Zeitschrift: Studies in Communication Sciences : journal of the Swiss Association of Communication and Media Research

Herausgeber: Swiss Association of Communication and Media Research; Università della Svizzera italiana, Faculty of Communication Sciences

Band: 5 (2005)

Heft: 1

Artikel: "Museum of non-european cultures" : a design traceability case study adopting the TRAMA approach for interactive applications"

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DOI: https://doi.org/10.5169/seals-790918

Studies in Communication Sciences 5/1 (2005) 145-166

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"MUSEUM OF NON-EUROPEAN CULTURES": A DESIGN TRACEABILITY CASE STUDY ADOPTING THE TRAMA APPROACH FOR INTERACTIVE APPLICATIONS

This paper presents a traceability case study taken from an academic project in the field of interactive applications for cultural heritage.

Traceability is the ability to discover and to maintain relationships between project artefacts in both a forwards and backwards direction (Gotel & Finkelstein, 1995). In a project life-cycle, relationships can be stated between stakeholders, goals, requirements, design artefacts, prototypes, pieces of code and usability tests, at different granularity levels. The model exemplified in this paper focuses on Design Tracing, i.e. on documenting the reasons of design decision in the hypermedia field. In particular, the model focuses on different aspects of the tracing activity: client validation, design versioning, "negative" design, non-traceable design and reverse requirements specification.

The case study that will be used to show the main characteristics of the model is taken from the project of re-launch of the "Museo delle Culture Extraeuropee" (Museum of non-European cultures) in Lugano. This museum has a culturally significant collection but is very poorly known in the local community and risks closure. The case study is related to the website supposed to be developed to support this re-launch, in addition to other initiatives and to other interactive applications.

Keywords: design traceability, requirements tracing, cultural heritage applications.

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1. Introduction

In the software requirements engineering[1] community, the problem of tracing and maintaining relationships between different artefacts or pieces of documents have been for a long time a myth. According to the Merriam-Webster dictionary, a myth is "a usually traditional story of ostensibly historical events that serves to unfold part of the world view of a people or explain a practice, belief, or natural phenomenon". The story that has been told in this community in the last 15 years, was a story about a world were the problem of checking the quality of a software application has been solved by the mean of a tracing practice; a world where software developers write down in detail every step of their work, the reasons of every choice, their assumptions, their goals and their beliefs related to the piece application they are working on; a world were these people can spend half of the project time in documenting and recording all these information using complex tools or formal languages to link it to each other in a (more or less) meaningful way; a world where, at the end of the day, someone could draw useful conclusions for the quality of the application from this huge network of relationships.

But this is not just a false myth: the problem of the quality still has a central place in the development of software artefacts. In short terms and according to Kenny (1996), the quality of a software application can be defined as:

- the totality of features and characteristics of a software product that bears on its ability to satisfy given needs, for example to conform to specifications
- the degree to which software possesses a desired combination of attributes
- the degree to which a customer or user perceives that software meets her/his composite expectations
- the composite characteristic of software that determine the degree to which the software in use will meet the expectations of the customer

[1] The first step in any software developmental effort is to determine exactly what the software system shall do. Software Requirements stipulates what must be accomplished, transformed, produced or provided. Additionally, a Software Requirement is a software capability that must be met or possessed by a software component in order to satisfy a contract, standard, or specification.

According to these definitions, the quality degree of a software application depends on the compliance of the artefact developed with the goals and the needs of *all the people that have a stake on the success of the application* (i.e., clients, sponsors, stakeholders, etc.) and with the motivations of the final users. How can this compliance be understood and proven? How an analyst can keep trace of the *reasons why* some choices have been implemented and other ones have been rejected? How can she/he link *needs* and *goals* to *solutions*?

The traceability myth described before gives some answers: bring all your documents, specifications and artefacts produced during the project, log them into a support tool and trace all the relationships that you consider meaningful; other relationships will be automatically created by the tool itself. This "tool-based" solution does not consider that in the actual practice, some specifications are not taken, some documents are not written or are written after the application has been implemented and that some "knowledge" (about reasons, beliefs, etc.) is never recorded or explicitly considered; besides, another aspect of the problem is the difficulty of maintaining the huge mass of dependencies among the many objects (often not adequately defined) produced by a large software system development effort.

A proposal to find a reasonable and usable solution to these problems is TRAMA, the methodology used in the case study presented in this paper. TRAMA stands for TRaceability Analysis Methodology for (interactive) Applications; it is a first attempt to reduce this complexity considering requirements-to-design relationships between objects of adequate granularity; TRAMA can be applied even in case of missing documentation: it is also useful to write an *ex-post* specification of the work done; TRAMA can be used without any specific software tool: objects are related each other using simple matrices; TRAMA analysis discover or highlight the main reasons for conceptual design[2] choices and which is the impact of a goal or of a requirement on the application.

This case and other experiences have shown that the methodology is easy to use and to learn, and that the tracing activity is reduced to an average of the 5% of the time spent for the entire project.

[2] In the interactive application field, conceptual design defines the general architecture of the application, types of contents, navigation capabilities, features and services provided. It is usually used before the implementation phase to discuss solutions or changes within the development team and with the client.

The paper is organized as follows. Section 2 highlights how traceability methods can be applied in different phases of a software development project. Section 3 refers to some major contributions from state-of-the-art research in this field, considering some open problems in current practices. Section 4 summarizes the TRAMA approach, highlighting activities, phases and tools involved. Section 5 exemplifies the approach and introduce further TRAMA concepts through a case study. Section 6 wraps up the proposal in its key elements and provides an input for future research.

2. Contextualisation

Traceability is the activity of explicitly defining and documenting relationships between the different phases of a project's life-cycle. A specification can be considered as "traceable" if the origin of each of the artefacts or objects described in such a specification is clear and if it facilitates the referencing of each object in future development or enhancement documentation (Gotel & Finkelstein 1994).

The traceability needs of the stakeholders involved in the system development life-cycle differ due to differences in their goals and priorities (Ramesh et al. 1993).

Therefore different kinds of traceability can be performed, and different definitions can be proposed. These definition can be grouped considering the main activities supported by traceability (requirements analysis, design or usability evaluation) and, on the other hand, the directions of established relationships (backward or forward traceability).

Traceability during requirements phase[3]. A requirement analyst could establish relationships between user profiles and goals owned by these users, or between requirements and goals these requirements fulfil, keeping traces of the reasons of the strategic decisions taken during the analysis phase. Some structured methods (such as i*, KAOS or AWARE) provide conceptual tools to document the relationships between a stakeholder and the goals she/he expresses and between a requirement and the goal(s) it fulfils.

[3] In this phase the requirement analyst decides with the client which are the main distinctive features of the final application.

Traceability during conceptual design phase. This kind of traceability helps designers to prove to their client that requirements have been understood, that the product will fully comply with the requirements and that the product does not exhibit any unnecessary feature or functionality. From this point of view, traceability helps ascertain how and why system conceptual design solutions satisfy stakeholders requirements (Jarke 1998).
Traceability during usability evaluation[4]. Usability experts have to taken into account high-level goals of the product, evaluating it according to its real scope. Keeping traces between these two activities can help usability inspectors performing a more effective and efficient evaluation and showing that the main goals have been consistently tested.
Backward traceability to previous development stages depends upon each requirement explicitly referencing its source in previous documents.
Forward traceability to all documents spawned from the software requirement specification depends upon each requirement in the software requirement specification having a unique name or reference number.

Traceability can therefore improve the quality of the development process. Traceability can be seen as a powerful communication mean, that helps designers defending their choices with clients and proving that the solutions adopted fit the strategic goals of the project (Pinheiro 1996). Traceability can then facilitate communication among the various stakeholders involved: project manager and project planner, customer, requirement analyst, designer, verifier and maintainer.

3. State-of-the-art and open problems

In the last 10 years traceability for interactive applications has been studied as a part of requirements analysis process (cf. the concept of Requirements Tracing in Pinheiro 1996). Traceability is perceived as the activity to trace relationships from and to the requirements specification. In this track I will include the works of Gotel & Finkelstein (1995) and Van Lamsweerde et al. (1998).

Orlena Gotel proposed an approach ("Contribution Structures") that provides a way to define links between authors/contributors and artefacts

[4] Usability is the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in particular environments (Triacca 2004).

(contributed_to, contributed_by). Gotel introduces the concept of "social infrastructure", which refers to the overall system of agents in the process, along with the various relationships they are involved in. Social relations reveal information about the social network and answer the 5 questions of: Involvement, Responsibility, Working arrangement, Change notification and Ramification.

Alex Van Lamsweerde suggests an approach (KAOS) where goal hierarchies express system goals and the requirements that support the achievement of system goals. The impact of changes to goals or requirements can be examined by traversing up and down the goal hierarchy. Traceability can be a way to keep all the changes in the track of the original goals. The KAOS methodology provides a specification language for capturing why, who and when aspects in addition to the usual that requirements, a goal-driven elaboration method, and meta-level knowledge used for local guidance during method enactment.

Some last developments in research domain proposed a general approach called "rich traceability" (Dick 2002), nowadays widely adopted by the Requirements Engineering community; this concept can be summarized in the idea of adding semantics and rationales[5] to the traced relationships. Some major examples are:

- the concept of a "design justification" in the REVEAL method (Hilton 2003); in this approach, information is collected to justify traceability, and the concepts of conjunction and disjunction are used to characterize the way in which design requirements combine to satisfy the high-level requirements
- the concept of "elaboration" in the MoD SMART procurement process (Farncombe 2004); here a single statement explaining how the requirement is satisfied accompanies each requirement, and represents a simple form of rich traceability
- the latest versions of the KAOS tool, that support a simple form of rich traceability.

[5] In the requirements traceability field, the word „rationale" is used to refer to a logical explanation or to the structured motivation of the reasons of an artefact, activity or decision.

The open problems in current traceability practices can be summarised as follows:

- current approaches require the use of a software tool to become usable and manageable
- current methods often need a quite long training time to be properly understood
- some practices require an overlong time to be accomplished
- methodologies are often not clear, not complete or too formal
- some practices have access problems for the user (communication problems)
- it is difficult to maintain the huge mass of dependencies among the many objects produced by a large software system development effort
- current tools have problems in maintaining relationships concerning artefacts expressed in natural language, often ambiguous, or artefact created independently by non-interoperable tools and that evolve autonomously.

4. TRAMA: a design traceability approach

As stated before, current practices consider traceability as a part of the requirements analysis process. My experience and research in the field seems to show that traceability can be rather considered as a self-standing activity (and discipline). In fact, if requirements are the strategy to satisfy stakeholders' goals and the design is how the application have to behave, tracing can be see as the activity of arguing why design solutions satisfy requirements. In fact, the traceability expert is not a requirement analyst or a designer but he/she needs specific competences and skills; besides, due to psychological issues, analysts or designers cannot easily perform self-observation.

Starting from these considerations, the Technology-Enhanced Communication Laboratory (TEC-Lab) at the University of Lugano is developing TRAMA (TRaceability Analysis Method for – interactive – Applications), an approach that treats traceability as a self-standing structured inquiry activity. The following paragraphs and the case study in this paper will show some details of the TRAMA approach.

In current practices, during a project life-cycle a lot of documentation and deliverables are produced as specifications of the project status or result. These specifications document:

- not the process, just the results
- not the reasons, just the solutions and
- not possible or proposed solutions, just the accepted ones.

TRAMA takes in consideration these aspects and allows documenting rich traceability chains from two points of view:

- the impact that goals, requirements, constraints, etc. have on the conceptual design of an interactive application
- the motivations or sources of the design choices.

In real-world cases, it cannot be assumed to have (useful) documentation both on the requirements or on the design side. In fact, it could happened to have a combination of the following cases:

- the design documentation is absent or incomplete
- the requirements specification is missing
- the requirements specification is unstructured or incomplete.

The TRAMA approach can be applied in any case, no matter if previous documentation is available or not.

As a self-standing process, traceability in the TRAMA method is structured as follows:

- Preliminary Plan: understanding which are the stakeholders of the traceability analysis, the traceability goals, the constraints (time and budget, related to ROI) and the expected results
- Elicitation: understanding requirements and design from documents or from interviews with designers
  - Reverse Requirements Elicitation
  - Requirements "normalization"
    - Structuring the previous knowledge in terms of visions, stake-holders, goals, users, motivations, requirements, constraints and scenarios
  - Design "normalization"
    - Knowledge comes from previous documentation or from a reverse engineering process of the application
    - Structuring the design in terms of topics, relevant relations, group of topics and dialogue acts
- Analysis: tracing relationships and developing the Requirements Impact and the Design Motivations Models
- Specification: documenting stakeholders, goals and analysis results

• Validation: checking the results with requirements analysts, designers and clients.

As stated before, TRAMA considers traceability from two points of view:

• the impact on design of: visions, stakeholders-goals, users-motivations, domain issues, scenarios, constraints and requirements; these traces form the Requirements Impact Model (RIM)

• the justification or motivation of the design, that can comes from specific requirements or goals, from visions, from an understand of the specific domain, form the expertise of the designer or form constraints; these traces are called Design Motivations Model (DMM).

The analysis approach for both models consists in one or more matrices representing traces between two families of objects (e.g. requirements and design topics). Each matrix can be used as a checklist supporting the traceability analyst in considering the relevance and the meaning of each possible pair of objects. A simple example (cf. Table 1) will clarify this aspect.

Table 1: RIM Goals-Design matrix for the project "Museum of the non-European cultures"

TOPICS

GOALS	Object	Themed tour	Artist	Interactive feature	Visual quiz	Visual comparison	Temporary exhibition	Activity / Event	About the museum	Visit the museum	The collection	Contact	Site map
Attract visitors							X	X		X			
Educate visitors		X		X	X	X							
Increasing knowledge and appreciation of the collection	X	X		X	X	X							
Promoting multi-culturalism in the community						X		X					
See the museum attract more visitors							X	X		X		X	
Have other, broader concerns such as the impact of the museum on how the city is perceived									X				
Enrich the offerings provided to tourists and tour operators							X	X		X			

RELEVANT RELATIONS

GOALS	Visual quiz INCLUDES Object	Visual comparison ILLUSTRATED BY Object	Object INCLUDES Visual comparison	Visual comparison INCLUDES WORK BY Artist	Visual quiz INCLUDES WORK BY Artists	Object IS PART OF Themed tour	Themed tour INCLUDES Object	Object SAME THEME Object	Object SAME REGION Object	Object CREATED BY Artist	Artist CREATED Object	Artist SAME MOVEMENT Artists	Object INCLUDES Interactive feature	Interactive feature IS PART OF Object	Themed tour SAME THEME Themed tour	Temporary exhibition INCLUDES Activity / Event	Activity / Event IS PART OF Temporary exhibition
Attract visitors																X	X
Educate visitors	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Increasing knowledge and appreciation of the collection	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Promoting multi-culturalism in the community		X	X	X												X	X
See the museum attract more visitors																	
Have other, broader concerns such as the impact of the museum on how the city is perceived																	
Enrich the offerings provided to tourists and tour operators																	

GROUP OF TOPICS

GOALS	All quizzes	All comparisons	Exhibitions by date	Activities by date	Keyword search on description	Timeline	5 minute tour	Objects by type	Collection highlights "10 best"	Art	Culture	Geography << Region	Significant historical events	Artists by movement	All artists	All features
Attract visitors			X	X			X		X							
Educate visitors	X	X				X	X		X	X	X	X	X	X		X
Increasing knowledge and appreciation of the collection	X	X				X	X	X	X	X	X	X	X	X		X
Promoting multi-culturalism in the community		X								X	X	X	X			
See the museum attract more visitors			X	X												
Have other, broader concerns such as the impact of the museum on how the city is perceived																
Enrich the offerings provided to tourists and tour operators			X	X												

The matrix in Table 1 shows the relationships between high-level goals and design elements of the project "Museum of the non-European cultures" (this is the case that will be discussed later in this paper). The analyst considers it line by line (goal by goal), answering the questions: "what is the impact that this specific goal has on the design?" and "which design elements fit this goal or answer to this need?". The analyst fills in this way the matrix, finding all the strategies used in the design as solution to problems and needs highlighted in the requirements phase. Usually, the elements taken into account in columns/rows of the matrix are:

- for RIM matrices – visions, stakeholders, goals, users, motivations, constraints and requirements (in rows); topics, relevant relations and group of topics (in columns)
- for DMM matrices – topics, relevant relations and group of topics (in rows); motivation types (in columns).

The TRAMA approach helps the analyst in different ways:

- knowledge "normalisation" for requirements and design provides a standard and structured set of concepts that can easily be related to each other
- the models used in the "normalisation" allow expressing a big set of concepts in a few elements (the case presented in figure1 and in the rest of the paper is an extreme maximum of complexity)
- a set of "motivation types" i.e. a library of motivation categories is provided to the analyst
- a set of aspects and elements to take into account filling the matrices is provided to the analyst.

Since the traceability analyst starts investigating relevant traces using the matrices, he/she have to consider the following aspects and questions.

Client validation

Traceability analysis is a way to set up a structured argumentation to show to the client that all the needs have been taken into consideration and how. When the analyst trace a relationship in the matrix, he/she have to be aware of setting up strong evidence showing the reason of each design decision.

"Negative" objects

These elements are those visions, goals, requirements or design objects that have been eliminated or modified because of a direct rejection, because of a change in related objects or because of business, technology or law constraints. Keeping trace of old choices is useful to remember why a decision and not another has been taken or rejected, to validate negative decisions with stakeholders and to show the "negative" impact of a specific constraint or requirement.

Design versioning
When a designer presents a project, she/he needs to highlight different design aspects for different stakeholders. Relationships traced in the matrix allow understanding which parts of the design are relevant for which stakeholder. This feature helps creating different versions of the design documentation, addressed to a specific target.

Design motivations
Traces between design elements and their motivations are not just the opposite of requirements-design relationships. According to real cases analysed at TEC-Lab (University of Lugano), a little part of decisions (10%-30%) are taken because of specific requirements; 70%-90% of design comes from designer expertise, a particular understanding of the specific domain, technology constraints, "graphic" constraints, budget constraints, time constraints or laws obligations.

Reverse requirements specification
Often requirements are written after design and implementation, just for documentation, or they are not updated after a certain step of the project. Traces in the TRAMA matrices are useful to check the consistency between design and requirements, "fine-tuning" requirements specification according to the real stakeholders' goals and extracting consistent requirements specification from design. This kind of activity is useful to keep trace of strategic decisions, to better argument design decisions and to provide information and material for a consistent usability test.

Usability on design documents
The usability evaluation should be done as soon as possible in an application development life-cycle: the error correction is more expensive in advanced development phases and it is better anticipate the main errors and problems before implementation. Considered that scenarios for usability evaluations are goal-based, keeping trace of the relationships between requirements and design artefacts helps selecting the elements in the design involved for a specific task, evaluating the quality of the product with respect to the high-level goals and identifying test procedures that should be rerun to validate an implemented design change.

These aspects can be summarized by the questions that the analyst should ask to his/her-self to find traces:

• between stakeholders and design elements: "Which design element fits with the needs of this stakeholder?"; "If I had to present the project to this stakeholder, which part of the design should I highlight?";
• between goals and design elements: "Which design element fits with this goal?"; "Which is the impact of this goal into the design?";
• between users and design elements: "Which design element better fits with the needs of this user?"; "How can I argue design choices to show that this user is considered in it?"
• between user motivations and design elements: "Which strategy is set-up in the design to fit with this user motivation?";
• between constraints and design elements: "Which is the (positive or negative) impact of this constraint into the design?";
• between requirements and design elements: "Which are the design elements that fit with this requirement?"; "How can I show that this requirement has been properly taken into account in the design?";
• between design elements and motivations: "Why the designer chose to put this element into the design?"; "How can I show that this element is not an extra-feature in the design?".

The following case study will be used to show how the main elements related to the TRAMA method can be applied in the cultural heritage domain.

5. Case study

The Museo delle Culture Extraeuropee (Museum of non-European cultures) in Lugano opened in 1989. It houses approximately 600 objects donated to the city by Serge and Graziella Brignoni in 1980. Serge Brignoni, an accomplished and recognized painter in his own right, dedicated many years of his life to assembling the collection of objects from Oceania, Africa and India. Although the collection is culturally significant, due to poor management and lack of promotional activities on the part of museum and city officials, it was virtually unknown in the local community. As a result, the museum received very few visitors, which led the city of Lugano to propose closing the institution in 2003. Objects in the collection were to be sold or loaned to other ethnographic museums in Europe.

A local citizen group successfully challenged this proposal and, in 2004, the city agreed to reappraise the museum's situation. Following this reappraisal, the city is now planning to invest money and resources to re-launch the museum. A permanent curator will be appointed in the coming months. In addition, they are considering developing a website and other interactive applications to support the re-launch.

TEC-Lab and the Master in Technology-Enhanced Communication for Cultural Heritage (TEC-CH) received the task to design a general purpose website for the museum. As present no website exists and the only information available online is a QuickTime VR tour of the gallery which is located on the city of Lugano site.

5.1. "Normalisation" phase

As a first step for the traceability study, I reorganised and "normalised" in a structured way the huge amount of information raised out from the documentation provided by TEC-CH feasibility analysis. These information can be summarised as follows:

- Visions and assumptions
  - Stakeholders are essentially united in the desire to see the museum stay open
  - The re-launch of the museum have to be supported
  - Users will have very little motivation to visit our website or the museum
  - Our target audience has little or no interest in Oceanic or Extra-European art
- Stakeholders and goals
  - Museum director: Attract visitors
  - Curator: Educate visitors, Increasing knowledge and appreciation of the collection
  - Citizen group (who petitioned the city on behalf of the museum): Promoting multi-culturality in the community, See the museum attract more visitors
  - Local authorities: See the museum attract more visitors, Have other, broader concerns such as the impact of the museum on how the city is perceived
  - Tourist information office: Enrich the offerings provided to tourists and tour operators
- Users and motivations
  - Local Italian speakers: Get motivation to visit the museum, Get

overview of the collection, Get the overall picture: Why should I care?, Get detailed information on collection objects, Find out what's new/activities, Make personal contact, Be entertained

  ◦ National/international non Italian speakers (Swiss German tourists, Domain experts from universities and other cultural institutions residents of Lugano): Get motivation to visit the museum, Get overview of the collection, Get the overall picture: Why should I care?, Get detailed information on collection objects, Find out what's new/activities, Make personal contact, Be entertained, Plan visit/Get practical info

- Requirements
  - Content: Information on collection objects, Information on related artists, artworks and objects, Practical information about the museum, Background and history of the museum and collection, Information on temporary exhibitions, Information on activities and events
  - Structure of content: Highlight the parallels and differences between modern Western culture and the indigenous culture which produced the work, In presenting exhibitions and activities focus on upcoming rather than past events
  - User interaction: Inside some articles or narratives additional interactive mechanisms should allow users to engage directly with the museum by posting text or pictures
  - Presentation: Reflect the feeling of Oceanic art, Simple non-domain specific language
  - Access paths to content: Allow indirect access to objects through tours according to possible areas of user interest: Art, Culture / Lifestyle, Geography, History; Allow access to objects through other interactive techniques, such as quizzes; Allow direct access to objects by keyword search on description; Allow direct access to objects by traditional timeline; Allow direct access to objects by type of object.

In this case, the design was already expressed in a structured way, in terms of topics, relevant relations and group of topics; the model used is IDM (Interactive Dialogue Model). The following schema summarises the conceptual design:

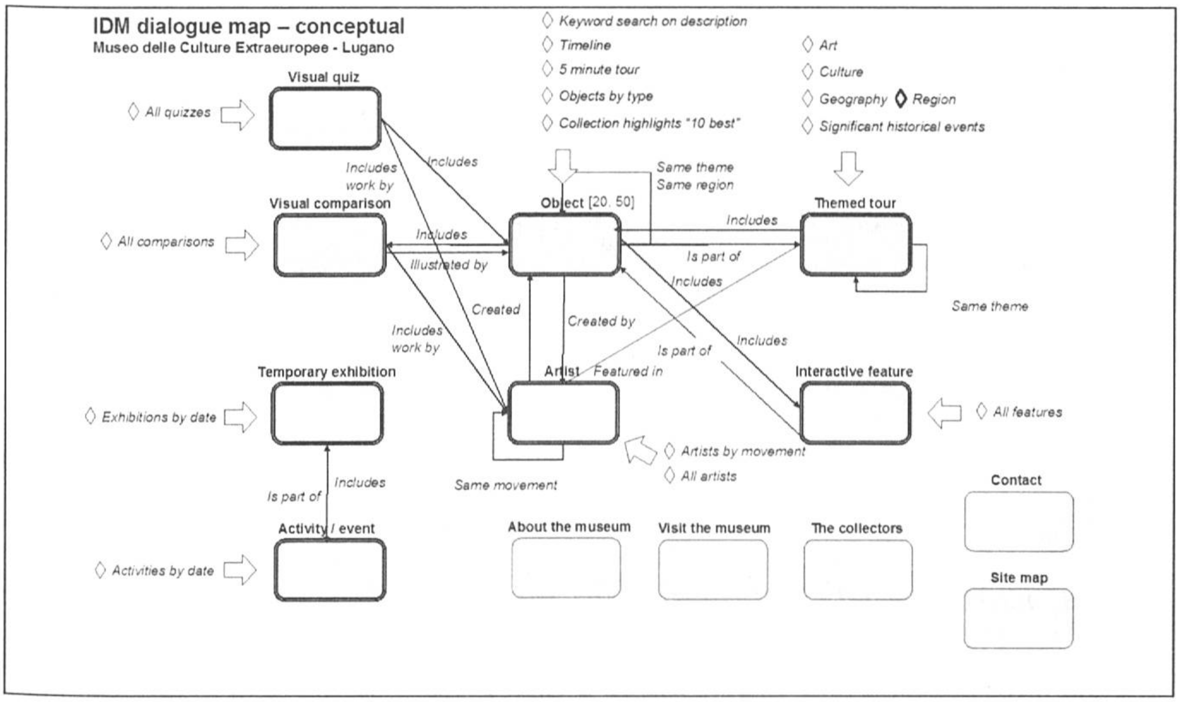

Fig. 1: IDM Dialogue Map

After these two preliminary steps, the core of the analysis was the creation of the two models, RIM and DMM, through annotated matrices.

5.2. Requirements Impact Model

The RIM matrices are filled keeping in mind the three main aspects of the model: "client validation", "negative requirements" and "reverse requirements specification". A Visions-Design matrix, a Stakeholder-Design matrix, a Goals-Design matrix, a Motivations-Design matrix and a Requirements-Design matrix have been created (cf. Tables 2, 3, 4, 5 and 6).

Table 2: RIM Visions-Design matrix for the project "Museo Etnografico"

		TOPICS												
		Object	Themed tour	Artist	Interactive feature	Visual quiz	Visual comparison	Temporary exhibition	Activity / Event	About the museum	Visit the museum	The collections	Contact	Site map
VISIONS	Stakeholders are essentially united in the desire to see the museum stay open													
	We have to support the re-launch of the museum								X	X	X			
	Users will have very little motivation to visit our website or the museum				X									
	Our target audience has little or no interest in Oceanic or Extra-European art				X	X	X							

		RELEVANT RELATIONS																
		Visual quiz INCLUDES Object	Visual comparison ILLUSTRATED BY Object	Object INCLUDES Visual comparison	Visual comparison INCLUDES WORK BY Artist	Visual quiz INCLUDES WORK BY Artists	Object IS PART OF Themed tour	Themed tour INCLUDES Object	Object SAME THEME Object	Object SAME REGION Object	Object CREATED BY Artist	Artist CREATED Object	Artist SAME MOVEMENT Artists	Object INCLUDES Interactive feature	Interactive feature IS PART OF Object	Themed tour SAME THEME Themed tour	Temporary exhibition INCLUDES Activity / Event	Activity / Event IS PART OF Temporary exhibition
VISIONS	Stakeholders are essentially united in the desire to see the museum stay open																	
	We have to support the re-launch of the museum																	
	Users will have very little motivation to visit our website or the museum														X			
	Our target audience has little or no interest in Oceanic or Extra-European art	X	X		X	X												

		GROUP OF TOPICS															
		All quizzes	All comparisons	Exhibitions by date	Activities by date	Keyword search on description	Timeline	5 minute tour	Objects by type	Collection highlights "10 best"	Art	Culture	Geography << Region	Significant historical events	Artists by movement	All artists	All features
VISIONS	Stakeholders are essentially united in the desire to see the museum stay open																
	We have to support the re-launch of the museum			X	X												
	Users will have very little motivation to visit our website or the museum																X
	Our target audience has little or no interest in Oceanic or Extra-European art	X	X					X		X	X	X	X	X	X		X

Table 3: RIM Stakeholders-Design matrix for the project "Museo Etnografico"

STAKEHOLDERS	TOPICS												
	Object	Themed tour	Artist	Interactive feature	Visual quiz	Visual comparison	Temporary exhibition	Activity / Event	About the museum	Visit the museum	The collection	Contact	Site map
Museum director		X		X	X			X	X	X		X	
Curator	X	X	X		X	X	X		X	X	X		
Citizen group (who petitioned the city on behalf of the museum)							X	X	X	X			
Local authorities							X	X	X		X	X	
Tourist information office							X	X		X		X	

STAKEHOLDERS	RELEVANT RELATIONS																
	Visual quiz INCLUDES Object	Visual comparison ILLUSTRATED BY Object	Object INCLUDES Visual comparison	Visual comparison INCLUDES WORK BY Artist	Visual quiz INCLUDES WORK BY Artists	Object IS PART OF Themed tour	Themed tour INCLUDES Object	Object SAME THEME Object	Object SAME REGION Object	Object CREATED BY Artist	Artist CREATED Object	Artist SAME MOVEMENT Artists	Object INCLUDES Interactive feature	Interactive feature IS PART OF Object	Themed tour SAME THEME Themed tour	Temporary exhibition INCLUDES Activity / Event	Activity / Event IS PART OF Temporary exhibition
Museum director					X											X	X
Curator	X	X	X	X		X	X	X	X	X	X	X	X	X	X		
Citizen group (who petitioned the city on behalf of the museum)																	
Local authorities																	
Tourist information office																X	X

STAKEHOLDERS	GROUP OF TOPICS															
	All quizzes	All comparisons	Exhibitions by date	Activities by date	Keyword search on description	Timeline	5 minute tour	Objects by type	Collection highlights "10 best"	Art	Culture	Geography << Region	Significant historical events	Artists by movement	All artists	All features
Museum director	X		X	X	X				X						X	X
Curator		X	X		X	X	X	X	X	X	X	X	X	X	X	X
Citizen group (who petitioned the city on behalf of the museum)			X	X												
Local authorities					X							X			X	
Tourist information office			X	X												

Table 4: RIM Goals-Design matrix for the project "Museo Etnografico"

GOALS	TOPICS												
	Object	Themed tour	Artist	Interactive feature	Visual quiz	Visual comparison	Temporary exhibition	Activity / Event	About the museum	Visit the museum	The collection	Contact	Site map
Attract visitors							X	X		X			
Educate visitors		X		X	X	X							
Increasing knowledge and appreciation of the collection	X	X		X	X	X							
Promoting multi-culturalism in the community						X		X					
See the museum attract more visitors							X	X		X		X	
Have other broader concerns such as the impact of the museum on how the city is perceived									X				
Enrich the offerings provided to tourists and tour operators							X	X		X			

GOALS	RELEVANT RELATIONS																
	Visual quiz INCLUDES Object	Visual comparison ILLUSTRATED BY Object	Object INCLUDES Visual comparison	Visual comparison INCLUDES WORK BY Artist	Visual quiz INCLUDES WORK BY Artists	Object IS PART OF Themed tour	Themed tour INCLUDES Object	Object SAME THEME Object	Object SAME REGION Object	Object CREATED BY Artist	Artist CREATED Object	Artist SAME MOVEMENT Artists	Object INCLUDES Interactive feature	Interactive feature IS PART OF Object	Themed tour SAME THEME Themed tour	Temporary exhibition INCLUDES Activity / Event	Activity / Event IS PART OF Temporary exhibition
Attract visitors																X	X
Educate visitors	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Increasing knowledge and appreciation of the collection	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Promoting multi-culturalism in the community		X	X	X												X	X
See the museum attract more visitors																	
Have other broader concerns such as the impact of the museum on how the city is perceived																	
Enrich the offerings provided to tourists and tour operators																	

GOALS	GROUP OF TOPICS															
	All quizzes	All comparisons	Exhibitions by date	Activities by date	Keyword search on description	Timeline	5 minute tour	Objects by type	Collection highlights "10 best"	Art	Culture	Geography << Region	Significant historical events	Artists by movement	All artists	All features
Attract visitors			X	X			X		X							
Educate visitors	X	X				X	X		X	X	X	X	X	X		X
Increasing knowledge and appreciation of the collection	X	X				X	X	X	X	X	X	X	X	X		X
Promoting multi-culturalism in the community		X								X	X	X	X			
See the museum attract more visitors			X	X												
Have other broader concerns such as the impact of the museum on how the city is perceived																
Enrich the offerings provided to tourists and tour operators			X	X												

Table 5: RIM User motivations-Design matrix for the project "Museo Etnografico"

MOTIVATIONS	TOPICS												
	Object	Themed tour	Artist	Interactive feature	Visual quiz	Visual comparison	Temporary exhibition	Activity / Event	About the museum	Visit the museum	The collection	Contact	Site map
Get motivation to visit the museum		X					X	X					
Get the overall picture Why should I care?		X					X	X					
Get overview of the collection							X						
Find out what's new/activities							X	X					X
Get detailed information on collection object	X						X				X		
Make personal contact												X	
Be entertained		X		X	X								
Plan visit/Get practical info							X			X		X	

MOTIVATIONS	RELEVANT RELATIONS																
	Visual quiz INCLUDES Object	Visual comparison ILLUSTRATED BY Object	Object INCLUDES Visual comparison	Visual comparison INCLUDES WORK BY Artist	Visual quiz INCLUDES WORK BY Artists	Object IS PART OF Themed tour	Themed tour INCLUDES Object	Object SAME THEME Object	Object SAME REGION Object	Object CREATED BY Artist	Artist CREATED Object	Artist SAME MOVEMENT Artists	Object INCLUDES Interactive feature	Interactive feature IS PART OF Object	Themed tour SAME THEME Themed tour	Temporary exhibition INCLUDES Activity / Event	Activity / Event IS PART OF Temporary exhibition
Get motivation to visit the museum																	
Get the overall picture Why should I care?																	
Get overview of the collection																	
Find out what's new/activities																X	X
Get detailed information on collection object								X	X	X	X	X					
Make personal contact																	
Be entertained																	
Plan visit/Get practical info																	

MOTIVATIONS	GROUP OF TOPICS															
	All quizzes	All comparisons	Exhibitions by date	Activities by date	Keyword search on description	Timeline	5 minute tour	Objects by type	Collection highlights "10 best"	Art	Culture	Geography << Region	Significant historical events	Artists by movement	All artists	All features
Get motivation to visit the museum							X		X	X	X	X	X			
Get the overall picture Why should I care?							X		X	X	X	X	X			
Get overview of the collection						X	X		X							
Find out what's new/activities			X	X					X							
Get detailed information on collection object						X		X						X	X	
Make personal contact																
Be entertained							X		X							X
Plan visit/Get practical info			X	X												

Table 6: RIM Requirements-Design matrix for the project "Museo Etnografico"

			TOPICS													RELEVANT RELATIONS																	GROUP OF TOPICS															
			Object	Themed tour	Artist	Interactive feature	Visual quiz	Visual comparison	Temporary exhibition	Activity / Event	About the museum	Visit the museum	The collection	Contact	Site map	Visual quiz INCLUDES Object	Visual comparison ILLUSTRATED BY Object	Object INCLUDES Visual comparison	Visual comparison INCLUDES WORK BY Artist	Visual quiz INCLUDES WORK BY Artists	Object IS PART OF Themed tour	Themed tour INCLUDES Object	Object SAME THEME Object	Object SAME REGION Object	Object CREATED BY Artist	Artist CREATED Object	Artist SAME MOVEMENT Artists	Object INCLUDES Interactive feature	Interactive feature IS PART OF Object	Themed tour SAME THEME Themed tour	Temporary exhibition INCLUDES Activity / Event	Activity / Event IS PART OF Temporary exhibition	All quizzes	All comparisons	Exhibitions by date	Activities by date	Keyword search on description	Timeline	5 minute tour	Objects by type	Collection highlights "10 best"	Art	Culture	Geography << Region	Significant historical events	Artists by movement	All artists	All features
REQUIREMENTS	content	Information on collection objects	X	X					X																																						
		Information on related artists, artworks and objects			X			X										X	X	X			X		X		X																				
		Practical information about the museum										X																																			
		Background and history of the museum and collection									X		X																																		
		Information on temporary exhibitions							X																																						
		Information on activities and events								X																																					
	structure of content	Highlight the parallels and differences between modern Western culture and the indigenous culture which produced the work						X									X	X	X		X	X												X								X	X	X	X			
		In presenting exhibitions and activities focus on upcoming rather than past events																																	X													
	user interaction	Inside some articles or narratives additional interactive mechanisms should allow users to engage directly with the museum by posting text or pictures				X																																									X
	presentation	Reflect the feel of Oceanic art		X																																					X			X		X		
		Simple non-domain specific language																																			X											
	access paths to content	Allow indirect access to objects through tours according to possible areas of user interest: Art, Culture / Lifestyle, Geography, History		X																																						X	X	X	X			
		Allow access to objects through other interactive techniques, such as quizzes					X									X														X				X														
		Allow direct access to objects by keyword search on description																																			X											
		Allow direct access to objects by traditional timeline																																				X										
		Allow direct access to objects by type of object																																						X								

The matrices by itself is very useful as reasoning support for the analyst, but it only documents the relationships between goals and design elements, relationships that without an appropriate comment do not mean very much. In this case, for example, the goal of attracting visitors is fulfilled twofold: convincing users that the exhibition is worth-visiting (thanks to "5 minutes tour" and "collection highlights '10 best'" groups) and allowing users to plan the visit (thank to "Exhibition by date" and "Activities by date" group and to "Visit the museum" topic).

Besides, a matrix can be understandable for an expert analyst but it is not very communicative for a manager or a responsible that should understand the results of the analysis. The main relevant elements should be expressed in a communicative way for the client; TRAMA lets the analyst choose the preferred way to communicate results; in this project, the schema in Figure 8 has been used to express how the "attract visitors" goal has been taken into account in the design.

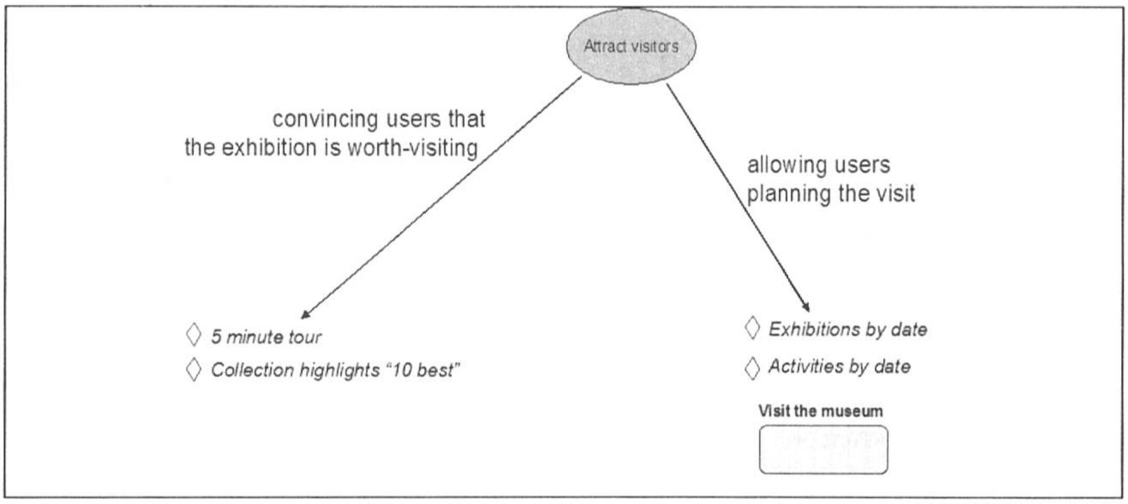

Fig. 2: How the Web site attracts visitors for the Museo Etnografico

In this project, just one negative content requirement has been documented: the decision not to include the 3D animated tour (now in the City of Lugano website). The current page of the museum of the City of Lugano website contains a 3D animated tour which should not be included in the new website. In its current form it is not an effective tool to encourage visitors to come to the museum. While some form of 3D tour of the building may be useful, it is not essential to the promotional or educational goals of the current project.

5.3. Design Motivations Model

The DMM matrices are filled keeping in mind the main aspects of the model: "client validation", "design versioning", "negative design" and "design motivations". A Topics-Motivations matrix, a Relevant Relations-Motivations matrix and a Group of topics-Motivations matrix have been created (cf. Figures 9, 10 and 11).

Table 7: DMM Topics-Motivations matrix for the project "Museo Etnografico"

		Visions	Stakeholders	Goals	Users	Motivations	Requirements	Specific understanding of the domain	Designer expertise	Technology constraints	"Graphic" constraints	Budget constraints	Laws obligations
TOPICS	Object						X						
	Themed tour			X			X						
	Artist						X						
	Interactive feature			X					X				
	Visual quiz								X				
	Visual comparison			X				X					
	Temporary exhibition		X	X			X						
	Activity / Event		X	X			X						
	About the museum		X						X				
	Visit the museum				X	X							
	The collectors		X										
	Contact				X	X			X				
	Site map								X				

Table 8: DMM Relevant Relations-Motivations matrix for the project "Museo Etnografico"

		Visions	Stakeholders	Goals	Users	Motivations	Requirements	Specific understanding of the domain	Designer expertise	Technology constraints	"Graphic" constraints	Budget constraints	Laws obligations
RELEVANT RELATIONS	Visual quiz INCLUDES Object							X					
	Visual comparison ILLUSTRATED BY Object							X					
	Object INCLUDES Visual comparison							X					
	Visual comparison INCLUDES WORK BY Artist							X					
	Visual quiz INCLUDES WORK BY Artists							X					
	Object IS PART OF Themed tour							X					
	Themed tour INCLUDES Object							X					
	Object SAME THEME Object							X					
	Object SAME REGION Object							X					
	Object CREATED BY Artist							X					
	Artist CREATED Object							X					
	Artist SAME MOVEMENT Artists							X					
	Object INCLUDES Interactive feature								X				
	Interactive feature IS PART OF Object								X				
	Themed tour SAME THEME Themed tour							X					
	Temporary exhibition INCLUDES Activity / Event		X						X				
	Activity / Event IS PART OF Temporary exhibition		X						X				

Table 9: DMM Groups of Topics-Motivations matrix for the project "Museo Etnografico"

		Visions	Stakeholders	Goals	Users	Motivations	Requirements	Specific understanding of the domain	Designer expertise	Technology constraints	"Graphic" constraints	Budget constraints	Laws obligations
GROUP OF TOPICS	All quizzes								X				
	All comparisons								X				
	Exhibitions by date		X						X				
	Activities by date		X						X				
	Keyword search on description		X										
	Timeline							X					
	5 minute tour								X				
	Objects by type		X										
	Collection highlights "10 best"								X				
	Art							X					
	Culture							X					
	Geography << Region							X					
	Significant historical events							X					
	Artists by movement		X										
	All artists								X				
	All features								X				

I documented also a "negative" design topic: "Kind of object". The motivation of the rejection is that the dialogue risked to become very complex for a non-expert users; I preferred to add a short introduction to the group of topic "Object by type".

The main results of this analysis can be summarised as follows:

- the goal "enrich the offerings provided to tourists and tour operator" is poorly supported by the design
- the motivation "make personal contact" of the user is not supported by the design; the goal is now considered only in the contact information, but this element is insufficient to answer to this (possible) user need; this aspect could be emphasized as means to fulfil a stakeholder's goal
- the big quantity of relevant relations risks to overemphasize the navigation possibilities on the site and to disorient the user; in fact, the majority of these relationships are designer choices and they do not come from a precise goal; a reduction of the relations should be discussed.

6. Conclusions

In this paper I presented the case study of the "Museo delle Culture Extraeuropee" (Museum of non-European cultures) in Lugano as example of use of the TRAMA traceability approach. The approach is structured in two main parts: a model documenting the impact of visions, goals, motivations, requirements, etc. on the design (RIM) and a model investigating the motivations of each design choice (DMM). The analysis in TRAMA is carried out thanks to traceability matrices that state the relationships between the elements of the model: these elements are "normalized" objects expressing the knowledge related to requirements and design. In TRAMA each matrix is an analysis means; to support a presentation of the results, a more communicative way have to be adopted.

The case study analysed in this paper brought to three main considerations related to the method: TRAMA matrices can be useful to highlight goals or requirements that are poorly considered in the design, to highlight errors or imperfections in the requirements analysis (some goals that do not find in the design a precise expression could be a more generic vision rather than a goal) and they can be a communicative notation or some guidelines for the analysis presentation are needed.

A further step in research will be the enrichment of the approach with guidelines for the analysis and a structured library of "solution patterns", i.e. good and useful solution to recurrent needs and requirements in a specific domain. The methodology will be also enhanced by a clear and communicative notation useful to graphically present single elements and problems raised out from the analysis.

The approach is continuously validated in an empirical way, applying new versions of the model to a number of case studies. TRAMA is in fact an empirical research that tries to use experiences to comes to one or more general models; these results, in an iterative process, are used to perform new experiences and to refine the model. Experimentations are performed both on academic projects and on industrial cases, after the design phase and during the design phase, considering in a separate way the different aspects of the problem. Other case studies that have been taken into consideration until today are the following:

- Munch in Berlin: development of advanced techniques for accessibility to cultural heritage for visually-impaired users, partially funded by the HELP EU project (www.munchundberlin.org) – academic project
- FaTe: an application about fairy-tales and technology for children – academic project
- Pompei: an advanced multichannel application for the Pompei archaeological park – industrial case
- CM group: development of a web site and of a Intranet for the

"Consiglio Superiore dei Lavori Pubblici" (Italian Ministry of Public works) – industrial case.
• Learing@Europe: an educational virtual reality game about the building of modern national countries in Europe – industrial case.

The intrinsic usability of the method will be assured by following some principles, presented in Triacca (2004): the tracing process has to be engineered and standardized, the method has to be systematic, the reusability of the method has to be enhanced in different fields (making TRAMA cost-effective) and the notation of the method has to be as simple as possible, easily learnable, flexible, modular and scalable.

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