Enabling Relationship Management: Agent Technology for Facility Management Integration

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ABSTRACT: Integration is a common effort in every industry. On the operational level, establishing effective communication and collaboration between business actors is a vital contemporary need for "Total Quality". Business patterns in construction industry depend on "Projects". Despite the efforts of sharing knowledge in order to establish and discern excellence in construction, every project is naturally a closed system hiding great amount of "Information" from the participants of "other" projects. A reasonable amount of this hidden information may be "discovered" from post-construction phases of a project's lifetime. Providing a strong relationship mechanism between different project actors is possible through facility management integration. This paper presents basic concepts of a "Customer service call tracking system for facility management" which by design puts the customer at the center of post-construction processes and enables various actors of construction industry to serve in collaboration within a platform providing effective communication and collaboration. The framework proposed within this research consists of various process models which are designed to resolve Business to Business (B2B), Business to Enterprise (B2E) and Business to Customer (B2C) relationship types. The Meta system in which the common standards and protocols of communication defined is implemented as a web based project model and agent technology is used to provide a loosely coupled integration mechanism. The core of the model is named as CC-Agent (Customer to Construction Agent) and is implemented as a series of web services.

1 INTRODUCTION

This paper presents a framework for collecting design data from use processes of a building, by use of agent technology and discusses the logic and technology of a project model developed within a PhD research. Taking into account that design quality is where the construction excellence begins, a continuous data stream between design processes and use processes of projects' lifetime is considered beneficial. The function of agent technology within that framework is to initiate and trace the relationship between different parties of the AEC/FM cluster.

1.1 *Problem Description*

Construction project teams typically consist of numerous participants; "End users", "Owners", "Architects/Engineers and specialized Designers", "Design - builders", "Contractors and sub-contractors", "Construction managers", "Product representatives, suppliers and manufacturers", "Financial institutions", "Regulatory authorities", "Attorneys", and "Facility managers" (CSI 2004, OGC 2003).Various information and communication technologies (ICT) are available within the design and construction phase of a project including knowledge management tools and design data management systems to facilitate knowledge acquisition between those actors but the main problem resides in the building use phase of the process. Despite the common awareness that the information collected from building use processes is very important and valuable in order to keep track and increase the quality of architectural and engineering design and the design management process, very little effort is observed in the industry to efficiently achieve learning and facilitate information collection from use processes.

In practice, several factors make it virtually impossible that all the participants know and remember all the relevant requirements and especially their relationships to each other and to design solutions (Kiviniemi & Ficher, 2004). Main problems of design management are poor communication, lack of adequate documentation, deficient or missing input information, unbalanced

resource allocation, lack of co-ordination between disciplines, and erratic decision making. Also, the design process usually lacks effective planning and control, to minimize the effects of complexity and uncertainty, to ensure that the information available to complete design tasks is sufficient, and to reduce inconsistencies within construction documents (Tzortzopoulos & Formoso, 1999).

Although the problems listed herein are related with design process and design data management; organized, analyzable and continuous end user feedback provides a means to develop standards among industrialization. As the number of standards and level of industrialization increases problems concerning design data management decreases. But there is very little effort in the field to bride the gap between design and use processes (Ercoskun & Kanoglu 2003a)

2 BACKGROUND

The competitive atmosphere of the Architecture, Construction and Engineering (AEC) Industry has a high cost, low profit nature and no actor taken part within a project would "care" about the "little problems" of the operation and maintenance phase of buildings though, many of the subcontractors, suppliers and manufacturers also provide support for Facility Management (FM) in which the economical and financial patterns of business environment dramatically changes and shows a low cost, high profit character.

Above determination gave an idea of using FM firms as agents whom would facilitate Post Occupancy Evaluation (POE) of buildings to designate dynamic progresses and enable a continuous and interactive data flow between use processes of buildings to a central data repository with the help of ICT. Thus it will be possible to reproduce strategic intelligence for design processes and design data management. However to design such a model, a multi-layer problem system has to be solved.

The agent technology developed will serve as a resource locator for every actor of the system and control the relationship between them. Every project within itself is a closed system in terms of knowledge management. While "On progress" information (information which is created, captured and used during construction phase) is essential in order to improve overall construction performance; "on use" information is also very important to have an idea about the performance of the final product, in terms of design, materials, cost and workmanship.

3 RELATED WORK

Related work of this research is listed under three topics, "The Building Design Process", "Relationship Management", and "Integration".

3.1 *The Building Design Process*

It is generally accepted that the quality of a product is largely determined in the early phases of design (Redelinghuys 2000). Building Design Process involves thousands of decisions, with numerous interdependencies, under a highly uncertain environment. As distinct from production, quality in the design process has to be achieved by a careful identification of customer needs and subsequent translation of those needs into specifications. (Tzortzopoulos & Formoso, 1999).

Ballard & Koskela (1998) point out the need for integrating the three views of design (conversion, flow and value generation) and suggest a number of practical guidelines for such integration. "Encouraging direct interaction between designers and customers" is a significant guideline designated in their research.

Quality of information, which the design based on, is extremely important. Baldwin works on the problem and suggests an information flow model for the early stages of design (Baldwin et al. 1999). Mokhtar works on managing design changes (Mokhtar et al. 1998).

Houvela and Seren defined customer oriented design methods for construction projects (Houvela & Seren, 1995). Kiviniemi defines a vision and states that design and construction will be closely connected to the core business of end users and must provide not only the physical spaces for activities, but also essential information for the use and maintenance of the buildings as well as services based on the information. (Kiviniemi et al. 1999).

3.2 *Relationship Management*

Relationship management is a Knowledge Management (KM) activity. Although not definitely defined, every integration effort in the AEC/FM cluster is a matter of Relationship Management (RM). Figure 1 shows the expected value by integration within various applications of RM. Fahey et. al. (2001) defines every aspect of KM, demonstrating B2B, B2E and B2C relationship types within a framework to indicate the rudiments of an action agenda that e-business driven change in business or operating processes can be handled to deploy a KM-based approach for transforming businesses.

Product knowledge, persuasion and problem solving are the basic tools of traditional sales process. Planning – customer goal discovery,

communication and measures useful for assessing relationship milestones – is the primary tool for key account management. Thus Downey states that deepening relationships is essential in order to have a better position to understand how customers define value – what their goals are, how they prioritize them and what needs arise as a result (Downey, 2005).

3.3 *Integration*

Majahalme details an integration model by modelling significant activities and data flows due to facility management (Majahalme, 1994). Froese (1999) presents the requirements and a methodology for developing, implementing, and possibly standardizing, a set of message-based protocols for exchanging AEC information, thus supporting AEC/FM Systems Interoperability via Industry Foundation Classes (IFC)-Based Messaging Protocols. Halfawy and Froese (2002) gave examples of designing data models by implementing IFC. Turk states that the construction process information can be observed from two perspectives: as (1) information creation or publishing and (2) information use. The two need to be glued together by (3) an integration process (Turk, 1996).

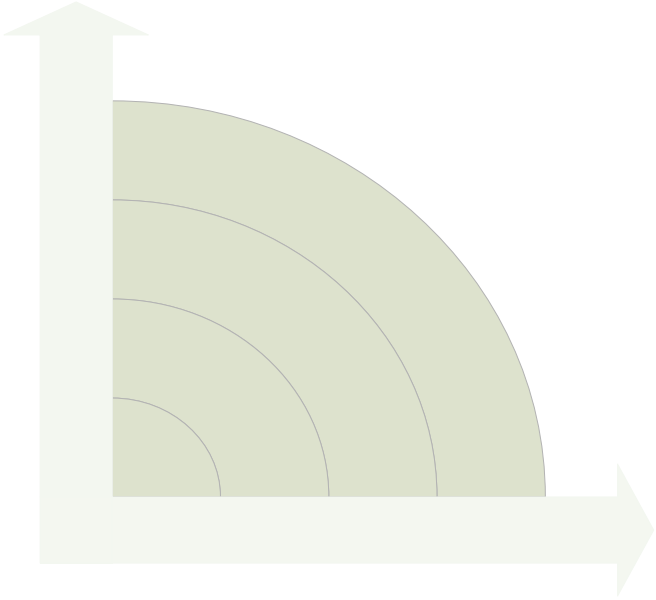

Figure 1. Expected value through FM integration (An IT perspective - Based on an illustration by Gunzer 2002)

4 AGENT TECHNOLOGY FOR FM INTEGRATION

The main objective of this research project is to define a meta-model for integrating Facility Management processes within a framework which is dependent on the service call requests from building users in order to track the final quality and performance of the "finished" building and its parts. The proposed management information system will be consisting of following components:

- Performance measurement and quality assessment system for maintenance and services
- Relationship model(s) between different actors of the system
- Communication and collaboration protocols, between the actors of the system
- Security and privacy rules
- The database and coding structures (object model) of the system

4.1 *Technology, Development Platform and Methodology*

The new technologies give opportunities for integration in document and method-based models. As a result, the web and any integration protocols will change how data lives its life (Froese 2004).

The integration architectures we have today are very limited. IT Integration can be synchronous. If it is synchronous, it probably means that a proprietary direct object call is used. This option is tightly coupled and scalable.

It is possible to deploy an asynchronous integration option, which can be done with a message-based loosely coupled system such as a queuing application. The integration model using Simple Object Access Protocol (SOAP) can be synchronous or asynchronous, but because of its message-based architecture, it enables loosely coupled integration in all cases. Therefore, SOAP gives a solution to integrate heterogeneous objects, and objects in different physical boxes in a loosely coupled manner both in synchronous or asynchronous models. The core of the project model - "CC-Agent" is dependent on web services, and provides a loosely coupled integration mechanism.

Using asynchronous message-based architectures eliminates the need for systems to be tightly linked to each other. Loosely coupled architectures have the advantage that messages are passed, instead of method invocations. These messages provide a degree of independence between the sending system and the receiving system. The table in Table 1, The Integration Matrix shows a matrix of coupling versus invocation (Travis & Ozkan 2002).

Organizations have been successfully using methods to send messages to trading partners without knowing anything about their business implementations for years using paper documents. By deploying SOAP over HTTP, an organization can make DCOM or CORBA calls over the Internet in the same way, without knowing about the implementation details of the target organization. These technologies can also be used for business document exchange.

Table 1: The Integration Matrix (Travis & Ozkan 2002)

	Tightly Coupled	Loosely Coupled
Method Based	• RMI/RPC • COM/DCOM • CORBA	• SOAP for RPC (Message is the Method)
Message Based	• IVAM • Proprietary	• SOAP for Messaging • Querying Systems

In real systems, there is a combination of message-based / method-based, synchronous / asynchronous, loosely coupled / tightly coupled interactions. In fact, these concepts are usually tied together to create reliable or efficient systems. The COM+ SOAP service in the .NET Framework platform allows taking an existing component and publishing it as an XML Web service (MSDN Library, 2005). Clients can continue to access the component using previous methods.

It is important to clearly distinguish Web Services and how they are related to traditional middleware. The definition given by WebServices.org states: "Web Services are encapsulated, loosely coupled contracted functions offered via standard protocols" where:

– "Encapsulated" means the implementation of the function is never seen from the outside.
– "Loosely coupled" means changing the implementation of one function does not require change of the invoking function.
– "Contracted" means there are publicly available descriptions of the function's behaviour, how to bind to the function as well as its input and output parameters.

Roughly speaking, Web Services are applications that can be published, located, and invoked across the Internet (Erl, 2004). Typical examples include

– Getting stock price information.
– Obtaining a complaint from user.
– Making an appointment (service call).

Middleware is a class of applications that provide a common method for moving data between systems and invoking applications or procedures from external systems. Early middleware systems, such as remote procedure calls (RPCs) and remote database access, offers developers a common transport mechanism for moving data and invoking services. Business processes are dependent upon multiple independent systems, each with their own purpose and lifecycles. When business processes change, multiple systems will have to change and each of those changes potentially creates ripple effects. To effectively manage a series of changes, organizations require Enterprise Change Management systems that capture asset configuration, dependencies, and attributes and provide real-time access to administrators and managers across an enterprise. The CC-Agent process model includes mechanisms to facilitate change management procedures.

The web services in CC-Agent are XML web services. Web portal is based on .NET technology. FM objects and building elements are modelled in accordance to IFC standard and Unified Modelling Language (UML) is used as the primary modelling language. Process models are prepared as IDEF0 activity diagrams. In this paper we elaborate on the logical layout of the model so only the general layout and the basic processes are included. SQL Server is used for database development.

4.2 *The logical model layout*

The proposed system consists of three main modules: "USER" – **U**ser **S**ervice **E**ntrenched **R**epository, "ITEM" – **I**ssue **T**racker for servic**E** **M**anagement and "SHAPED" – **S**ystem for **H**abitual **A**rchitectural **P**ractice and **E**ngineering **D**esign. CC-Agent (**C**onstruction **C**lient Agent) is the integration platform of these modules based on agent technology in which various data mining techniques are used in conjunction. By terms of implementation the solution will be consist of a "Call Center and a "Shared" Internet Portal. A more general layout of the proposed project model was presented in a previous work (Ercoskun&Kanoglu 2003b).

Table 2: Commercial Modules of CC-Agent RM Application

Marketing Modules • Campaign Automation • External List Management • Marketing Optimization and Refinement • Marketing Calendar • Supply Chain Integration • Enhanced Segmentation and Planning	**Sales Modules** • Enhanced Opportunity, Order, Contract, and Activity Management • Improved Contact and Account Management • Territory Management • Leasing
Service Modules • Professional Services • In-House Repair • Case Management • Service Parts Order Fulfilment • Product Service Letter Management • Planned Services • Enhanced Service Order, Complaint, and Contract Management, and Solution Search	**Analytics Modules** • Enhanced business content for, Customer, Marketing, Sales, Service and Channel Analytics • Real-Time Analytics

CC-Agent is still under development. It has been proposed as a research project to the Ministry of Industry and Trade of Turkey in collaboration with Siemens Business Accelerator (SBA) and Istanbul Technical University Project Management Centre

(ITU-PYM) and when finished it will also include essential RM modules (Marketing, Sales, Service and Analysis) as shown in Table 2 (Gunzer 2002):

There are various change mechanisms hidden in CC-Agent and these mechanisms are established in order to enable continuous evolution in terms of business culture and industrialization. By providing professional solutions to issues collected from customers "State of the art" design solutions may be identified, collected and be shared. This leads to continuous quality improvement in terms of competence, standardization and industrialization. Figure 2 shows the general logical layout of CC-Agent.

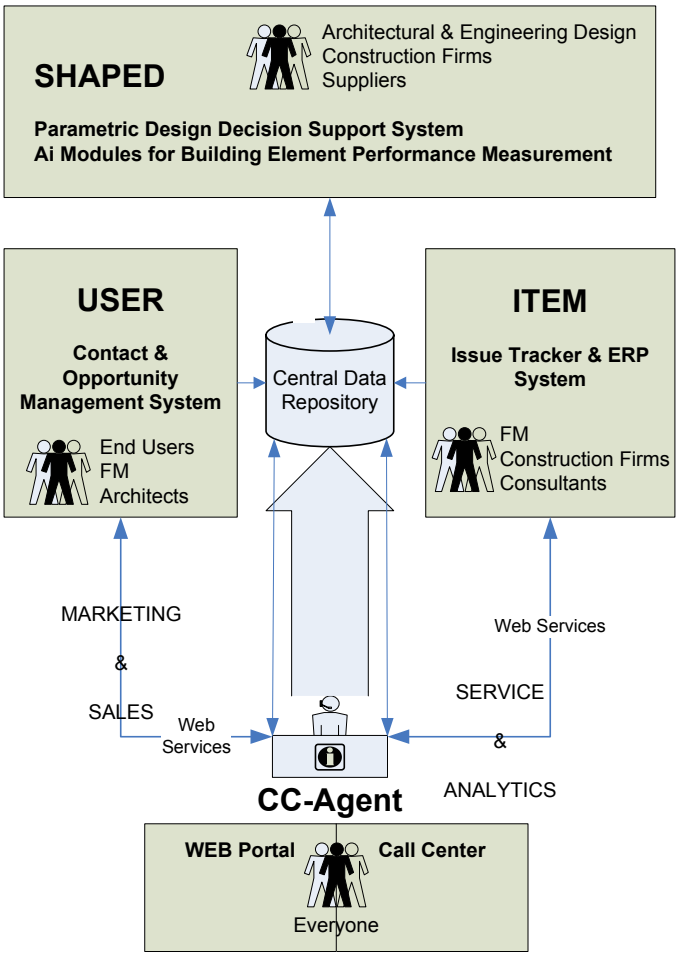

Figure 2: The Logical Layout of CC-Agent

4.3 *System for Habitual Architectural Practice and Engineering Design (SHAPED)*

SHAPED is a parametric product design decision support system. It is possible to track the performance of building materials bound to suppliers. Using this information it is also possible to design a building element and compute and guess the approximate performance of the parametric design. SHAPED is in its early stages of development but the logic behind is simple: In terms of building element design if the performance of materials is high it is expected that the performance of the designed building element will be high also. If the performance of the building element is high, it is also expected that the overall performance of the space created by those elements is high. The chain is continuous from the scale of materials to the scale of cities. Of course it is not possible to resolve every relationship within that chaos but it is possible to collect end user information in order to compute the performance of various architectural and engineering designs with regard to the associated feedback.

The main scope of SHAPED is to guide architects and engineers with "available" data about; "performance parameters (as far as possible)", cost information, registered information about suppliers or manufacturers in terms of "Logistics, after sales service, workmanship quality, reliability, and Overall Customer Satisfaction", of accompanying design Elements

SHAPED will be the integration node of CC-Agent with the CONNET – Turkey, the gateway to construction in Europe" (Dikbas et. al., 2004). SHAPED is modular by design. That is, because it is not possible to compute every performance parameter about a specific "design focus (object being designed)" various computing methods for various design parameters may be plugged-in later. Computing a specific performance parameter may deal a standalone research subject. Within CC-Agent, we only elaborate on customer feedback, cost, and supplier or manufacturer reliability.

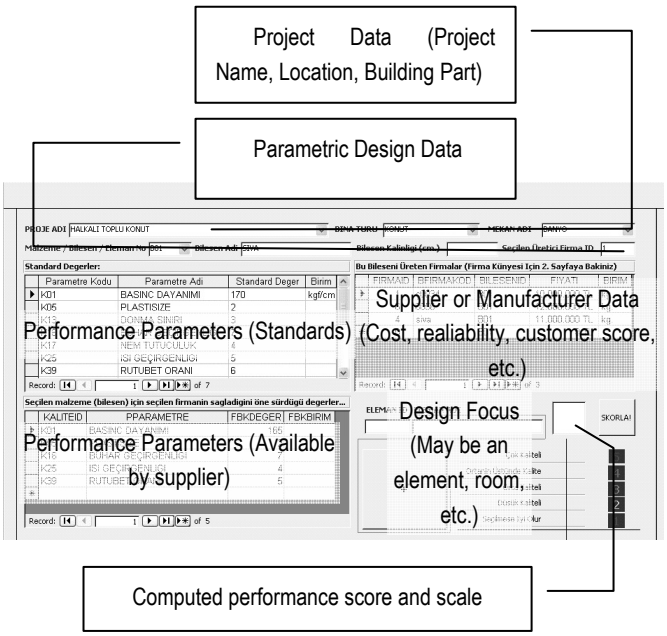

Figure 3: User interface of SHAPED

4.4 *User Service Entrenched Repository*

USER consists of an interface and a universal project database. It is designed to allow users to put data at the right place the first time. The main scope of USER is facilitating the process of "First Call Resolution (FCR)". USER is not implemented yet. The database structure and object model is under

development. USER is a door to let all kinds of feedback within a classified scheme. Omniclass (OCCS) classification system and IFC objects in conjunction is used to disseminate and classify those data.

USER is the welcome scene of CC-Agent. In the foreground, it deals KISS (Keep It Simple, Stupid) principle to interact with the user of the system. It is designed to enable communication with people whom does not have any idea or technical knowledge about the situation which made them to act with CC-Agent. In the background it deals intelligent classification algorithms to collect data as organized as possible.

At the user interface level, it will be possible to visually point the focus of the feedback. 2D visualization will be used for the beginning but we aim at implementing VRML in the future.

4.4.1 *The KISS Principle*

The KISS Principle is self-descriptive and recognizes two things:

1. People (including product and service users) generally want things that are simple, meaning easy to learn and use.
2. A company that makes products or furnishes services may find simplicity an advantage for the company as well, since it tends to shorten time and reduce cost. (Where the company is trying to use the principle on behalf of users, however, design time may take longer and cost more, but the net effect will be beneficial since easy-to-learn-and-use products and services tend to be cheaper to produce and service in the long run)(whatis.com).

4.5 *Issue Tracker for servicE Management*

ITEM is the heart of CC-Agent. All the activity within a service call is tracked through the ITEM module. As a user interface while USER serves for the end users, ITEM serves for the FM. Both USER and ITEM depend on same database however the data collected from USER is stored in static tables while data collected from ITEM is stored in dynamic tables within a data warehouse. The database behind is web oriented supporting all of the advanced features that a web oriented database (Turk, 1997) should have.

4.6 *The Process Model*

There is an increasing need for all actors involved in the construction- and facility management process to have a common framework for describing their work and creating a more efficient business process (Björk et al. 1999). Creating a more efficient business process facilitates knowledge acquisition. The acquired knowledge can be re-used for Strategic and Tactical plans of enterprises, standardization by design, and thus the industrialization of the entire AEC/FM cluster.

The knowledge acquisition process in CC-Agent creates a "Knowledge Circle (Information > Implementation > Dissemination > Knowledge)". The overall progress consists of nine basic processes (Feedback, Redirection, Update, Inspection/Record as Information collection processes; Solution and Issue tracking and Analysis as Implementation Processes; Design, Promotion, Change as Dissemination Processes; Knowledge is acquired as an output of the whole progress). Here SHAPED, ITEM, and USER are not explicitly shown because they exist as sub-modules of CC-Agent. Where appropriate, the dominant function related with those modules is explicitly indicated (Figure 3).

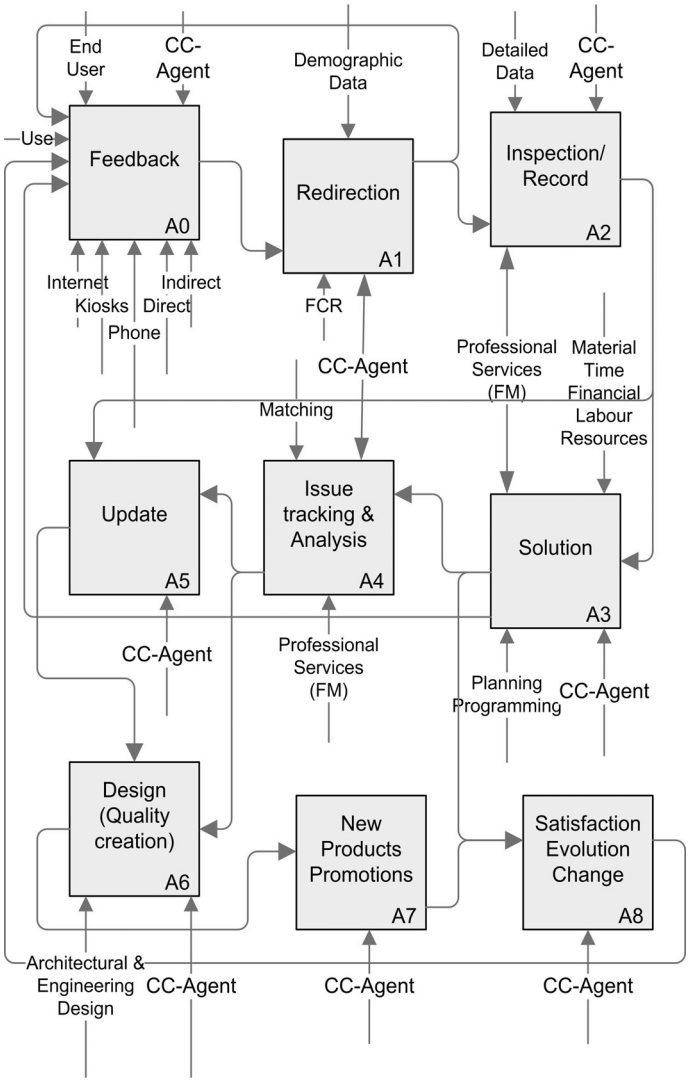

Figure 4: IDEF0 – Principle activity diagram for CC-Agent

5 CONCLUSION

Neither maintaining good and efficient relationship with the users or in wider terms "customers" nor establishing an agent system to achieve such work are novel ideas but with emerging ICT the way that relationship handled is. The outcomes of those efforts may be listed as follows: (1) In terms of marketing, it becomes easier to catch up "up-sell" and "cross-sell" opportunities. (2) By use of ICT, customer needs, desires and requirements can be analysed making it possible to improve products and services to better suit those needs. CRM, by this way helps customers to become more aware of their rights and provides a means of driver towards "change" in long term. (3) Marketing of products "designed" according to the trends and requirements of society is much easier. Not directly related with the content of this paper but positive effects of the process is seen in terms of physiological health of society to quality of life, and productivity increase at work. (4) Reduced costs, shortened production periods, increased quality, and competitive advantage are natural outcomes of the process and all dependent on the "design quality".

Collecting data from various projects through "service requests" and analyzing them in one pool makes it possible to discover the secrets of design professionals and provide an open system for sharing knowledge. In long term CC-Agent will help to:

- Set performance criteria for buildings and building delivery processes that are based on the values and business practice
- Evaluate performance by getting feedback from customers, assessing the technical and financial performance of buildings, and comparing these evaluations to other benchmarks within and outside
- Analyze and interpret evaluation results in ways that allow staff of participants of the system and customers to apply the results to their own situations with future buildings.
- Broadly disseminate results in ways that are meaningful to key decision-makers, in language and formats that they can use on future projects.
- Create the conditions for effective implementation of results, including changes in work processes, adequate resources and organizational incentives and support.
- Develop marketing and training strategies for FM firms, customers and other stakeholders.

An other long term outcome from the system is that, CC-Agent would provide, various "Key Performance Indicators (KPI)", "CRM metrics", "New managerial tools and techniques" specific to construction sector. By using this information, construction firms would gain strategic intelligence for the next step and user requirements would be the major driver for the strength and length of that step.

The following (introductory but not limited to) KPIs can be output from the system:

- Customer preference index or Customer Loyalty
- Percentage of customer calls answered in the first minute (As an example of specialty KPIs)
- First Call Resolution Rate
- Customer Acquisition
- Life span of facilities
- Industrialization (In terms of lean design & construction, shortened production period, reduced amount of workmanship)
- Standardization (Of an accepted design solution in terms of preference)

CC-Agent will also provide support for the evolution and development of Deign Quality Indicators (DQI). CC-Agent is believed to be an essential tool towards construction excellence and industrialization in the AEC/FM cluster.

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