



UNIVERSITI PUTRA MALAYSIA

**DEVELOPMENT OF AN AUTOMATED COST CONTROL SYSTEM IN
CONTRACTORS FIRMS**

KHALID ABDELGHAFAR ALI

FK 2000 58

**DEVELOPMENT OF AN AUTOMATED COST CONTROL SYSTEM IN
CONTRACTORS FIRMS**

KHALID ABDELGHAFAR ALI

**Master of Science
Universiti Putra Malaysia**

2000



**DEVELOPMENT OF AN AUTOMATED COST CONTROL SYSTEM
IN CONTRACTORS FIRMS**

By

KHALID ABDELGHAFAR ALI

**Thesis Submitted in Fulfilment of the Requirement for the
Degree of Master of Science in the Faculty of Engineering
Universiti Putra Malaysia**

July 2000



**To my parents, brothers, sisters and to whom
my heart is belonged to...Alya**

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science.

**DEVELOPMENT OF AN AUTOMATED COST CONTROL SYSTEM
IN CONTRACTORS FIRMS**

By

KHALID ABDELGHAFAR ALI

July 2000

Chairman: L. Jawahir Nesan, PhD

Faculty: Engineering

There are still widespread use of papers as a medium to capture and exchange of information among participants in construction cost control process. Although there is a relatively little use of automation tools, there is a distinct word processing environment formats. Each package creates its own data files in different formats resulting in difficulties with exchanging data electronically. These difficulties lead to inefficient flow of information to control cost, and some feedback problems among sites and across organizational boundaries. This negatively affects the availability of cost historical database as well as data from projects at hand. This implies that, it is time to automate cost control to achieve some kind of uniformity and standardization. To effectively achieve this, one specific IT tool, namely shared databases through data accessibility capability, has been used.

The automated cost control has been developed using the Entity-Relationship modeling (ERM) methodology. It started with a formal definition for the problem, and conceptually been designed. Then a logical refinement for the conceptual model is developed that lead to the physical implementation of the system. The resulted

system. The resulted cost control system has been developed in a formal and systematic manner. It has used Microsoft Access as a target database Management System (DBMS), under windows environment. In addition, the cost control system has the capabilities to prepare cost reports, undergo different types of queries with users and update data.

The cost control system described in this research represents a significant contribution in construction cost control, since it satisfies the condition of uniformity under windows environment. It is easy to use, since the user can interface it by just 'point and click', as it uses Query-By-Example (QBE) language.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

PERKEMBANGAN SISTEM PENGAWALAN KOS AUTOMATIK

Oleh

KHALID ABDEL GHAFAR ALI

Julai 2000

Pengerusi : L. Jawahir Nesan, Ph.D.

Fakulti : Kejuruteraan

Buat masa ini kegunaan kertas masih digunakan secara meluas sebagai cara menerima dan dan menukar maklumat dalam proses kawalan kewangan bagi sektor pembinaan. Walaupun terdapat sedikit alat pengautomatan yang di gunakan, seperti sistem pemprosesan kata,ianya masih tidak ketara. Ini kerana Setiap pakaj mencipta fail data tersendiri dalam format yang berbeza-beza, yang menyilitkan penukaran data secara elektronik. Keadaan ini menyebabkan aliran informasi yang kurang berkesan untuk mengawal kewangan, dan juga masalah-masalah antara tapak-tapak dan organisasi. Ianya juga memberi kesan negatif terhadap sejara pangkalan data kewangan dan juga projek yang sedang di jalankan. Ini membuktikan bahawa, telah tiba masanya kawalan kewangan di automasikan untuk mencapai keseragaman dan piwaiian. Untuk itu, sejenis alat IT yang dip-nggil pangkalan data yang dikongsi dan boleh dicapai telah digunakan.

Kawalan kewangan berautomatik telah dibangunkan menggunakan kaedah pemodelan Hubungan-Entiti Sistem ini dimulakan dengan dengan takrifan masalah, dan direkabentuk secara konsep seterusnya penelitian logik dibuat terhadap model

konsep yang telah dibangunkan yang membawa kepada perlaksanaan sistem tersebut.

Sistem kawalan kewangan yang terhasil telah dibangunkan dengan cara yang teratur. Sistem ini menggunakan Microsoft Access sebagai Pongkalan Data Sistem Pengurusan (DBMS) dibawah persekitaran tettingkap. Sebagai tambahan, sistem kawalan kewangan ini berkeupayaan untuk laporan kewangan, menangani banyak jenis personoalan dari pengguna dan mengemaskini data.

Sistem kawalan kewaangan yang di terangkan dalam penyelidikan telah menyumbang dalam kawalan kewangan dalam sektor pembinaan, kerana ia telah memenuhi keadaan penyeragaman dibawah persekitaran tettingkap. Ianya mudah digungakan kerana pengguna boleh mengantara muka hanya dengan kaedah 'tunjuk dan tekan', kerana ia menggunakan bahasa Tanya-Dengan-Contoh (QBE).

ACKNOWLEDGEMENTS

I would like first to thank our mighty God for shading on me health and keep my brain working to the extend of completing this research which I hope will contribute to the welfare of our nation.

I would like at this juncture to express my deepest appreciation and gratitude to my kind supervisor Dr. L. Jawahir Nesan for his support and unlimited assistance and beneficial advice throughout the period of my study. I gratefully acknowledge the support of the members of the supervisory committee Assoc. Prof. Dr. Mohd Razali and Eng. Nor Kamariyah Noordin.

Thanks and appreciation are extended to the staff at the Graduate School Office for their help and cooperation. My appreciation and gratitude to all of the individuals at the Department of Civil Engineering, who had been cooperative.

TABLE OF CONTENTS

	Page
DEDICATION	2
ABSTRACT	3
ABSTRAK	5
ACKNOWLEDGEMENTS	7
APPROVAL SHEETS	8
DECLARATION FORM	10
LIST OF TABLES	11
LIST OF FIGURES	12
LIST OF ABBREVIATIONS	14
 CHAPTER	
I INTRODUCTION	16
Definition of the Problem	18
IT as an Upcoming Trend	21
Construction Challenges and Strategies	22
IT Capabilities	24
Objectives	27
 II LITERATURE REVIEW (I)	
COST CONTROL AND INFORMATION	
TECHNOLOGY IN CONSTRUCTION	28
Introduction	28
Previous Related Work in Construction Cost Control	32
CONSCOM Model	32
Hendrickson's Model	33
Abudayyeh Information Model	34
Cost Control Integrated Environment	34
Information Modeling in Cost Control	35
Information Technology in Cost Control	37
Introduction	37
IT Potential	37
Strategic Application of IT	39
IT Implementation Problems	40
Project Management Approach in IT Development	45
Impact of IT upon Construction Industry	50
External Environment	51
Internal Environment	51

III	LITERATURE REVIEW (II)	
	DATABASE AND SYSTEM NETWORKING	52
	The Database	52
	Introduction	52
	Database Management Approach	53
	Types of Databases	54
	Data Resources Management (DRM)	56
	Entity-Relationship Model (ERM)	57
	Database Design	58
	Conceptual Database Design	58
	Logical Database Design	59
	Physical Database Design	60
	Database Management System (DBMS)	61
	Microsoft Access DBMS	62
	Database Interrogation	63
	Structured Query Language (SQL)	63
	Query By Example (QBE)	63
	System Networking	65
	Wide Area Network (WAN)	65
	WAN Topologies	65
	Transmission Medium	66
	Wireless WANs	67
	Tasks Performed by Wireless WANs	69
IV	DEVELOPMENT OF AUTOMATED COST CONTROL SYSTEM	70
	Introduction	70
	Step 1: Problem Definition	76
	Data Requirements	76
	Transaction requirements	77
	Step 2: Validation	78
	Data Requirements Validation	79
	Transaction Requirements Validation	81
	System Concepts Validation	84
	Step 3: Conceptual Data Model Design	89
	Step 4: Logical Data Model Design	89
	Step 5: Physical Data Model Design	90
	Relationships and Referential Integrity Definition	91
	Conceptual design and development	91
	Logical design and development	97
	Physical design and development	100
	Design base relations for target DBMS	100
	Cost Control System Database	102
	Networking the system	109

	Wireless Wide Area Network (WWAN).....	109
V	RESULTS AND DISCUSSION	111
	Introduction.....	111
	Resultant Tables Created	112
	Cost Control system Queries	113
	Building Select Queries using QBE	114
	Specifying Criteria for Queries	114
	Creating Multi-Table Queries	117
VI	CONCLUSION AND FUTURE WORK	119
	REFERENCES	123
	APPENDICES	126
	BIODATA OF AUTHOR	146



LIST OF TABLES

Table		Page
1	Construction Needs and IT Applications.....	18
2	Major Relationships of (ACCS).....	93
3	Attributes Associated with Entities.....	95
4	Entities Primary and Alternate Keys.....	97

LIST OF FIGURES

FIGURE	PAGE
1.1 Effect of Market Forces and IT Capabilities on Construction Firms.....	25
2.1 Value of IT at the Firm and Project Level.....	29
2.2 Fisher’s Context Diagram.....	42
3.1 Types of Databases.....	55
3.2 WAN Topologies.....	66
4.1 Research Methodology Diagram.....	72
4.2 Flow Chart of Cost Control Modeling Methodology.....	75
4.3 Entity Type.....	92
4.4 Simple Entity Relationship Diagram.....	93
4.5 The Entity-Relationship Model.....	99
4.6 The Microsoft Access Database Window For the Cost Control System.....	102
4.7 The New Table Dialog Box “Design View Highlighted”.....	103
4.8 Design View of Site Table Displaying the Field Properties Section for the Site-No Field.....	104
4.9 The Field Properties Section for the Street Field of SITE Table in Design View.....	105
4.10 The Field Properties Section for the Amount Field of INTERIM PAYMENT Table in Design View.....	106
4.11 The Field Properties Section for the Payment-No field of INTERIM PAYMENT Table in Design View.....	108

4.12	The Relationship Window of the Site-Manager and Progress-Reports Tables.....	109
5.1	Site Table Datasheet.....	112
5.2	New Query Dialog Box.....	113
5.3	(a) QBE grid to retrieve Site—No, Cont.-No, and Owner-No Fields of the SITE Table (b) Resulting Datasheet.....	115
5.4	QBE Grid of Selects Query to Retrieve the Sites in Specific City with A contract Number Between 10 and 15.....	116
5.5	Cost Control QBE Grid of Select Query to Retrieve Together the Data Needed From Multiple Tables.....	117
5.6	Resulting Datasheet.....	118

LIST OF ABBREVIATIONS

ACCS	Automated Cost Control System
CAD	Computer Aided Design
CBS	Cost Breakdown Structure
CIC	Computer-Integrated Construction
CPU	Central Processing Unit
DBDL	Database Definition Language
DBMS	Database Management System
DDL	Data Definition Language
DLL	Dynamic Link Library
DML	Data Manipulation Language
DRM	Data Resource Management
DSS	Decision Support Systems
EDI	Electronic Data Interchange
IEEE	Institute of Electrical and Electronics Engineers
EIS	Executive Information Systems
ERM	Entity-Relationship Model
IT	Information Technology
KBES	Knowledge-Based Expert Systems
LAN	Local Area Network
MFCs	Microsoft Foundation Classes
NASA	National Aeronautics & Space Administration, US
NIAM	Nijssen's Information Analysis Methodology
OO	Object-Oriented

QBE	Query-By-Example
RAM	Random Access Memory
SQL	Structured Query Language
WAN	Wide Area Network
WBS	Work Breakdown Structure
WWAN	Wireless Wide Area Network

CHAPTER I

INTRODUCTION

The prediction that extensive use of Information Technology (IT) would transform business organisations was first made by Leavitt and Whisler, (1958) in their research, 'Management in the 1980s'. IT, a term coined by them, was considered to be the main agent for change in business organisations. Their predictions about the organisations in the 1980s were found to be, for the most part, true.

In the cost control area, information technology (IT) is creating new possibilities and, consequently, its advancement is placing new demands upon construction organisations. IT can no longer be viewed as an enhancement to traditional manual procedures but rather as an innovative agent that enables new and different alternatives to organise and operate cost control enterprises. Therefore, construction organisations are faced with opportunities as well as challenges (Ahmed, Russell, and Zeid, 1994). Technological advancement, market expansion, global competition and a renewed demand for quality and productivity are making the issue of integration of various stages involved in the process of cost control more critical than ever (Schimming, 1993).

The flow of data between the members of a cost control team is very important and dealing with it occupies a considerable amount of time of those with managerial responsibilities. Data flow systems are likely to become increasingly more important, as the benefits of IT are achieved from linking applications, and perhaps more likely from the 'step changes' caused by the new, more beneficial ways of working that are made possible.

Manual data-acquisition in traditional cost control systems are subject to human errors in many ways: (1) Filing data collection forms out by hand; (2) Summarizing these paper forms onto others; and (3) Keying this information into a computer workstation. Therefore, automating data acquisition should improve the quality of data substantially by eliminating error-prone tasks and processes. Computer would perform additionally summarizing data, thus improve the timeliness of the cost control system.

Traditionally fragmented cost control systems are searching for new ways to integrate cost process functions electronically. There is a need to identify the roles IT can play in this changing environment. Likewise, it is important to understand how the cost control activity would be impacted by IT. Formulation of organizational strategies and plans should be based on this comprehension.

Table 1 lists the critical needs of construction firms with corresponding IT capabilities. Available tools under each broad category of the IT capabilities are also identified in Table 1. It should be noted that the needs are primarily in the area of

integration involving various functions of planning, procurement and construction. Communication tools can help construction firms to coordinate their activities, by overcoming the barriers of time and distance. Training tools, such as multimedia, can help train workers. Mechanisms of remote supervision or self-supervision can also be established with the help of communication tools.

Table 1: Construction Needs and IT Applications
(From Ahmed, Russell and Zeid, 1994)

Needs	IT capabilities	IT tools
Integration Co-ordination Training Supervision	Communication	Voice mail/e-mail/fax Electronic network Document imaging Multimedia
Internal(project/company) & external(industry) standards Data capturing, storage & retrieving	Data accessibility	Shared database Electronic Data interchange Bar code 3-D graphics
Decision making Consensus reaching Technical analysis	Common systems	Knowledge-based sys. Decision support sys. Executive info. systems

Definition of the Problem

There are still widespread of paper as a medium to capture and exchange information among participants in construction cost control process. There is

relatively little use of automation tools that depend on computer-readable documentation, especially in the cost control area. Most construction projects deal with cost control and cash flow as main issue, require the services of many different experts, various contractual relationships, and numerous functions. Uniformity of procedures and standardization of data would greatly enhance the effectiveness of communication among the multiple construction firms teaming up to build one constructed facility specially in the cost control field among many sites at the same time. To effectively achieve this kind of uniformity in cost control area, one specific IT application tool can be used, shared databases through data accessibility capability. Each construction project is almost unique and there are large amounts of data generated during the project life cycle. There are a large number of project participants with different specialties that make cost control a complex and fragmented task. In this fragmented environment, it is necessary for the various participants to share information pertaining to cost control concepts. Cooperation between the large number of project participants is essential in order to achieve the purpose of the project from profitability point of view. Communication, in many forms, is the means for information and data exchange between those different participants.

The sharing of information requires the deliberate and international exchange of messages through a physical medium comprising the communication channel. The traditional communication channel used in the construction industry contains symbolic messages consisting of text graphics in the paper medium. This communication channel has existed virtually unchanged for several centuries, in

spite of deficiencies, for one simple but subtle reason, the same channel is sufficient to establish communication with a variety of participants.

The introduction of microcomputers in the early 1980s stimulated revolutionary change in the work environment and initiated evolutionary change to communication channel. Tasks previously performed by manual methods were soon relegated to computer-assisted environments, especially those tasks associated with the information processing. This transition contributed to gain in human efficiency, but also created additional fragmentation in the construction industry. The large number of and variation in computer environments is a significant problem (Howard, 1989). For example, project documents can be written in a variety of word processing environments. Each package creates its own data file in a distinct format resulting in difficulties with exchanging data electronically. This difficulty in data exchange can affect productivity negatively by communication inefficiency. Howard *et al.* (1989) said that the introduction of computers to the construction process has changed the means of generating the paper, but has not fundamentally changed the methods of sharing data across organizational boundaries. Unlike human environments, messages must be translated from one environment to another, which raises the distinct possibility that each communication channel can be different.

From the above it can be argued that, information plays a key role in cost control. For project cost to be well controlled and managed, data from the past projects stored in a historical database as well as data from the project at hand must be readily available. Data is an essential and valuable resource for cost planning,

