Spatial Data Infrastructure in the Perspective of Modern Geo-communication
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Models, Mutual Dependencies and Definitions

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ABSTRACT

The purpose of geo-communication is to bridge the gap between reality and data sources on one side and a reasonably basis for decision-making on the other side. This is achieved through several types of activities, where web-services and spatial data infrastructure (SDI) as well as knowledge of communication-theories play important roles. The introduction of web-services as index-portals based on geo-information has changed the conditions for both content and form of geo-communication. A high number of players and interactions as well as a very high number of all kinds of information and combinations of these characterize geo-communication carried out through web-services.

This paper discusses the nature of geo-communication put into relation to the different components of SDI, as well as the impacts thereof. Awareness of the complexity is necessary, and structure is needed to make it possible to handle the increasing complexity.

Modern web-based geo-communication and its infrastructure looks very complex, and it will get even more complex! Therefore there is a strong need for theories and models that can describe this complex web in the SDI in the perspective of modern geo-communication.

1. THE PAPER'S BACKGROUND

The focus of this paper is the requirements driven or user driven development of the web consisting of geo-communication, web-services and Spatial Data Infrastructure (SDI). Most GIS-, cartography- and SDI-literature lacks theories, models and methodology for the systematic user requirement assessment, which comprises user awareness, situation awareness and capability awareness. This paper describes some of these aspects on a general level through conceptual models. This paper is *not* a description of technical implementation methodology or prototyping.

2. INTRODUCTION

The purpose of geo-communication is to bridge the gap between reality and data sources on one side and a reasonably basis for decision-making on the other side. This is achieved through several types of activities, where web-services and spatial data infrastructure (SDI) as well as knowledge of communication-theories play important roles.

Geo-communication is carried out through the combination of geo-information and its distribution through e.g. web-services. The introduction of web-services as index-portals based on geo-information has changed the conditions for both content and form of the distribution. A high number of players, interactions, a very high number of all kinds of information, and combinations of these, characterize web-services, where maps are a part of the whole. This is a complete new situation compared to what the mapping-world was just a few years ago. This new situation demand new ways of modelling the processes contained in geo-communication.

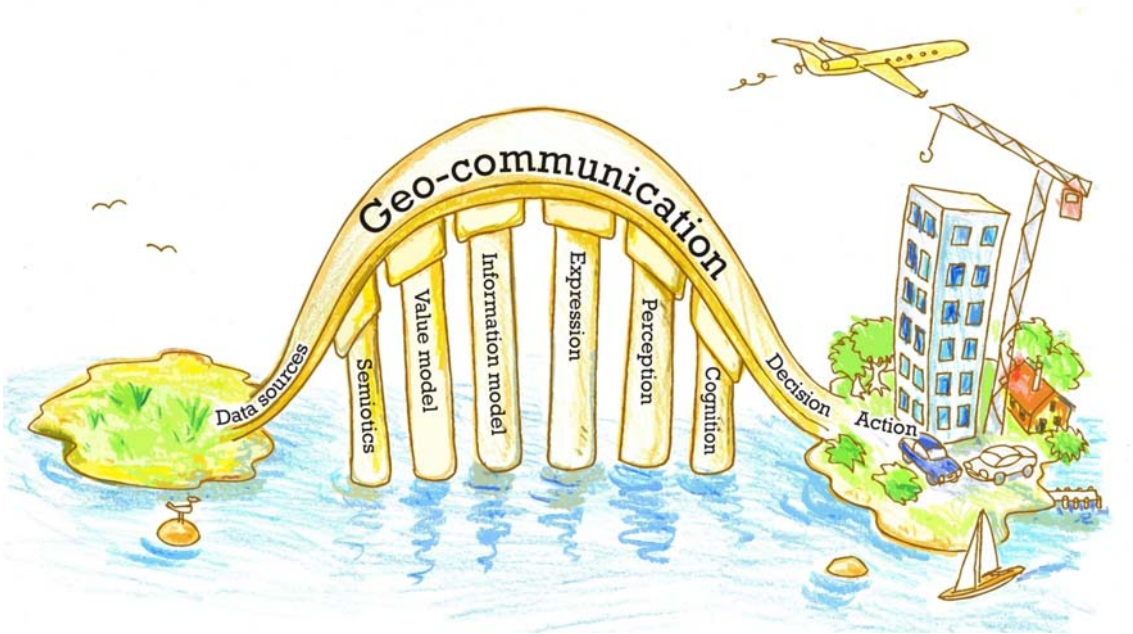

Figure 1. The purpose of geo-communication is to bridge the gap between reality and data sources on one side and a reasonably basis for decision-making on the other side (Brodersen, 2005).

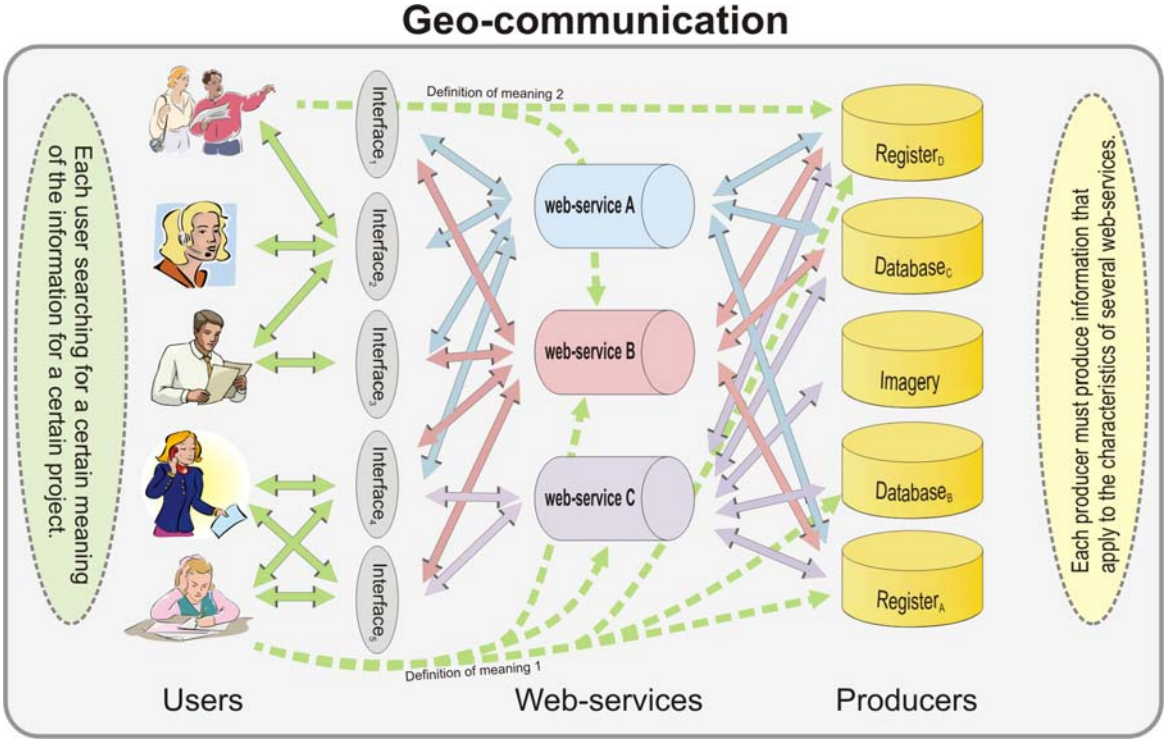

Figure 2. Geo-communication consists of several types of players, several types of activities and several types of information, where maps are a small part of it. Web-services and spatial data infrastructure play an important role in this web (Brodersen, 2005).

The role of geo-information and the conditions for the distribution of geo-information have changed dramatically since the introduction of web-services on the Internet. In this context web-services perform the function as *index-portals* to further information. This index-function is based on geo-information, e.g. maps. Therefore maps are no longer an aim in themselves. Maps and cartography are linked to geo-communication as 'disciplines of expression'.

3. The Elements of Geo-communication

3.1 Definition of Geo-communication

Communication is the achievement of an agreement on one or more aspects of a certain case. This is happening on the basis on a number of transmissions of information. *Geo-communication* is communication where agreement is achieved at least on *the position* of the case. (VB to (Peirce, 1992-1998) and (Gadamer, 1986)).

The *purpose* of any communication is to conduct the behaviour of the user! (Shannon et al, 1949). This is done by submitting relevant information, on the basis of which the user may decide. Hopefully the user will be able to act. The above mentioned agreement is achieved when the user finds he has a reasonably basis for decision-making. Decision-making demands supply of information. Decisions are made on the basis of mental connections and integration with previous experience in the person's mind. Action is based on further mental activity and is part of the epistemology, which is outside the scope of this paper.

Carrying out explorative analysis and explorative visualization is also communication as the person discusses with himself inside his mind. The ideas are discussed inside the person's mind; the preliminary results are discussed inside his mind. The decision to make changes and try again is made inside his mind. Everybody will know the feeling of discussing a difficult case with oneself. The tricky point is to split this process into smaller pieces and study one transmission at a time. It is close to impossible to investigate all aspects of one communication process in one go, because every transmission changes the conditions at both ends of the transmission-line.

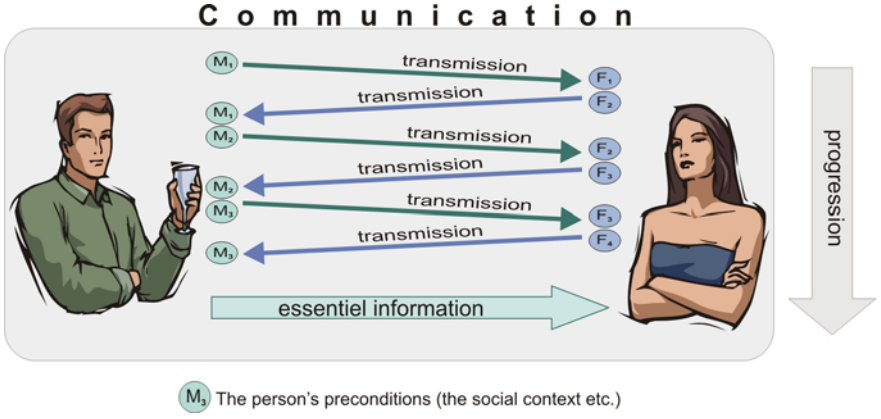

Figure 3. Communication is the sum of a number of transmissions. In geo-communication is the 'feed-back transmission' established through quality control. Or, transmission both ways happens when two people discuss explorative visualization. Or, transmission both ways happens when one person carries out explorative visualization and 'discusses it' inside his own mind.

As the first thing agreement on the pre-conditions must be achieved. When this has happened, it is possible to transmit the essential information (see Figure 3). This procedure is valid for both 'geo-communication through travel-planning' as well as for 'explorative analysis and explorative visualization'.

3.2 The Producer's Responsibilities in Geo-communication

In order that the producer may transmit the necessary information to the user, the producer must as the very first activity analyse the phenomena of the case. The result of this analysis must be described in detail. The aim of the analysis is to identify and select that kind of information that is relevant to the user's contemplated activities. The purpose of the producer's analysis is to form a reasonable basis for the user's decision-making (Brodersen, 2005). All together geo-communication describes a *value-chain* from reality to decision and the according action.

The user may want a basis for making decisions on a possible trip, i.e. a suggestion of an itinerary, see Figure 4. For this purpose the user starts a web-service intended for this use. The user types the start point and the end point of the trip, date and time, and after a short while, she will receive a number of proposals for the itinerary. On this basis she will be able to make the decision, "Yes" or "No", to travel. The primary problem for the producer is to catch this problem and to deliver the relevant information containing the relevant meaning. The secondary problem for the producer is to master the complex network of processes and their mutual dependencies.

Figure 4 illustrates such an example of travel planning. The process shown in the figure consists of geo-information and the spatial data infrastructure (SDI), i.e. the passive elements of geo-communication (plus a user). All processes shown in the illustration can be iterative. The illustration can be seen as a longitudinal section of the overall process. Compare also Figure 5 showing the cross section of the geo-communication.

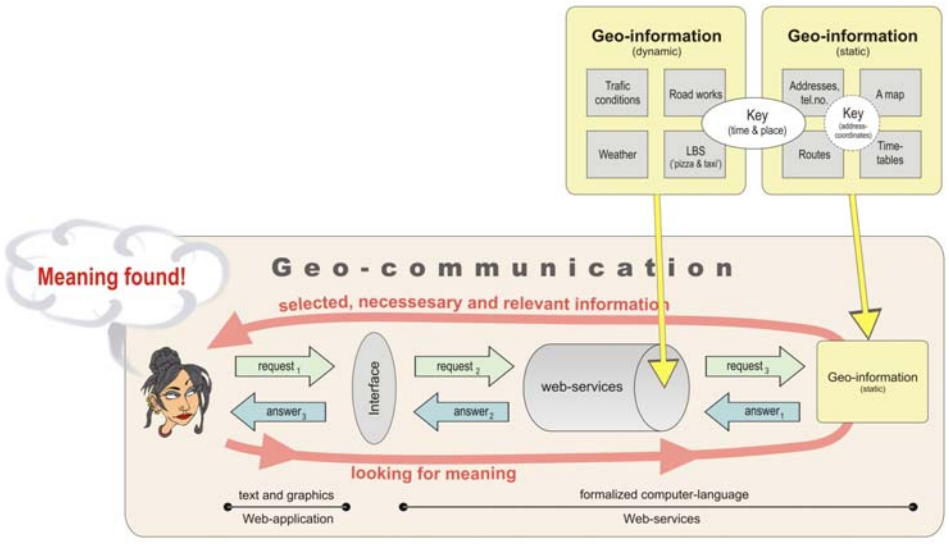

Figure 4. The user is looking for information enabling her to decide whether to take the trip or not. The primary problem for the producer is to catch this problem and to deliver that information containing the relevant meaning. The secondary problem for the producer is to master the complex network of processes (Brodersen, 2005).

Behind the interface of the web-service several things happen which the user need not to know about. On the basis of the web-services algorithms a number of questions are send to certain databases about certain geo-information, such as timetables, maps, road work, etc., which can be both static and dynamic.

It is important to note that the user does not ask for a certain timetable or a certain map, but only for the *meaning* of these in relation to the trip she wants to make. The *meaning* for the user is to have a basis on which first to make the decision to travel or not to travel, and if she decides to travel, then to know how to do it.

With reference to the above definitions of communication and geo-communication it can be stated that the example in Figur is *not* just a transmission. It is a communication because an agreement is achieved. It is even geo-communication, because it is relevant to achieved agreement on the position of the case. The agreement is achieved in that moment where the user says: 'Okay, I'm able to make a decision'. This decision can be both 'Yes' and 'No', which is not crucial. The crucial point is the basis for the decision-making. If the user leaves the web-services without a basis for the decision-making the agreement has not occurred.

It is to assume that the control, whether this crucial point of decision-making is achieved or not, actually is carried out by the web-service provider. In the actual example in Figure 4 it is possible for the web-service provider to make this quality-control. The web-service provider can check if the user orders the ticket (e.g.).

3.3 New Conditions in Geo-Communication

Compared to the 'good old days' when maps were maps, geo-communication is characterized by new and complex structures.

- Several new producers have become active on the market
- The costs of the means of production have been reduced dramatically
- The user's requirements have increased
- There is no longer a given relation between producer and end user, as it was the case in the 'good old days'
- The service providers have influence on the content

Today several producers are now active in producing geo-information, and several web-service-providers are carrying out the transmission of this geo-information to a huge number of users, i.e. are carrying out geo-communication. On top of the SDI a huge number of users are all trying to find that particular meaning of the geo-information that satisfies their particular needs. Therefore the producers have to cope with several, different types of definitions of meaning.

The web in the Figure 2 illustrates a simple version of a web-based geo-communication community. The second point to be made here is that there is no longer only *one* definition of meaning with which everybody has to be satisfied. All users have the possibility to find a producer or a service provider who accepts to take care of *that* particular definition of meaning demanded by that particular user. The producers have lost control of the users' behaviour!

4. Geographical Information Systems (GIS) and Geo-communication

Geographic Information Systems (GIS) is often understood as the combination of *software, data and methods*. This might well be so. However, it can be argued that this no longer is sufficient to be able to understand the role of GSI in modern geo-communication based on SDI. GIS can be

seen as the cross-section geo-communication, as Figure 5 illustrates. GIS and SDI have several elements in common.

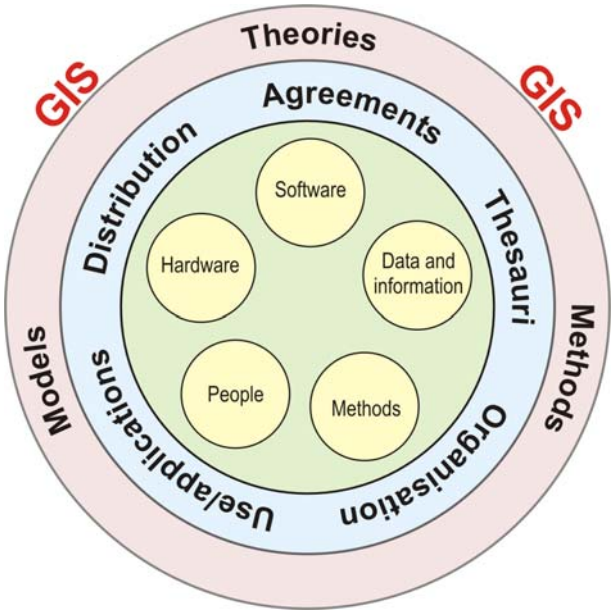

Figure 5. GIS is the framework for geo-communication. GIS consists of several elements, not only software and data. The diagram can be seen as a cross section of geo-communication. Compare also Figure 4 with the longitudinal section of the overall process of geo-communication.

5. THE ROLE OF SPATIAL DATA INFRASTRUCTURE (SDI)

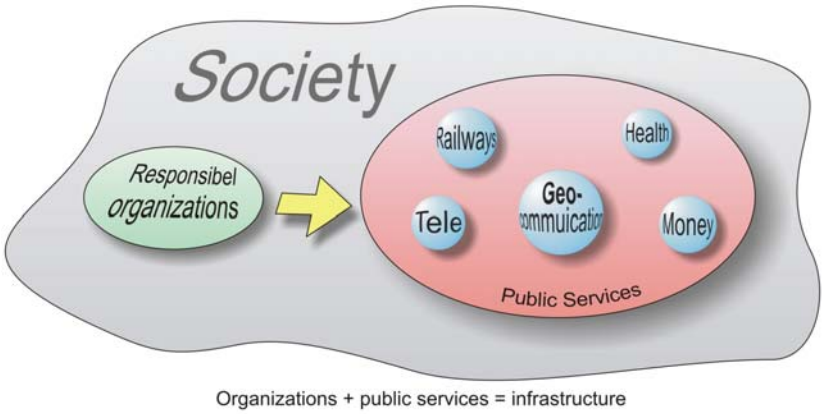

Figure 6. The combination of public services and the responsible organizations can be seen as the infrastructure of a society. SDI is concerned with geo-communication and the respective responsible organizations.

SDI is the framework for geo-communication. Where geo-communication is based on the dissemination of geo-information through any available media for the purpose of making the meaning of information available, SDI is the framework that makes it possible to carry out the trans-

mission and dissemination of geo-information. Therefore some kind of overlapping can be identified. The geo-communication view-point is concerned with the meaning of the geo-information. The SDI view-point is concerned with the organisation and the services, systems etc. that make the transmission of geo-information possible. From an *organisational* view-point SDI can be seen as the combination of *organizations* and *public services* (VB to (GSDI, 2004)).

6. ACTIVE AND PASSIVE COMPONENTS IN SDI

6.1 THE ACTIVE COMPONENTS IN SDI

From an *activity* view-point SDI can be defined as a combination of active components and passive components. The active components in SDI are those organisations that get things running. The active components have the responsibility, and they must be active. Otherwise nothing will happen! The *active* components in SDI are:

- International Organizations like UN, NATO etc.
- Governments
- National Mapping Agencies
- Standardization bodies
- Custodians for various services
- Producers of geo-information

6.2 THE PASSIVE COMPONENTS IN SDI

The *passive* components in SDI are those *documents* that the active components have to produce to get the information about their activities distributed. These documents, the passive are the following (see Figure 7), here presented in their mutual dependency. The mutual dependency is of iterative nature. (VB to (GSDI, 2004) and (OGC Reference Model))

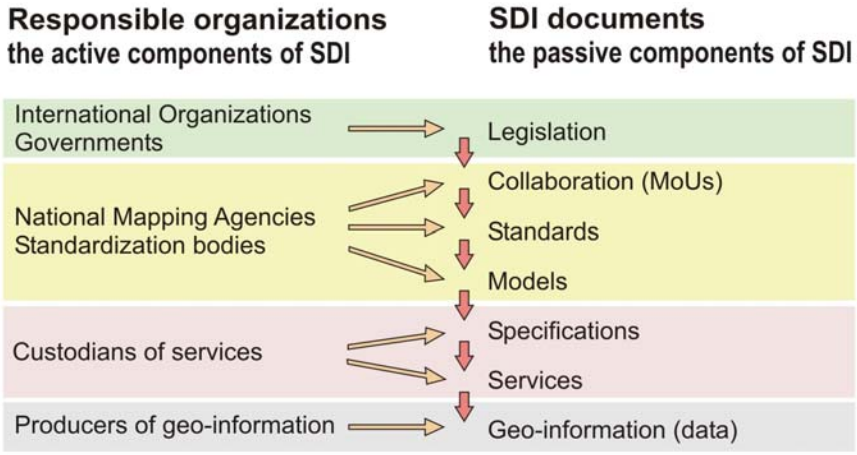

Figure 7. The active components in SDI are those organisations that get things running. The active components have the responsibility, and they must be active. The passive components in SDI are those documents made by the active components. The passive components are created to get the information distributed about the active components activities.

6.2.1 The Elements of the Passive Components

The passive components are those documents containing and presenting the *results* of the activities of the active components. The passive components are dependent upon the activities in the organisations. Therefore they are called passive. These passive components are not active in themselves.

(1) *The legislation* is made by the organisations, the active components. The legislation must act on a general level taking care of:
- Enacting the framework for the deeper structures of SDI
- Setting the areas of *responsibilities*

(2) *Collaboration* (Memory of Understanding, MoU) are policy statements (position paper). Collaboration is based on the framework given by the legislation. Without this framework it is basically not possible to establish partnerships. Collaboration must act on a general level taking care of:
- Setting the area(s) of *interest*
- Establishing operational *partnerships* (within the framework of legislation)
- Inclusion of services as a full palette of joint government and commercial theatres
- Agreements upon the intention of sharing meta-information on services

(3) *Standards* are the necessary basis for activity within SDI. Standards are the logic and practical conclusions of the agreements made in (2) Collaboration. Collaboration is a *declaration of intent. Collaboration* does not say anything about *what* to work on. Standards define what to work on, and they define the activities. Standards are *general* and can therefore be used for several concrete projects, where a *specification* is concrete and valid for one project. A few examples of standards (of which a few are Danish standards):

Principals of standards within the domain of SDI and geo-communication as well as some of their attributes

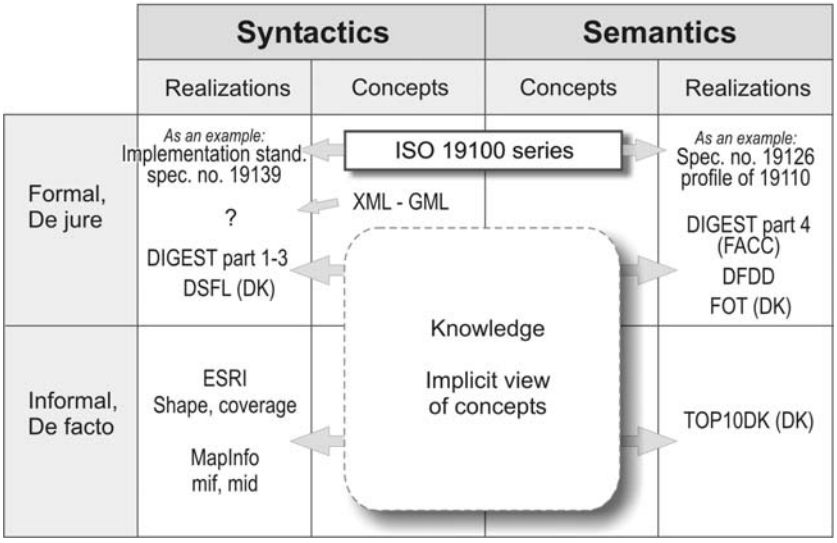

Figure 8. A few examples of standards. Standards define what to work o, and are the necessary basis for activity within SDI. Standards are general and can be used for several projects.

(4) *Models* describe how to use certain standards for a given project. Models bridge the gap between standards and specifications. Models describe:
   - Value Model (Identification of content)
   - Business process engineering (Information and resource flow, Requirements driven service development)
   - System Use Case (Application schemas, General Feature models)
   - The need for specifications (Implementation process)

(5) Specifications are descriptions of what has to be done in a certain project. A specification can e.g. specify that things have to be done in accordance with certain standards. A specification is concrete and valid for one given project; standards are general and valid for several projects. Specifications describe *rules* and *contents* for one given project:
   - Categorizations and classifications of real world phenomena (features) within a standardized universe of discourse
   - Definitions and descriptions of attributes on the level of the classified features
   - Definitions of the information flow; sources, update strategy; components value assessment etc.
   - Storage and security strategies
   - Filtering and retrieval methodologies
   - Strategies for multistage representation (incl. semantically and geometrical granularity and generalization)
   - Symbolization strategy, design manuals and legend drafting

(6) *Services* are the concrete, practical set-up of the passive components no. 1 through 5. The passive components no. 1 through 5 can all be carried out on a piece of paper; nothing practical, actual has happened until here. Web-services bridge the gap between producer's databases and the users. Web-services are the technology making the use of geo-information possible. Services establish the technology; i.e. the software, the hardware, the user-interfaces etc.

(7) *Metadata and Information* is the 'fuel' to put into the machinery (the services) once the services have been created. Metadata and Information is *not* the technology! Metadata and Information are the actual, practical, concrete result of a certain production carried out in accordance with the characteristics of the services, with the specification, with the model, with the standard, with the MoU, and with the legislation. Information (data) is not products!

7. CONCLUSIONS

The supply of geo-information is *always* made with the purpose of conduction the behaviour of the user. Therefore it is necessary to incorporate *communication-theories* into the world of geo-information, GIS and spatial data infrastructure (SDI). Success is achieved when there is an agreement between producer and user on one or more aspects of the case. *Geo-communication* is the agreement on at least *the position* of the case. This is made possible through a number of transmissions of (geo)information. The agreement on e.g. the position makes it possible for the user to decide. So, geo-communication can be seen as a decision-making system.

With the introduction of web-based geo-communication things have become most complex, compared to the 'good old days' when maps were maps. The user’s decision and contemplated action is conditioned by the supply of geo-information, and the following mental connection and integration with previous experience in the user’s mind. In order that the producer may transmit the

necessary, relevant information to the user, the producer must be able to analyse the phenomena of which the case are based, and be able to describe the result of this analysis in detail.

The framework for web-based geo-communication is the *spatial data infrastructure (SDI).* SDI consists of both active components and passive components. The active components get things happening. The passive components are the documents describing the results of the activities with the actives components. As there is a mutual dependency between all the components none of them can be left out. If just one component is missing, the impact is that the geo-communication is based on a non-systematic and non-conscious foundation.

Modern web-based geo-communication and its infrastructure is very complex, and it will get even more complex. Therefore there is a strong need for theories and models that can describe the 'web' of geo-communication and SDI in order to make it possible to handle the complexity and to give the necessary framework.

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