PRODUCT IDENTIFICATION SYSTEMS FOR CONSTRUCTION AND FACILITY MANAGEMENT

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PRODUCT IDENTIFICATION SYSTEMS FOR CONSTRUCTION AND FACILITY MANAGEMENT

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ABSTRACT: This paper presents a state-of-the-art analysis of current systems for product identification utilized within the Swedish sector of construction and facility management. The study also discusses the concept of object and class identification in information systems development. The purpose of the study is to identify and define concepts in a common information structure that provides a framework for handling construction product information that utilize the advantages of information technology. The conclusion implies that a common system for product identification with characteristics of being international, non-sector specific, without property or class referencing attributes and with explicit criteria regarding changes of identifiers as a result of property alteration is one of the means for achieving this. Among the systems in current use EAN-13 is regarded as the most suitable since it is international, non-sector specific, in correspondence with a barcode standard for automatic data capture and has the widest propagation, however the EAN-13 system, like the other systems, lacks explicit norms that guarantee valid identification in a historical perspective especially required for product information management within facility management processes. EAN-13's main disadvantage in the construction context is its total focus on trade items, thus its deficient handling in standard product units, which is the common view for actors outside the sector of trading.

KEYWORDS: construction product identification, EAN, RSK, E-NR

INTRODUCTION AND SUMMARY

This study is a part of the industry doctorate research project 'Product information in computer-integrated construction and facility management processes, which aims at studying methods for handling product information and contribute to the development of computer based systems for product information management.

During recent years an increasing amount of research has been dedicated to define methods, integrate and utilize information technology in handling the vast amount of information used, created and transferred within the construction and facility management processes. In Sweden, the central focus has been on classification systems and product models as central means for establishing a framework for information handling. The efforts have up to the present been directed towards the classification needs for building specification e.g. of construction products such as building elements and results. The BSAB96 system does for example not yet include a classification table over construction products whereas such tables exist for both production results and building elements, which has improved effectiveness in the construction process.

This paper presents a study of the concept of a common construction product identification system with a focus on the establishment of principles within a computer integrated

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construction and facility management process.

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Numerous research has been conducted during the past 50 years in Sweden with the objective of defining information structures that constitute a framework for efficient product information management. These investigations have to various extent all stressed the importance of concepts like common classification, identification and attribute systems as central means for enabling efficient systems for handling product information (Swedish Building Centre 1999). It must therefore be considered a riddle that we today are in total absence of a common system for product classification, a system for product identification and a system for standardized attributes.

This study shows that separate actors within the building process so far have developed systems for product identification without support for the process as a whole. A common system for product identification is considered to be relatively easy to define and implement in comparison with common standards for product classification, attributes and product models since the latter ones are aspect dependent, which is an impeding factor in construction- and facility management due to its fragmented thus multi-aspectual nature.

A common system for product identification would in general facilitate handling of product information in computer integrated construction and facility management processes. Some of the more specified advantages would for example be to enable;

- Direct product information retrieval in case of a present identifier on a product, catalogue page or advertisement
- Exactness in production follow-up, i.e. when consumed production resources are registered.
- Dynamic invocation of distributed components (e.g. CORBA) representing the product via a link relation residing in a database connected to the Internet.

THE CONCEPT OF PRODUCT IDENTIFICATION

An identifier is an object that uniquely refers to either a particular object or a class. Identifiers can be divided into object identifiers and class identifiers. Identifiers can further be divided into natural and artificial identifiers. The social security number is an example of an artificial object identifier, whereas a retina pattern is an example of a natural object identifier. A class identifier denotes all objects with characteristics that entail membership in the particular class. For example, the term ‘wood beam’ designates the class of “wood beams” which comprises objects with the property ‘material=wood’, however other characteristics can differ among the class members. Terms in our natural language like ‘car’, ‘house’, ‘computer’ etc refer to objects with properties represented by the concept wherefore terms can be considered as class identifiers (Ekholm and Fridqvist 1998).

The distinction between object identifiers and class identifiers are crucial but not clear according to an analysis of some investigations regarding article numbering in the sector of construction and facility management. The most common misconception is comparable with placing social security numbers on equality with identifiers like ISBN-numbers for books. This is a misconception since a social security number constitutes an object identifier and the ISBN-number a class identifier although the ISBN-number refers to a very detailed class, so detailed that two books with the same ISBN-number is called as ‘the same book’ in everyday speech. The social security number should instead be compared to ‘serial numbers’, which is a prevalent term in everyday speech for identifiers that uniquely refers to one specific product

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(instance) in a given context.

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An identifier can also either be an object with a physical existence, physical identifiers, or it may be an object with conceptual existence, conceptual identifiers. For example, the social security number is an artificial conceptual identifier while fingerprints and retina patterns are examples of natural physical identifiers. Conceptual identifiers cannot be distinguished by means of a natural object analysis, which is the case with physical identifier as retina patterns. Physical identifiers are values of actual object properties.

DESIGN PRINCIPLES

Among methods applied in identification-systems are e.g. bar codes, OCR, sound recognition, vision systems and radio frequency systems. The most common method applied for identifying objects are bar codes in combination with the code in plain alphanumerical text physically attached on the product.

This section discusses different methods for designing identifiers based on alphanumerical characters. In the following we shall distinguish (i) classifying identifiers, which consist of elements referring to the objects actual properties, and (ii) non-classifying identifiers, which are composed of elements without reference to the object's actual properties. Identifiers composed by both classifying and non-classifying elements are here named (iii) mixed identifiers.

Classifying identifiers can be of different types: (i) Independent group codes are composed of several grouped sub codes, which each is independent of preceding or subsequent sub codes. (ii) Dependent group codes where each sub code's name is dependent on the preceding sub code. The Dewey Decimal System of Classification is an example of a system with the latter characteristics (Engdahl et al 1999).

Systems without connection between the identifying code and the corresponding object's properties have the advantage of taking full use of the code length and of being insensitive to change in aspects which is a common obstacle in managing a classification system. Since it is impossible to determine a single property from the identifying code one must use other methods for information retrieval, for example systems with possibilities for information retrieval through identifiers. Even if a code is loaded with information it is not certain that this is the information in demand or that the user has got the knowledge or equipment of interpreting the codes.

The number of characters subsumed within the code, i.e. the code length, and whether numbers and/or letters are used, further characterize the design of an identification system. The more separate information units an identifier must reference the longer the code will get, which sets practical limits for the information content within an identifier. The utilization of the code length diminishes if the classes comprise few objects within the context of the system. It can also be difficult to handle new objects that cannot be classified within the current system. This is an issue from the static nature of classification systems and the dynamic change of the characteristics and number of objects handled by the identification system.

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IDENTIFICATION AND SYSTEMS DEVELOPMENT

Object-oriented programming

The use of identification in object-oriented programming is described in the following section with examples from Smalltalk, an object oriented programming language.

In object oriented programming languages every object receives a unique internal identifier, which is fully independent of the objects attributes and their values. This means that objects with exactly the same property sets can exist in conjunction in an object oriented system. Thus, in object-oriented modeling it is not, as for relational databases, necessary to specify any identifying attributes, so called external identifiers. The use of external identifiers is therefore limited to situations where identifying attributes are pertinent for the real world being modeled.

The unique object reference is returned in connection with the creation of the object. Objects created in an object-oriented programming language are transient, meaning that they exist only during program execution. The unique reference is used in all communication with the object during program execution and thus an absolute condition. Internal identifiers can be stored as values of external identifiers, which are used within object-oriented programs as references to objects. Several external identifiers can reference the same object but an external identifier can only reference a single object. There is thus a 'one to many' relationship between objects and external identifiers.

Many conventional object-oriented systems implement associations between objects by means of external identifiers i.e. identifying attributes instead of internal object identifiers. The use of external identifiers implicates according to Naraghi et al. (1999) that the systems comes hard to both implement and maintain, that the risk for data inconsistency increases and also a decreasing systems performance. External identifiers should therefore not be used for implementing association between objects except for situations where the use of these identifiers is unavoidable.

The decrease of system performance when using external identifiers for implementing associations is caused by the need for an initial search for the internal identifier though a separate register. There is also a risk for inconsistency with the use of external identifiers when changes are made to the state of the conceptual schema. The risk is expressed by the possibilities of associations withholding identifiers referencing non-existent objects. Changes to an external identifier must be made to every occurrence of the identifier to withhold consistency. Methods for search for associated objects with certain properties get more complex due to the need for methods that return objects through the external identifier.

The UML (Unified Modeling Language) has no special notation for identifying attributes, however UML has a notation for restrictions that are placed within brackets { } adjacent to the element implicated by the restriction. The restriction {id} is used in the example above to denote identifying attributes.

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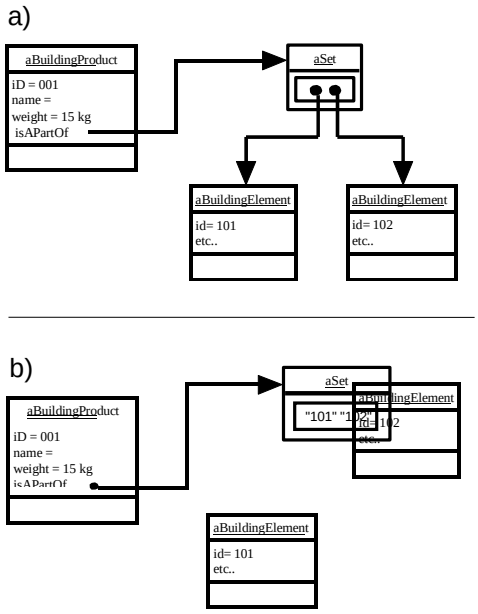
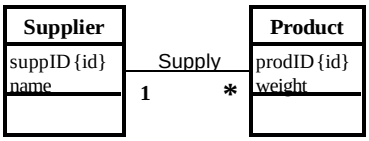


Figure 1: Two different models for implementing associations in object-oriented modeling (Naraghi, B., et.al., 1999). Model a) shows an implementation using internal identifiers, which is preferable in most situations, and at the bottom b) an implementation with external identifiers i.e. identifying attributes.



Methods for the Supplier Class implementing the association 'Supply' with **internal** identifiers;	Methods for the Supplier Class implementing the association 'Supply' with **external** identifier;
Methods for private-acquisition: (handeling instance variables for association)	Methods for private-acquisition (handeling instance variables for association)
supply ^supply.	supply ^supply.
supply: aContainerObject supply := aContainerObject.	supply: aContainerObject supply := aContainerObject.
Methods for initialization:	Methods for initialization:
initiate self supply: Set new.	initiate self supply: Set new.
Methods for associations:	Methods for associations:
supplyProduct: aProduct self supply add: aProduct.	supplyProduct: aProductID self supply add: aProductID
supplyProducts ^self supply.	supplyProducts ^self supply.
Methods for abstraction:	**Methods for abstraction**
supplyProductsWithWeights **^(self supplyProducts collect:[product | product weight]).**	**supplyProductsWithWeights: aProdReg** **^(self supplyProducts collect:[:prodID | (aProdReg find: prodID) weight]).**

Figure 2: Different approaches are needed when implementing associations whether external identifiers or internal identifiers are used in object-oriented programming. The example above illustrates the difference between the two approaches when writing methods for abstracting objects (products) in an association (the last method). The approach with external identifiers requires a register object that is passed as a parameter and a method (find) that returns objects with the appropriate identifiers (prodID), thus a more complex implementation.

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(Smalltalk and UML).

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Relational databases

A relational database is a model built with the relational data model and represents a particular aspect on the real world. This aspect of the real world is in the case of database systems development often expressed with the Entity-Relationship model. A database is thus a model of a model representing an aspect of the real world making it pointless to argue weather the database is a correct representation of the real world or not. The relational data model consists of a collection of concepts that refer to a particular universe of discourse. It is regarded as an implementation data model placed between the conceptual data models which provides concepts close to users perception of data and the physical data models which provides concepts that can be used to describe the details for how data is physically stored within a computer (Elmasri and Navathe 2000). The relational data model is widely used by commercial database management systems and this section discusses the concept of identification within this data model.

Informally the relational data model stores data in tables with rows and column headers. In the formal relational model terminology originating from relational mathematics, tables are called relations, rows are called tuples, and column headers are called attributes. Tuples consists of attribute values representing the actual properties of a real world object or relationships within the aspect being modeled.

Information about complex real-world objects in a relational database must often be scattered over many different relations, which in combination with the fact that object identifiers may be represented by different names in different relations makes it difficult to comprehend a direct correspondence between the real-world object and its database representation.

Relations must meet certain restrictions and this is where the importance of the concept identification within the relational data model is revealed. The relational data model states that two tuples in a relation may not be identical i.e. one or more attribute-value pairs must be able to uniquely identify a tuple, which at the extreme only is achieved by the set of all attributes in each tuple. An attribute or a group of attributes with the characteristic to functionally determine the entire tuple called a key. Relations that hold data about physical object properties often need an additional attribute consisting of a serial number performing the function of a key since it cannot be excluded that any combination of the real properties is non-unique. In building product databases different forms of article numbers often serve as keys in relations comprising building product data.

Object oriented databases have, in contrast with relational databases, the advantage of being able to comprise all the information about a complex object in a single encapsulated structure. The object is referenced by a unique system-generated object identifier (OID), which enables direct correspondence between a real-world object and its database representation. An important feature of the OID is that it is absolute i.e. its value is unchangeable which enables reference preservation with real-world objects during the database object's total lifetime.

Database applications handling unique article numbers in its information retrieval interfaces provide the means for direct product information retrieval of known products since the article number is the product's unambiguous reference. Despite the advantages of direct information retrieval in many situations this search method is not commonly available in building product database applications.

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EXISTING PRODUCT IDENTIFICATION SYSTEMS

The following section describes current product identification systems utilized in the communication of product data between different actors within the Swedish construction sector.

RSK numbering system

RSK is an acronym for 'Rörbranschens Standard-Katalog', the heating, ventilation and sanitation sectors standard catalogue, published jointly through VVS-Information Data AB, a company owned by the three major trade associations within the sector of heating, ventilation and sanitation (HVS) in Sweden. The catalogue comprises all products within the sector and has also been implemented as a database reachable trough the internet. The RSK numbering system was developed in the late 1960's with the aim of making information handling of HVS-products more efficient. The HVS sector was the first sector within the Swedish building industry that realized the need for a common standardized identification system to enhance effectiveness regarding information management both in manual and automatic data processing systems.

The RSK numbering system comprises heating and sanitary products. Ventilation products are currently not covered by the system. The system is used in internal information systems by HSV-designers, installation engineers and suppliers and in the communication amongst these actors. The RSK code is composed of both classifying and non-classifying segments and therefore named here as a 'mixed-identifier'.

The identifying objects are composed of a 7-digit numeric code that uniquely identifies low-level classes, i.e. the codes are 'class identifiers'. RSK numbers are composed of three sections, se figure 3. The first section expresses the product's class defined by the RSK system. An early ambition was to use the VVS-AMA 1972 products classification system. The following non-class dependent sections limited to 4 digits made it impossible to retain this strategy as new products requiring new RSK-identifiers were introduced at a rapid pace.

aaa bb cc

aaa:	[001-999]	class dependent
bb:	[00-99]	serial number
cc:	[00-99]	serial number

example:

789 95 03 Wash-stand Gustavsberg 640 white

Figure 3: RSK Code construction.

E-number bank

The E-number bank constitutes a common system for article numbering within the Swedish electrical trade business, a sector of growing significance for the construction industry due to the increase of installations in every modern building.

The Swedish Electrical Wholesalers Federation SEG, who administrates and owns the copyright to the system, developed it during the 1960's with the aim of making it possible for customers to retrieve information about the same article with one unique E-number in the whole distribution chain from the manufacturer, through the wholesaler to the electrician. Its

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members represent approximately 90 % of the sector's turnover.

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The systems domain embraces essentially all electrical materials handled by the electrical wholesalers. It does not only comprise products for installation but also machinery commonly used by the electrician during the work of installing electrical components in buildings. At present some 169 000 articles from approximately 800 suppliers of electrical components are registered within the system.

The E-number is set after an analysis of product characteristics yielding to a class within the integrated classification system, which in turn determines the code structure, se figure 4.

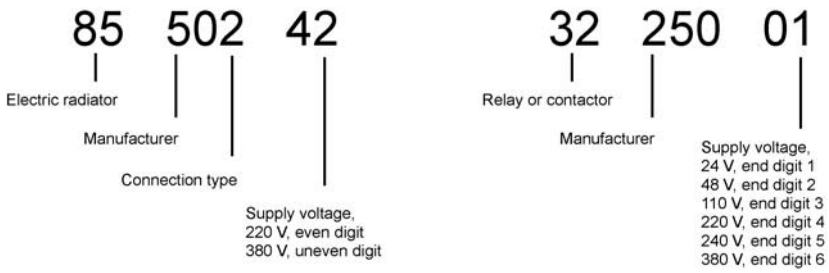

Figure 4: An example of two identifying E-numbers with different structure depending on the difference between the products classification within the E-numberbank. Elements of non-property dependent code segments are insignificant.

E-numbers principally consist of segments dependent on the product's actual properties entailing E-numbers to be categorized as 'classifying identifiers'. Products are divided at three levels; in main categories, functional lists and in sub groups. The super class 'main categories' is divided in sub classes according to the order of installation commonly applied during construction, whereas the second level is divided due to functional difference.

Products excluded from a suppliers range of products has their E-number locked for a long period of time before a new product receives the previously used identifier. This locking is important since every system utilizing E-numbers must be able to manage the update to maintain consistency, however the possibility for new products to receive a formerly used identification must be considered a weak point since it removes a prerequisite for efficient information retrieval in a historical perspective common in facilities management.

EAN

The European Article Numbering System, EAN, was introduced in the late 1970's as a global, branch neutral, system for article identification within the retail business, enhancing retail checkouts, inventory management and general article information management. Administration is carried out by national EAN organizations coordinated by EAN international residing in Brussels. Over 800.000 companies in the world are using the system making it the most propagated system for automatic identification.

EAN comprises article-numbering systems for several different fields of application for both consumer goods and retail packages in compliance with barcode standards (EAN13, EAN8, ITF14 and EAN128). The description which follows concerns EAN13, the most common standard for identifying trade items passing trough retail checkouts and which generally spoken is utilized by every manufacturer addressing the market of private consumers. A trade item is defined by EAN as any item (product or service) for which there is a need to retrieve

pre-defined information and that may be priced, ordered or invoiced for trade between participants at any point in a supply chain.

Recently, partly as a result of the advancement in internet and mobile technology, this standard has enabled new services concerning product information retrieval adopted by leading manufacturers and suppliers of consumer goods. An example of such a service is 'connectthings.com' described subsequently.

The adherent standard for encoding EAN13 numbers to barcodes utilizes efficient decoding by means of information technology. Barcodes, the prevalent technology for coding data within this context, is just one of several methods available but has, due to wide propagation and heavy standardization, become applicable and economically feasible in most situations where integration of information technology is pertinent.

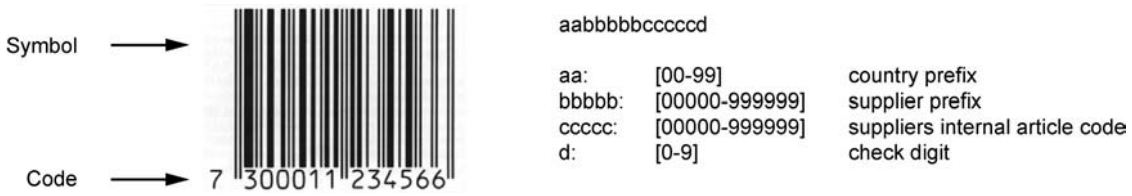

Figure 5: EAN-13 code construction. A complete EAN-13 mark consists of the code in clear adjacent to its barcode representation.

Suppliers are entitled to employ the EAN system only after requiring a certificate with specification of applicable system and supplier code. Requirements and system rules, which the companies must act in accordance with to obtain and retain the certificate, are specified in an EAN-handbook. With emphasis on the system's main objective to manage retail checkouts, follows an imperative condition stating that articles with different price must not have the same identification. However, the system allows for articles with identical price but with different properties, of for example color, to make use of the same article number, but there is no unambiguous way of how this is handled among suppliers. EAN-13 numbers begin with a country prefix, which only indicates where the company's certificate is issued. Multinational companies can hence make use of the country prefix at different locations around the world leading to an inability to determine the country of origin by means of the country prefix.

Construction products are characterized by a mixture of "off the shelf" components ready for their function in the finished building, and components such as standard plasterboards. Construction products produced to supply a special or an individual demand have generally been elaborated at a grater extent entailing a high degree of added value compared to latter products.

Articles sold within the retail business, vary regarding parameters like weight, length or volume. The Swedish EAN organization has partly solved the issues regarding variable measure articles within the framework of EAN-13 by means of a specific initial prefix indicating variable measure trade items followed by company prefix, internal item reference, weight/price-tag and lastly a check digit. The initial prefix determines the means of decoding the weight/price-tag.

This solution is not applicable in an international context due to the limitations in the code capacity. An international solution responding to these matters can be found in the UCC/EAN-128 standard, which in addition to pure identification also provides a standard for coding specific sets of attribute value pairs.

Comparison of RSK, E-nr and EAN-13

A comparison of system characteristics is summarized in the table below.

	RSK	**E-nr**	**EAN-13**
Year of origin	1968	1964	1977
System owner	VVS-Information Data AB	Swedish Electrical Wholesalers Federation (SEG)	EAN International
Domain	HVAC-products apart from ventilation products	Electrical components (trade items) installed by electricians and associated tools	Trade items, no limitation regarding sectorial or national origination.
Referent types	Classes	Classes	Classes
Propagation	National (Swede	National (Sweden)	International
Sectorial affiliation	Construction (HVAC sector)	Construction (Electrical sector)	Multi-sectorial
Main users	Manufacturers, wholesalers, consultants and installation engineers in the HVAC sector.	Manufacturers, wholesalers, consultants and installation engineers in the electrical sector.	Manufacturers, wholesalers and suppliers of consumer goods.
Code settlement [centralized, localized]	Centralized (VVS-Information Data AB)	Centralized (Swedish Electrical Wholesalers Federation)	Localized. Certified manufacturers and/or suppliers set the code.
Adjacent system for classification of products within the domain.	Yes, RSK-nummerbanken	Yes, E-nummerbanken	No
A standardized product manufactured by different companies can occupy the same identifier	Yes	Yes, however a new policy has been taken into place, which implies that new standard products receive different E-nr if they originate from different manufacturers.	No
New products can receive identifiers from abolished products.	Yes	Yes, a discarded products id can be succeeded to a new product after approx 6 moths	Yes
Changes of 'relevant' product properties must result in a new identifier	Yes	Yes	Yes
Code with elements referencing product properties.	No	Yes	No
Compliant with barcode standard for AID	No	No	Yes
Identifiers are derived from the adjacent system for classification	No	Yes	No
Handling of products having a no pre-defined attribute such as weight, length etc i.e. variable measure items.	Identifiers are referencing 'standard units' e.g. 1 meter, 1 kg etc of variable measure products.	Identifiers are referencing 'standard units' e.g. 1 meter, 1 kg etc of the product or/and a specific unit depending on the last digit.	The variable attribute is coded and inserted as an element in the identifying code. (Swedish solution only applicable nationally)

Table 1: Key characteristics of systems for identification applicable in the Swedish construction sector.

Information retrieval services utilizing identifiers

Connect Things Sverige AB, an Ericsson spin-off company, officially launched a new product information retrieval service 'connecttings.com' in October 1999, based on the EAN-13 system for trade item identification. Leading manufacturers of consumer products, e.g. AstraZeneca, Sony, and Electrolux, are committed to using the service providing them with

linkages between EAN-13 barcodes and company controlled product information on the

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Internet. Users are via Connect Things directly linked to an internet address containing product information by running a barcode reader connected to a computer with internet access over a products EAN-13 barcode. The identifier can also be entered manually in a form at www.connectthings.com.

The cognitive load when performing information retrieval tasks is usually high. Finding the right query formulation that will deliver a query result with high result precision is cognitively difficult (Ahlberg and Wistrand 1995). Information retrieval interfaces utilizing the possibilities of direct access by means of identifiers reduces the cognitive load to a minimum. Prerequisites for utilization of this method comprise a physical contact with an identifier either attached directly on the product or on any other object representing it such as brochures, models, pictures, magazine adds etc. Interfaces for construction product information retrieval offering this type of search method are still uncommon even if situations where this would mean least possible cognitive load are common in the construction process. Scenarios where the above prerequisites are met in the construction and facilities management processes are for instance during:

1. Production follow-up, i.e. when consumed production resources are registered. Securing feedback for future cost estimates is dependent on the quality of production follow-ups during construction. The production calculus is divided into activities comprising specification of quantities regarding man-hour, machine-hour, and materials. The part regarding materials could be improved by utilizing automatic identification of components consumed in each activity. A common method today is to capture activity costs by way of splitting invoices received from suppliers, which involves higher risk for errors.

2. Design, which after the early stages to a great extent is characterized by finding components on the market that applies to certain requirements. These findings could take place while studying product catalogues, advertisements, samples or reference objects leading to a demand for more specific information like cad-files representing the product and its properties.

3. Facilities management, when existing components are to be replaced. Via an internet connected pocket PC equipped with barcode scanner information about existing components could be retrieved directly without any knowledge about brand name, classification etc. The ordering of replacement parts and information retrieval for the facility manager in general purchasing processes would be significantly enhanced. However this requires that barcodes or identifiers are visible somewhere on the product also after the component is built into the facility. Most components built into a facility must be able to retain an attached identifier also after installation. An optimal position of the identifier would be a part of the product that is easily accessible but hidden during normal conditions. Products such as paint, filler and insulation materials can arduously retain identifiers physically attached after installation. The possibilities of saving identifiers after the construction is finished increases with pre manufactured components.

A fundamental prerequisite for this type of service emphasizing the importance of information structures is the one to one relationship between an identifier and a particular trade item provided by a standardized structure for automatic identification and data capture (AIDC)

such as EAN-13.

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CONCLUSION

Current systems for product identification have thus far been developed and utilized relatively isolated by separate actors in the construction process, i.e. RSK within the HVAC sector and E-nr within the electrical industry. Construction manufacturers and retailers increasingly use EAN, which gradually encroaches industry-specific systems like RSK and E-nr. Complete consensus prevails within HVAC and the electrical sector that their respective systems have entailed considerable economic benefits even if no compilation leading to concrete economic figures ever has been conducted (Engdahl et al 1999). Despite the lack of concrete figures it must be considered that a common system, which comprehends all building products, would entail similar benefits.

There is also total consensus within the retail industry that the implementation of an international non industry specific system for identification of trade items, i.e. EAN, has meant enormous cost savings due to significant improvements in logistics operations, information retrieval, reduction of manual data capturing, and enhanced information management of the whole supply chain.

Systems for product identification have also been a key prerequisite for product data management systems implemented by other industry sectors such as manufacturers of airplanes and cars i.e. Boeing, Ford and GM (Werner 1997). The use of identifiers by contractors and designers in the construction process are almost negligible partly as a consequence of the relatively low integration of IT in their respective processes. It is quite clear that a mutual dependence prevails between development and utilization of common standards for structuring information and the possibilities of utilizing information technology as an integrated resource for information management (Elmasri and Navathe 2000).

Among the systems in current use, EAN-13 is regarded as the most suitable since it is international, non-sector specific, in compliance with a barcode standard for automatic data capture and has widest propagation. However, the EAN-13 system, as with the other systems, lacks explicit norms that guarantee valid identification in a historical perspective especially required for product information management within facility management processes. The main disadvantage of EAN-13 in the construction context is its total focus on trade items, thus its deficient handling of standard product units, which is the common view for actors outside the sector of trading.

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