Measuring Building Change: A Method to Capture Building Knowledge

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ABSTRACT

Buildings are subject to change of requirements during their periods of use. In the last decades it has been mostly assumed that the rate of change is increasing. Exact description of the type of change or the amount of change is not always investigated. Requirements change knowledge in currently used buildings is lacking. A method is required that identifies empirical building change knowledge. Identification of changes in buildings has the objective of examining if the empirical change could be useful in forecast change in newly designed buildings.

The rest of the paper is organized as follows: Section 1 overviews general knowledge and building knowledge. Section 2 identifies and structures requirement change knowledge. Element change knowledge is structured and described in section 3. A change measurement method is introduced in section 4. Empirical analysis application to the change method is explained in section 5. A tool prototype in section 6 shows how change knowledge is captured from existing buildings and made useful to forecast change in new designs.

Key Words

domain-specific knowledge; requirement knowledge; element knowledge; change measurement; empirical change

KNOWLEDGE ACQUISITION

In the last decade more attention was directed towards understanding the knowledge human beings use to solve their everyday problems. It was computer scientists who first revealed the fact that human knowledge is not as trivial as they thought earlier. They also found out that solving everyday problems would require more than artificially intelligent computer systems. The field of knowledge and knowledge acquisition drew more attention compared to the field of applying artificial intelligence techniques originated in the 1950's.

Knowledge Engineering

Knowledge engineering evolved in the seventies as a sub-field of artificial intelligence concerned with applying knowledge to solve problems that ordinarily require human intelligence. It was accepted that most of the world's challenging mental problems do not yield to general problem-solving strategies, even when augmented with general efficiency heuristics [3]. To solve problems in areas of human expertise such as engineering, problem-solvers need to *Know what human problem-solvers know* about that subject. Knowledge in the context of knowledge engineering means those kinds of data that can improve the efficiency or effectiveness of a problem solver. Three major types of knowledge fit the description: facts that express valid propositions, beliefs that express plausible propositions, and heuristics that express rules of good judgments [3].

Building Knowledge

Building knowledge may simply be described as the knowledge essential to realize a new building. Building knowledge covers a broad field and involves many domains of knowledge. It may be regarded as a result of integration of different domains of knowledge. One could distinguish between building artistic knowledge and scientific knowledge. One could distinguish between the visual knowledge and the alpha-numeric knowledge. One could also distinguish between knowledge related to the domain of building makers and building users; or knowledge of building products and building processes. One can also distinguish the knowledge related building requirements and building elements.

Change investigation examines one domain of building knowledge, requirements change that cause building elements to change through use. Requirements and elements knowledge are identified and structured. Requirements are classified and structured in groups, where each group is composed of clusters and each cluster is composed of items. Building elements are also ordered in groups, clusters and items. A change of a requirement is defined and linked to elements influenced by that requirement change.

Domain-specific knowledge acquisition methods have the advantage of exploring one specific knowledge domain. Building change knowledge domain is represented as the specific investigation domain. Knowledge related to building change is explored and the measurement of facts that express valid building change records using empirical associations is examined.

Domain-Specific Knowledge: Change Knowledge

Capturing building knowledge starts with determining a specific knowledge domain.

Investigation of related knowledge domains will be addresses via that specific domain. If this method proves useful, other knowledge domains may be explored using the same procedure. In this research the chosen domain is: building change. Building change is defined as the change caused in one or more building elements due to a requirement change. Building change knowledge domain deals with two major fields: requirement change knowledge and element change knowledge. Change investigation examines requirements change that causes building elements to change through use.

Requirement change knowledge identification is about defining and structuring the requirements that are subject to change. Requirements are human wishes that building element(s) are expected to fulfil, for example well-being or safety. Elements change knowledge identification is about identifying and structuring building elements that are subject to change. Elements are physical building elements, for example walls or floors, that change due to a change of requirement.

REQUIREMENT CHANGE KNOWLEDGE

Requirement change knowledge acquisition is about understanding as much as possible about requirements that change in a building. Knowledge of requirements that are subject to change is explored. A requirement is generally defined as a statement of user need that is to be fulfilled by a building.

Methods used in practice to identify requirements refer mostly to a document titled "The program of requirements"[5]. User requirements are mostly described in the document in a checklist format. If requirement change is to be explored, the program of requirement document has to my mind a major weak point, requirements are not structured. Some requirements may contradict and some may depend on each other. Changing one requirement does not occur in an organized structure. A requirement structure framework is required that allows requirements to be exactly defined. A requirement change path has to be clarified, as well as the action of change taken.

Requirement Change Structure

A requirement structure is introduced. If a requirement is to change, the change path is to be made visible. The structure has the advantage of showing the exact specification of the requirement and the effect of the specification on the other requirements.

Requirements are classified and ordered in groups, clusters and items. A requirement is specified on three levels. First the overall requirement group is pointed out. Then the clusters of the requirement group are defined. This is followed by the requirement item indication [Figure 1].

The requirement change path is demonstrated. Change effects of one requirement on other requirements are also displayed. Requirement change definition is complete when the requirement definition path and action are determined. Requirement change path determines the requirement group, cluster and item.

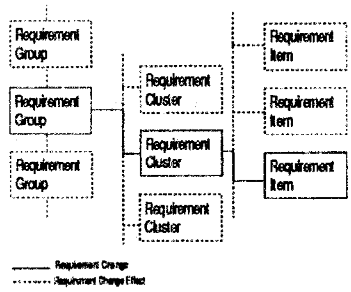

Figure 1 : Requirement Change Structure

Requirement change action describes the type of change action required to realize the change. Change actions are related to requirement items since items are responsible of specifying the requirement. Two basic change actions are addressed:increase or decrease of a requirement item. A change statement expresses the change path and the change action for a requirement.

Requirement Change Path	Requirement Change Action
[requirement group : requirement cluster : requirement item]	*[increase] or [decrease]*

In general requirements change effects other requirements. In this paper no further investigation is done to examine such dependencies. The objective is first to define and examine the requirements and their structure. Once the structure is operational dependencies analysis can start.

Requirement Knowledge

A literature survey was performed to explore requirement knowledge. Several program of requirements and books listing requirements were investigated. The literature survey revealed 148 building requirements that are subject to change [2]. Requirements are ordered in three levels: requirement groups, requirement clusters and requirement items. A requirement group is composed of requirement clusters. And a requirement cluster is composed of requirement items.

Requirement Groups

The total 148 requirements found in the literature survey are clarified to 10 groups.
The 10 groups cover various requirement aspects: economic requirements, facility requirements, mobility requirements, place requirements, perception requirements,

proportion requirements, safety requirements, space requirements, utility requirements and well-being requirements. Change investigation examines the change of requirements that are technically linked to building physical elements. Requirement groups that their change effect difficult to specify were not considered. These were economic, perception, proportion, utility, and place requirements. Next table presents the groups of Facility, Mobility, Safety Space, Well-Being as they are the groups examined further. Facility requirements are the requirements that provide a building with facilities, for example a power station or a data network. Safety requirements include stability and security requirements.

Changeable Requirement Groups
Facility Mobility Safety Space Well-Being

Well-Being requirements include for example hygiene and climate requirements. Each requirement group is decomposed to clusters. An example of how a requirement group, well-being is decomposed of clusters is showed.

Requirement Clusters

Requirement groups may all be decomposed to clusters. One group of requirements, well-being, is selected to demonstrate that possibility. Well-being requirements group is divided into 5 clusters: acoustics, climate, hygiene, tactile and visual requirements. For example the acoustic cluster is a requirement cluster effecting human hearing requirements. Climate requirements lists the requirements related to interior building climate such as air temperature or humidity. Hygiene requirements are requirements related to water and sewage. Tactile requirements are requirements that related to human touching. Visual requirements are requirements that effect the human vision in a building element. Requirement clusters of the group well-being are tabulated.

Changeable Requirement Group	Changeable Requirement Clusters
Well Being	Acoustics Climate Hygiene Tactile Visual

The table represents the classification of one requirement group to requirement clusters. Classification of the requirements to groups and classifying the group in clusters helps ordering the knowledge related to them. An example of how the climate cluster is decomposed of items is shown.

Requirement Items

Requirement clusters are decomposed into items. One requirement cluster is chosen to be worked out. The requirement cluster climate may be decomposed into temperature, humidity and ventilation items. The next table represents the items related to climate cluster and well being group.

Changeable Requirement Group	Changeable Requirement Cluster	Changeable Requirement Items
Well Being	Climate	Temperature Humidity Ventilation

The well being requirement is now exactly specified. The requirement group well being, the group cluster, climate and the cluster item are determined.

Requirement Change Knowledge

The well-being requirement is specified and represented by the theoretical structure of change knowledge. The structure displayed in figure 2 shows the change structure of the well-being requirement. Change effects of one requirement on other requirements are also displayed but currently not investigated.

Figure 2 demonstrates the requirement change. A requirement change is specified on three levels. First the overall requirement group is pointed out, well-being. One cluster of the well-being group is selected, the climate cluster. One item of the cluster, the temperature is chosen.

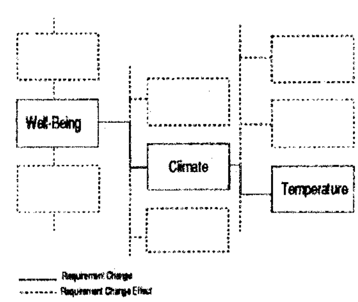

Figure 2: Well Being Change Structure

The complete change path is illustrated. Change knowledge can be expressed by the following statement. The change path defines exactly what is the requirement that is changing, and the change action describes how it is changing.

Requirement Change Path	Requirement Change Action
[Well-Being:Climate:Temperature]	*[Decrease] or [Increase]*

The well-being requirement is an example of how change knowledge can be modelled. Knowledge related to the change of requirements domain is identified by the change path and change action. Sofar the knowledge of the first field of building change domain, requirements change, is approached. The knowledge of the second field of building change, elements change is introduced.

ELEMENT CHANGE KNOWLEDGE

Element change knowledge investigates how element knowledge could be captured in order to represent the change of requirements. A building may be described as an ordered composition of various element. Building elements are physical objects such as floors or walls.

In practice, the most common method used to describe elements is referred to as the Sfb method also called the element method [6]. The Sfb method is an element classification method used in cost planning of new designs. The Sfb method is a useful method if requirements are already fulfilled by elements. It provides exact specification for example the site preparation works in m2. If dynamic change of requirement is aimed, elements knowledge needs to described in a way they could be linked to the change of requirements. Knowledge related to building elements is explored and structured. Building elements are like requirements classified to groups, clusters and items. Each element group is composed of clusters and each element cluster is composed of items.

Elements Change Structure

Previous structure describing requirement knowledge is also used to describe the elements. Elements are classified in groups, clusters and items. Hence, an element is specified on three levels. Element change effects other elements. In this paper no further investigation is done to examine such dependencies. The objective is first to define and examine the elements and their structure. Once the structure is operational dependencies analysis can start.

Element change path is determined by determining the element group, cluster and item [Figure 3]. First the overall element group is pointed out. The group cluster of the elements is defined followed by the element item . Element change path show element change path and possible effect.

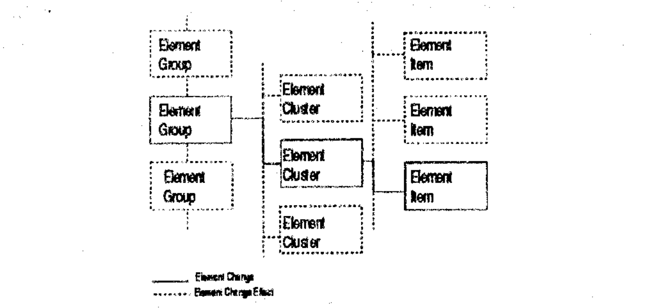

Figure 3: Element Change Structure

Element change knowledge is captured when change path and action are determined. Element change action is determined by two major actions that an element is subjected to: adding or removing.

Element Change Path	Element Change Action
[element group:element cluster:element item]	*[add] or [remove]*

Element change knowledge is introduced by determining the element change statement. An element change statement captures element knowledge. It describes what element is changing and describes how it is changing.

Element Knowledge

Elements knowledge acquisition is based on trying to structure the elements. A building element may simply be defined as an object that participates in fulfilling one or more building requirements. A physical element is defined as a composition of element groups. Each element group is a composition of clusters and each cluster is a composition of items.

Element Groups

Building elements may be divided into five basic element groups: location, structure, envelope, services and interior. A location is where the building is located, a structure is the load-bearing member carrying both live (people and furniture) loads, and dead (building own weight) loads. The envelope is the building enclosure that separates the inner from the outer environment. Services are all the machinery a building is equipped with for example mechanical, electrical and telecommunication systems. The interior consists of non-structural, non-mechanical elements used for finishing, space dividing or decorative purposes.

Element Groups
Location Structure Envelope Services Interior

Each of the previously mentioned groups is composed of a number of clusters. One element group is selected and is decomposed into clusters, the services element group. Its decomposition into clusters is demonstrated.

Element Clusters

Services element group is composed of various element clusters, for example conveyance systems or air regulating systems. Each cluster covers a specific services domain. Services clusters are presented in the next table.

Element Group	Element Clusters
Services	Conveyance System Power System Light System Communication System Security System Water System Sewage System Air Regulating System

Element clusters may also be decomposed into element items. For example, the Air regulating element cluster may be decomposed into a number of items.

Element Items

Element cluster decomposition into items specifies exactly the element. For example the Air regulating systems element cluster maybe decomposed to element items responsible of the regulation of the air in a building. Element items are for example, heating systems, cooling systems, ventilation systems and humidity systems.

Element Group	Element Cluster	Element Item
Services	Air Regulating Systems	Heating Systems Cooling Systems Ventilation Systems Humidity Systems

Sofar element change is identified. Building elements are classified into groups, clusters and items. An example of classification of the services element group is shown.

Element Change Knowledge

The services group element is specified and represented by the structure of change knowledge. The structure displayed in figure 4 shows the change path of the services element.

An element change is specified on three levels. First the overall element group is pointed out, services. One cluster of the services is selected, the air regulating systems. One item of the air regulating system, the cooling system is chosen. The complete change path is displayed in figure 4.

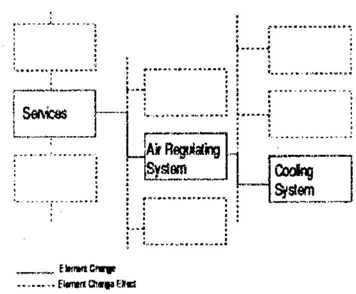

Figure 4: Services Change Structure

Change effects of one element on other elements are also displayed but currently not investigated. Element change statement is expressed by determining the change path and the change action. Change path and change action are expressed in the following statement.

Element Change Path	Requirement Change Action
[Services:Air Regulating System:Cooling System]	[add] or [remove]

Sofar Element change knowledge is introduced. Elements are exactly defined by classifying them into groups,clusters and items. A structure where the change path of the element can be traced is demonstrated. The services element is chosen as an example of knowledge representation of an element group. The air regulating system cluster is chosen as an example of the clusters of the services group. Air-cooling system item is chosen as an example of the items of the air regulating systems cluster and well-being group. If change action is addition. That means that the change action to be taken is "adding a cooling system".

So far the first field of change knowledge, requirement change, and the second field of change domain, elements change, were explored individually. Change path and action are determined. Change evaluation is the next step. A change measurement method is investigated.

BUILDING CHANGE MEASUREMENT

Measurements help in gaining knowledge. Knowledge in return assists new forms of measurements to be conducted. New measurement concepts are necessary to evaluate domains that have been difficult to evaluate sofar. Building change is one of the domains that need to be evaluated. A unit is required to display how difficult or how easy a change of requirement might be. First requirements need to be linked. A measuring unit may then be investigated.

Change Matrix

A change matrix presents a theoretical framework of how a requirements are linked to elements. If a change of requirements occurs, linked elements are effected. It orders requirement and elements and their direct and indirect links. The link signifies that if a specific requirement changes various element solutions can fulfil the requirement change.

A change of a requirement causes change of one or more building elements. If one requirement is changed at a time, the linked elements are indicated. The link determination is not always trivial, therefore first an indication of the elements that are subject to direct or indirect change is necessary. Direct change link describes the element directly fulfilling the change of requirement and indirect change links describe other elements effected by the change of the direct element. If for example the overall building internal temperature requirement has changed during building use different direct element are subject to change.

For example to change [Well Being: Climate: Temperature] requirement the element [Envelope: Openings: Windows] could be changed; or [Services:Air Regulating System:Cooling System] could be changed. Indirect changes might be in the case of [Envelope: Openings: Windows] change the electric installations that are effected by the changing the windows. An example of the indirect change in the case of [Services:Air Regulating System:Cooling System] could be changing the interior.

Figure 5 displays the change matrix of the requirement-element and the two possible link types, direct link and indirect link. Both direct and indirect changes occur in practice. If a change of requirement is addressed both change types occurring in the elements should be addressed. However in order to evaluate change exact measures are required. The direct and indirect effort of change need to be evaluated.

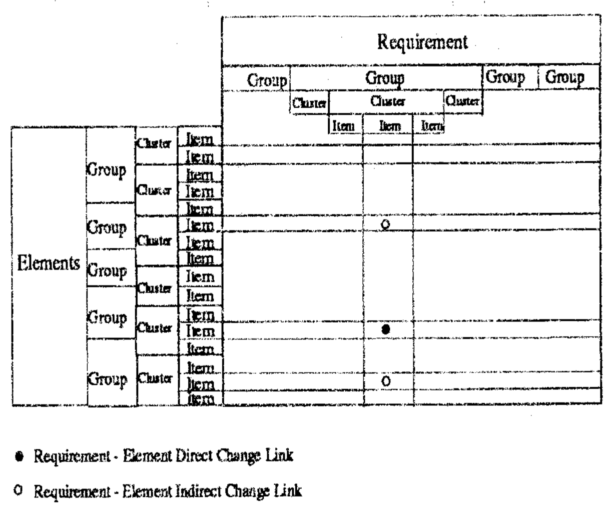

Figure 5: Change Matrix

Change Measurement Method

Building change could be better analyzed if it is exactly evaluated. The objective of change evaluation is to find a consistent way to evaluate direct and indirect changes of elements due to a requirement change. Previous research has shown that the only feasible way to measure the change of requirements is by linking the requirements to elements [1]. Using the same knowledge structure to describe requirement and element knowledge is regarded as fundamental. Therefore the term groups, clusters, items and actions are used in requirement and element knowledge definition. Measurement depends mainly on the definition of what is measured. A consistent structure clarifies the measurement domain.

Change measurement is only possible if knowledge of requirements, elements and links is structured. Knowledge structure allows measurement. Requirement change and action are to be determined, element change and action are to be determined and direct and indirect links need to be indicated. If this is achieved measuring the change of requirement is possible.

Measuring the change of requirement is defined as measuring the effort necessary to change one or more elements due to that change of requirement. If an element is easily changing the effort exerted is less compared to the effort exerted to another element that is difficult to change. Change effort could be measured using different units, for example the time required to change an element. It also could me measured by the cost required to change the elements.

Requirements		Elements		Links		Measurements	
Path	Action	Path	Action	Direct Link	Indirect Link	Direct Change Effort	Indirect Change Effort
[group:cluster:item]	[increase/decrease]	[group:cluster:item]	[add/remove]	Direct Link	Indirect Link	Direct Requirement Element Change Effort	Indirect Requirement Element Change Effort

A requirement change effort measurement abstraction is introduced. It measures the effort if one of the previously mentioned requirement items is subject to change.

Changeability Index

Changeability index is a unit proposed to describe a change effort. If the effort to change an element is high, than changeability is low. Changeability and effort are inversely proportional for the same building. Effort includes the direct and the indirect change effort due to a change of requirement shown in the change matrix.

A barchart representation of the changeability index for a specific requirement in a number of events is displayed in figure 6. For a specific change of requirement occurring in different events direct and indirect changeability of the elements are illustrated. A stacked bar chart shows the direct and indirect changeability.

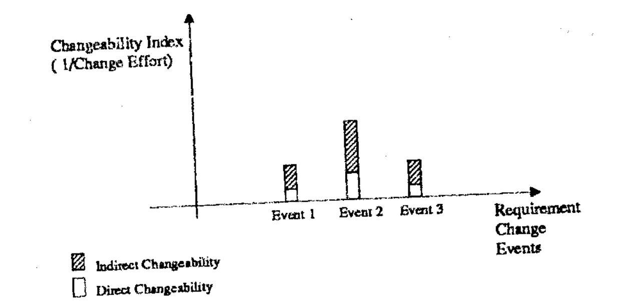

Figure 6: Changeability Index

If the stacked bar value at one event is bigger than by another event, that implies that changeability is higher in the first event than the second even. This is concluded as the effort was in the first case lower than the second case for the same building.
A building may be regarded changeable regarding a specific requirement if the changeability index is high. Changeability index is high when change effort is low.

Sofar requirement and element change knowledge structure is explored. A theoretical change matrix where direct and indirect change effort due to a change of a requirement are indicated. Measurement of element direct and indirect change effort due to a change of requirement are shown. A requirement changeability index is introduced. Empirical knowledge is now approached to test how the requirement knowledge structure and measurement method are applicable in practice.

EMPIRICAL BUILDING CHANGE

Building are subject to change of requirements during use. Objective change records are important for change analysis. First change records have to be found. Change records need to be ordered. As knowledge structure is defined, ordering the change records is possible.

One building of the Eindhoven University buildings the "bestuursgebouw" is examined as a test case for future empirical analysis. The "bestuursgebouw" is an office building. Its construction works were finished in 1985. It has basic rectangular form. Bruto area is 6552 m2, netto area is 3966 m2 and the building volume is 20918 m3. Investigation of the building requirement change records revealed that in the first six years of use 191 different requirement changes occurred. The requirements were first classified into groups and the effort consumed to change each requirement group was surveyed. Investment cost is used in this case to quantify the change effort.

Requirement Change Groups

Requirement changes were ordered to groups, clusters and items. Effort consumed to change requirements is indicated.

Requirement Group	Change Effort (Dutch Guilders)
Well-Being	553,327
Safety	128,724
Facility	120,678
Space	110,335
Mobility	6422

This change represents the total change that occurred during six years in the building. More details are required to investigate change. Further examination is necessary. The well-being requirement is investigated further.

Requirement Change Clusters

The following table represents the decomposition of the well being requirement group.

Change efforts in the clusters in a period of six years of use are indicated.

Requirement Group	Requirement Cluster	Change Effort (Dutch Guilders)
Well-Being	Hygiene	1,669
	Light	8,875
	Sound	4,826
	Climate	537,956

Total change effort of the change of the well being requirement is described in its clusters. [Well-Being:Climate] requirement changed actually in the six years with an effort equal to 553,327 guilders. The [well being:climate] cluster is decomposed into items to specify the effort per item.

Requirement Change Items

To fulfil the decrease of the temperature requirement various efforts were tried out. Adding cooling systems, adding ventilation systems, and adding various shades in different events.

Requirement Group	Requirement Cluster	Requirement Item	Change Effort(Dutch Guilders)
Well-Being	Climate	Temperature	537,956

One item, the cooling system is chosen to demonstrate how change effort occurred. Direct and indirect changes are presented and the changeability index value is introduced.

Requirement Item Change Measurement

The decrease of the temperature requirement of the "bestuursgebouw" is examined. The case describes different actions taken to decrease the temperature requirement.

Requirement [Group:cluster:item,action]	Element [Group:cluster:item,action]	Change Effort (Dutch Guilders)
[Well-Being:Climate:Temperature,decrease]	[Services:Air Systems: Cooling systems,add]	491,885
	[Services:Air Systems:Ventilation Systems,add]	4,875
	[Interior:Sun Shades:Exterior Shading,add]	34,103
	Interior:Sun Shades:Interior Shading,add]	7,094

Changing the temperature requirement by adding a cooling system is subjected to measurement to determine direct, indirect changes and the changeability index. Investigation of adding the cooling system to decrease the temperature did not occur at once. Four ares of the building were cooled in different events.

Requirement	Element	Change Event	Direct Change Effort Services (DFL)	Indirect Change Effort Interior (DFL)	Changea-bility Index
[Well-Being:Climate:Temperature,decrease]	[Services:Air Systems:Cooling systems,add]	1st	12,173	6,112	0.00006
		2nd	218,854	28,953	0.000004
		3rd	144,758	27,218	0.000006
		4th	6,976	54	0.00014

Direct change effort occurring in the services as well as indirect change efforts occurring in the interior are indicated. Changeability index of each event is also calculated. A stacked bar chart represents the changeability index for each event.

The changeability index has the objective to measure how much effort it took to change a requirement. Changeability index of each change event is displayed. Figure 7 shows the four events change to decrease the temperature occurred. In the first three events changeability was less than in the fourth case.

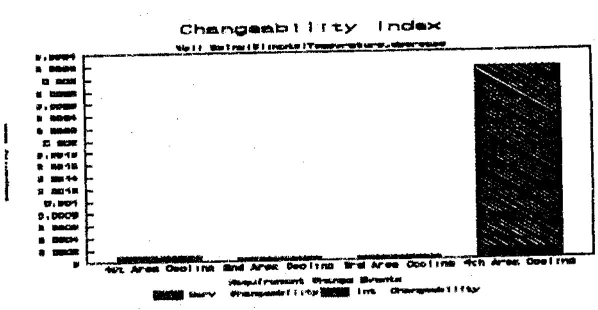

Figure 7: Well Being Changeability

Changeability measurement includes both direct and indirect efforts. Direct change effort are here the mechanical and electrical installation of the cooling systems. Indirect changes are changes made in the interior to install the cooling system. The changeability index has in the first three events a comparable value. In the last event changeability index is higher indicating that the effort done then was less than the three previous cases. Further research will have to understand the underlying reasons.

TOOL PROTOTYPE

A knowledge engineering tool reflects a general-knowledge engineering viewpoint, it involves a high level problem solving paradigm. Knowledge engineers are investigating diverse tool paradigms that vary along several dimensions: whether to use empirical associations or reason via first principles; whether to formulate knowledge in terms of formal logic or in terms of more informal heuristics; or whether to aggregate knowledge into large functional units or desegregate it so it fits a small, grain size format [3].

In practice various engineering and non-engineering specialisations are currently benefitting from knowledge acquisition tools. Chemists employ knowledge systems also known as expert systems to determine chemical structures for example, Congen system; in geology geologists use knowledge systems to provide a consultant system for mineral exploration, for example Prospector. In medicine knowledge systems provide advice on diagnosis and therapy for infection diseases, Mycin [10].

Building Knowledge Acquisition Tools

A review of current research related to building knowledge acquisition tools shows two major streams: The first research stream covers capturing visual knowledge: graphical knowledge acquisition methods [4] and image based design models [9]. The second stream attempts to describe global knowledge related to building design [7,8]. Both streams are significant, but they are not adequately representing the researched building change domain. Visual knowledge tools focus on building form generation and manipulation. Global knowledge tools focus on representing as many knowledge domains as possible which ,to my mind, limits their ability to address one domain specifically. So, both current trends are not able to address the researched change domain. The domain specific knowledge acquisition method was therefore examined. A hypertext system "Toolbook", is used as a tool prototyping system. It demonstrates how domain specific knowledge could be captured and used as a tool.

Tool Menu Layout

The tool menus cover the different aspects of the changeability research. First requirements change need to be structured, specified, and a change forecast strategy is chosen.

Elements are ordered in levels so their change operation is ordered. If a change of requirement is to occur, element change examination starts by the interior. If the change it is not in the interior the services are checked. Interior changes may then be regarded as indirect changes. If changes are not effecting, services or interior the envelope is checked. Measurement of each change effort is calculated showing direct and indirect changes. Figure 8 shows the menu layout.

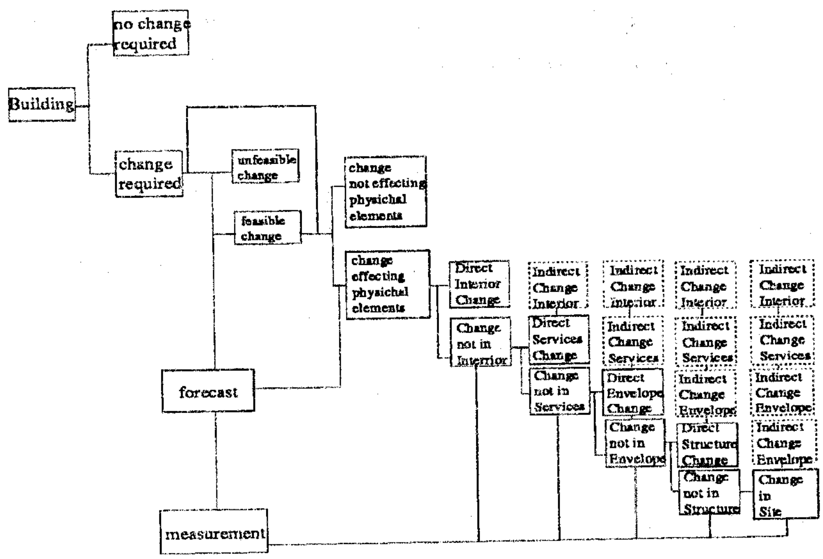

Figure 8: Menu Layout

Direct and Indirect changes are indicated for different change strategies. Change effort measurement of for each different strategy is examined. The changeability index is used to compare different strategies and determine the feasible change strategy.

Tool Operation

An example of how the tool operates is introduced. For example the change menu includes all the requirement groups. If one of them is to be changed, the well-being, for example, more information about the requirement item and cluster need to be specified. Change class describes the amount of change needed. Once this is decided, elements fulfilling this requirement change may be scanned.

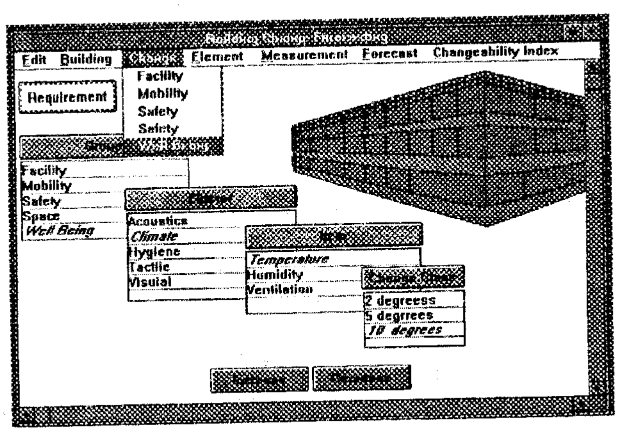

Figure 9: Change Menu

Tool implementation describes how the change knowledge is captured. The change knowledge is structured, linked to elements and measurement of different change strategies are checked. The tool has the objective to assist in increasing the effectiveness of the building changeability problem solving process. Tool implementation also has the advantage of testing and improving theoretical approach.

CONCLUSIONS

It is mostly agreed that building quality is a cornerstone of competing in the market. Quality is often a function of a design, which is in turn a function of dimensions, quantities, and in the final analysis, measurements. A buildings ability to change is regarded as one of many building qualities. Improving this quality explains measurement significance.

An increasing interest in the importance of initiating and improving measurement techniques is evident in the research annual spending in the most advanced countries. For example the United states measurements research and support budget has almost doubled over the last 15 years [11]. Unfortunately measurements is likely to be associated with the platinum-iridium meter bar, and the kilogram mass in Paris. In reality measurements is a sophisticated and dynamic endeavour and one that industries in general and building industry specially will increasingly depend on.

In this paper a building requirement and element knowledge acquisition method is introduced based on focusing one domain of knowledge, building change. A change measurement concept is introduced. The change concept introduces a dynamic measurement method. Unlike common measurement methods, the measurement is introducing a structure for what is to be measured in each case. A change statement indicates what is changing and needs to be measured in each case. Requirement and element change statements are fundamental to change measurement.

Measurement is used as tool to capture change knowledge. Utilizing empirical change knowledge to forecast change in newly designed buildings needs further examination. It is difficult to claim with the results achieved sofar that a building has an overall measurable changeability value. It is however possible to say more about a measurable changeability value of the building regarding the change of a requirement for example, the temperature requirement.

Research will now focus on improving the measurement unit to include parameters explaining different efforts, for example element weight, dimension or fixation. Change effort value should examine other effort units such as for example time. A forecast of the change strategy to be taken in a new design is to be examined, for example over-sizing the elements, or choosing decomposable ones.

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