRI's document [11], almost thirty indicators are presented and half of them are dimensionless numbers. Finally, the European Telecommunications Standards Institute (ETSI) offers environmental engineering methods incorporating some indicators. An impact study example of a FTTH network and a 3G network was carried out in document [12].

The next part explains the methodology we use.

3. METHODOLOGY

The X development method [9] is designed to perform developments of technical systems combining hardware and software, taking into account the whole life cycle. The general scheme is presented on figure 1. The horizontal central arrow represents the time. Above it, it is the field of information, data and software. Below, it is the physical and material field.

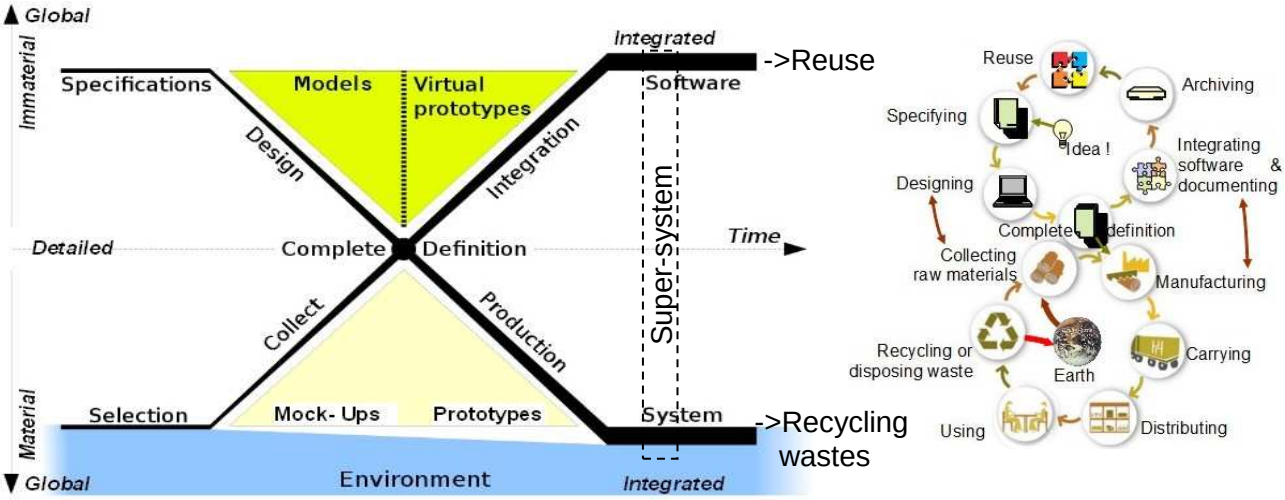

Figure 1: Scheme of the X-development method, presented as twinned cycles on the right.

The design process begins on the upper left branch by the definition of specifications. We delimit a super-system composed of the technical system and all that is in its environment interacting with it. By analyzing the interactions within the super-system, it is possible to give decision-making indicators at the earliest stage of the development. To go from the method to a formal model, we write the interactions in the super-system and the characteristics of the

system as presented in the expression (1), inspired by the Lisp language, where {P} is the set of performances, {S} the functions, {F} the constraints (on temperature, pressure, etc.), {G} the geometry of the device and its components, {M(p)} the properties of the materials.

{P} := ({S},{F},{G},{M(p)}) (1)

From the designer's point of view, the constants of the problem are the environment and the requirements. He translates these into performances, functions and constraints, and then he chooses the components, the materials, the software frameworks, etc. So it is not adapted to think in terms of length, time, mass, joule, etc. but in a metric space where all the variables and parameters are without dimension. Using the dimension analysis applied on the physical quantities, many dimensionless ratios can be forged.

In the next section we will delimit a super-system embedding the FTTH network, describing the interactions between its entities.

4. ANALYSIS

The issues studied in this part are first the identification of the traffic that could cause social effects, second the delimitation of the super-system of the functional unit (FU), and finally the listing of pertinent quantities. A LCA could be done in parallel, using the same concept of super-system, directly for land use, materials… but taking into account other quantities for greenhouse gas emissions, toxicity, eutrophication, etc.

The whole traffic of data through the network is separated in categories depending on the source and the final destination. Three kinds of destination are possible, humans (H), machines (M), and the rest, the environment (E), see table 1. Obviously there are devices at each end permitting the exchanges.

Table 1: exchanges between humans, machines and the environment

from\ to	H	M	E
H	H2H	H2M	H2E
M	M2H	M2M	M2E
E	E2H	E2M	E2E

The table 1 shows the different cases, where 2 means an exchange through the network, needing at least one device at each end. The web crawling evaluates the traffic matching to the interactions with one human (H) at least.

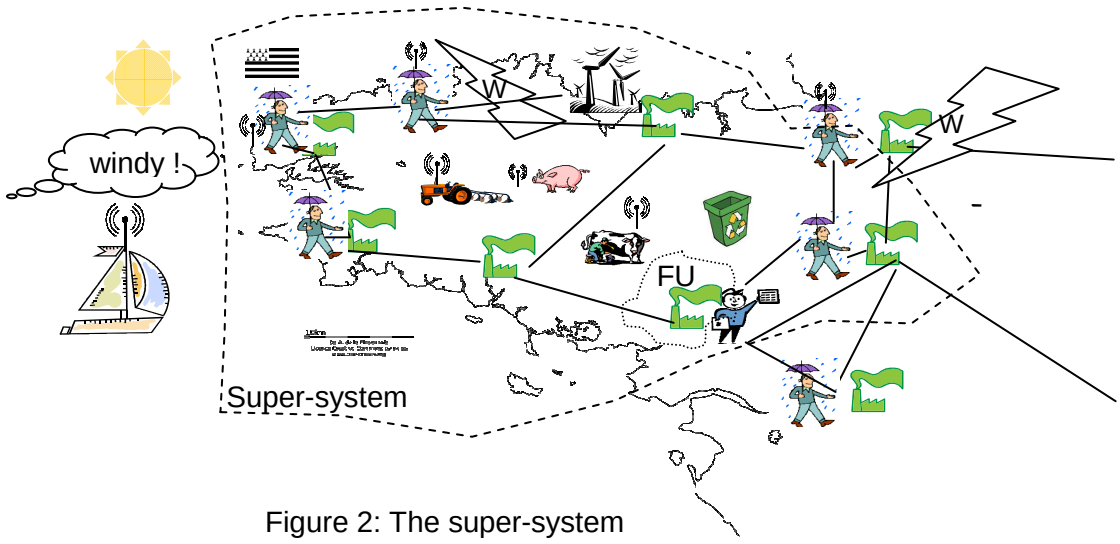

Figure 2: The super-system

The quantities exchanged between the super-system and its environment, are: the devices needed for the infrastructure, end-devices, the thrown devices, energy, heat,

cooling-water, air, data (streams). Between the entities inside it, the quantities exchanged are the same. The size of the whole region is 320kmx170km, for an area within of 27000 km², the shape is almost trapezoidal, see figure 2. The 3,2 10^6 inhabitants are living mostly near the shores and the eastern border, more than 60% are living in 16 urban areas. The agrarian surface represents 60% of the whole. The functional unit (FU) is a sub-region of 10000 nearby homes in Brittany connected to a FTTH network, used during one year.

The mass of the equipment and devices used by the FU is denoted M, and M_u(kg/s) the stream of new devices, that we consider equal to the mass of those thrown away. The typical diameter of a FU is denoted d (km), the covered area A_c (km²), A_o is the occupied area. The mean power consumption including cooling systems is denoted W (kW), the mean efficient power consumption W_{eff} (without cooling systems, etc.). We consider that all of the power is finally converted in heat; the reused heat is denoted W_r. The mean water consumption is denoted W_w (kg/s). The mean bit rate of the data throughput is denoted B (GBd or Gbit/s). The typical delay of transmission is denoted τ (µs), and τ_h (<100ms) the typical human delay acceptable for teleoperation or telepresence. All of the used units in these 12 quantities involve only 3 physical dimensions, mass, length and time (bit is not a physical dimension). We can choose 3 of those physically independent to forge 9 dimensionless numbers, we prefer the set M_w, W, d. It leads to the 9 dimensionless numbers:

M/M_u , A_c/d^2, A_o/d^2, W_{eff}/W, W_r/W, W_w / M_u , $(B^2 M_u d^2)/(W)$, τB, $\tau_h B$.

Notice that M_u, A_o , W, W_w are used in a LCA. In the next part we will point out the well known indicators, and how to use the other dimensionless numbers as new indicators.

5. INDICATORS

The first number is connected to the three indicators PDEEE QDEEE and DVPT [11]. If there are recycled devices or equipment, we could introduce an extra dimensionless number matching to the EN2 indicator of the GRI [10]. The fourth number is the well known DciE (= 1/PUE). The fifth is connected to the ERE indicator [11] (ERE is unusable by engineers because its definition and its dimension). The sixth is connected to the WUE indicator.

It appears that the second, third, seventh, eighth, ninth numbers are unknown as indicators but pertinent for our work, and for decision makers. The second and third are usable to select between wired and wireless solutions, both are connected to territorial considerations. For instance the ratio of the two last τ/τ_h reflects the ability to support new real-time on-line services. Such ratios are correlation formula, which could be verified after real-size experiments. Clearly the number $(B^2 M_u d^2)/(W)$ reflects strongly the sustainability of the network, it could be correlated with the second and the third numbers. These numbers open the door to sustainable social decision-making, using the SO1 indicator of the GRI[13].

6. CONCLUSION

This work is in progress. We will use these indicators in chapters dedicated to the sustainable aspects in our present and future works, both in research and teaching. Currently Mr. Muhamat (master 2 student), is performing a web crawling on the regional area. His work will be completed at the end of the summer; the results will be available at the autumn.

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INDICATEURS D'IMPACT RELATIFS AUX RESEAUX DE COMMUNICATION TRES HAUT DEBIT.

La région Bretagne lance un programme de déploiement d'un réseau de communication à très haut débit à base de fibres optiques, jusqu'aux domiciles des abonnés (FTTH). D'autres régions en France et en Europe appliquent déjà de tels programmes.

L'objet de notre travail est d'étudier les impacts territoriaux et sociaux des usages qui découleront de la mise en place d'un tel réseau. Les impacts environnementaux font partie des aspects abordés. Nous avons extrait de la littérature des indicateurs d'impact définis pour la mise en œuvre de systèmes d'information éco-responsables. Ceux-ci sont principalement dédiés aux équipements d'extrémité du réseau, serveurs et stations, ainsi qu'aux services et usages ; peu concernent l'infrastructure de communication. Nous proposons de nouveaux indicateurs centrés sur celle-ci, afin de permettre une comparaison entre diverses solutions (fils conducteurs, fibres optiques ou sans fil). Ces indicateurs sont composés en suivant les premières étapes de la méthode de développement en X. Nous délimitons un super-système composé du système technique et de tout ce qui est dans son environnement et qui interagit avec lui. Ensuite nous qualifions et quantifions ces interactions, les performances visées et les contraintes environnementales. Une analyse dimensionnelle est ensuite effectuée pour forger des nombres sans dimension. Parmi ceux-ci certains ont trait directement aux impacts du système sur son environnement depuis sa conception jusqu'à son retrait de service en passant par son utilisation. Nous retrouvons naturellement les quelques indicateurs adimensionnels existants dans la documentation sur l'éco-TIC, et nous montrons comment adimensionner les autres. Au terme de ce travail nous arrivons à de nouveaux indicateurs que nous souhaiterions présenter à la communauté.

Mots clés
éco-TIC, indicateurs d'impact, méthodologie, territoires, aménagement, urbanisme