Business process modelling in small- to medium-sized enterprises

A.S.M. Tam
Department of Industrial and Manufacturing Systems Engineering,
The University of Hong Kong, Hong Kong
L.K. Chu
Department of Industrial and Manufacturing Systems Engineering,
The University of Hong Kong, Hong Kong
D. Sculli
Department of Industrial and Manufacturing Systems Engineering,
The University of Hong Kong, Hong Kong

Abstract
Data flow analysis is used in a novel context for business process modelling. A framework is presented together with its enterprise modelling concepts and the associated modelling tools. The framework was specifically developed for small- to medium-sized industries. The strengths and weaknesses of the general data flow analysis approach are discussed in terms of its suitability for Hong Kong's small- to medium-sized industries. A case example is also presented to illustrate the methodology.

General introduction

To remain competitive, enterprises have to introduce improvement programmes for both their products and services. This, in turn, requires some business re-design programme. Such a programme normally incorporates three components:
1 the theories of management applicable to the industry;
2 the implementation methodology and process; and
3 the application tool or model of the enterprise.

The implementation methodology and process forms the heart of business re-design, while the theories of management support the implementation methodology, and the model provides a tool for evaluating the existing or proposed enterprise structure.

Business process modelling (BPM) can be defined as the process of the building functional activities of the whole or part of an enterprise as either an as-is model (current situation) or a to-be model (proposed situation). BPM is derived from the theory of enterprise modelling and integration (EMI), see Figure 1. EMI, according to Vernadat (1996): "is concerned with the definition, analysis, re-design and integration of business processes, process data and knowledge, software applications and information systems within an enterprise in order for it to achieve marked advancements in terms of overall organisation performance." In essence, the goals of EMI are achieved by the application of a combination of enterprise modelling and enterprise integration, see August-Wilhelm (1994), Bernus and Nemes (1996), Lim *et al.* (1997), and Scheer (1992). EMI consists of three main modelling tools:

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1 BPM, workflow modelling;
2 Workflow Handbook (1997); and
3 data modelling.

Other common modelling tools for BPM are discussed by Cheng and Gay (1993), Fung and Cheng (1994-95), and Kwong & Wong (1996-97).

BPM has the principal aim of helping identify critical processes and/or to improve the overall performance of the business, see Scheer (1992) and Scholz-Reiter and Stickel (1996). BPM has, essentially, three goals. First, it should be able to form a tool for business process re-engineering. Second, it should help to identify appropriate strategies for software packages implementation, enabling the company to benefit from implementing standard software packages. This may involve various tasks/developments in terms of matching the enterprise model and the standard software packages; some compromise changes to both the enterprise model and software package are usually necessary. Third, BPM should be able to help with the software development; BPM forms the first stage in defining user requirements, and a structured approach in specifications will aid software development.

This paper's principal aim is to explore the use of BPM as the implementation methodology for business re-design within Hong Kong's small- to medium-sized industries (SME) through the use of data flow analysis (DFA).

Proposed frameworks for SME's in Hong Kong

DFA can form a fundamental starting point for performing BPM in general, and this is also a good starting point for applications in Hong Kong's SME's. In terms of business efficiency, DFA offers the distinct advantage in that it is relatively simple to apply and the time taken to undertake a business process re-design project is not excessive. Further,

Figure 1
Enterprise modelling and integration (EMI)
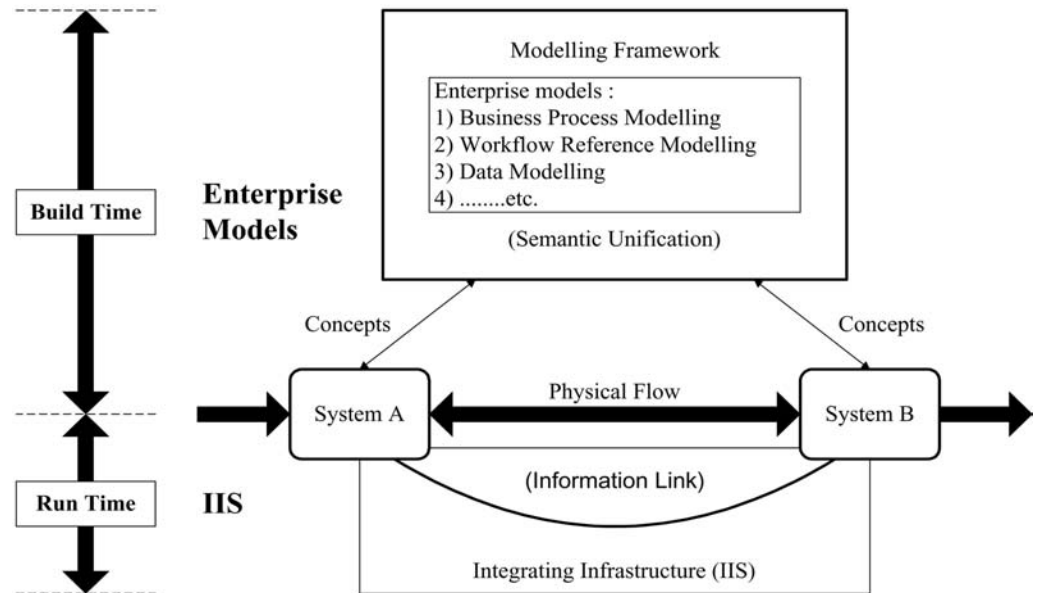
DFA is a popular procedure in the information systems profession in general and has a wide area of application.

There are three stages in the DFA methodology, see FitzGerald (1987), Yourdon (1989), and Kendall (1996) as follows:

1 information acquisition – questionnaire needs to be established and put to key respondents during interviews;
2 analysis – using DFA techniques; and
3 report – the report should specify the immediate and future re-engineering solutions.

For the information requirement analysis, see Segura (1985) and James (1997), the principle of "5W+1H" rule is normally used. The "5W" stands for Who, What, When, Where and Why; and "1H" stands for How. The guidelines for an analyst are listed as follows:

· *Who* is involved in the situation we are analysing?
· *What* is the current situation?
· *When* must the new system be in place?
· *Where* will the new system fit within the old environment?
· *Why* is a new system being sought?
· *How* will the new system function?

In addition, other critical constraints need to be studied, for example, the computer hardware configuration, the cost of developing the system, and the programming language to be used.

Two approaches are normally used to collect information for the DFA exercise, see Vernadat (1996). They are: information collection through group meetings, and information collection through interviews. Information collection by group meetings requires the forming of groups of people from the enterprise. The groups continue discussion until they reach a consensus view, which forms the basis for model development. This approach usually consumes a lot of time and, because of the high number of people involved can be costly. Companies are normally reluctant to allow highly paid employees to consume time in such meetings, particularly companies which fall into the SME's category. This type of group discussion is therefore very difficult to arrange in the business environment of Hong Kong's SME's.

The other method of collecting information is through individual interviews, see Bradburn (1979). This requires experienced consultant analysts, who are assigned to the enterprise for the collection of user descriptions and samples of the documents/ data used directly in the operations. In comparison with group discussions, this method requires less time and is generally less costly, but tends to provide less exposure with model users, and may lead to sup-optimal solutions.

Our experience suggests that the second approach tends to produce results of nearly the same quality as the first and in a much shorter period of time. Increasing the number of expert consultants will certainly increase cost, but may not proportionately increase the reliability of the information after a certain point. A trade-off exists

somewhere; our experience suggests that four or five expert analysts are sufficient for the collection of necessary information in Hong Kong's SME's. Increasing the number of analysts beyond this number will not produce an equivalent increase in the reliability of the information collected.

DFA, see Yourdon (1989), and Kendall (1996), is in fact a structured systems analysis and design methodology. It uses a data flow diagram (DFD) to model or analyse the current system and to find solutions for an improved system. It is principally based on:
- the purposes of the application: its functions or processes; and
- the treatment of the problem in a top-down manner. A top-down analysis is performed to determine the external interfaces of the application first, then high level functions, and finally, lower level functions.

The DFA procedure consists of steps to create the following items:

Context diagram
The context diagram is the highest-level diagram of a set of DFD's, and reveals an external picture of the information system. It consists of the three components of input and output, terminators, and general functions.

Event list
The event list is a simple textual listing of the events in the environment to which the system must respond. A DFD uses symbols including external entity, process, data store and data flow.

Current physical DFD
The formation of the current physical DFD involves the re-organisation of a context diagram or several context diagrams. The current physical DFD shows the flow of data amongst entities such as persons and departments within the system. The current physical DFD is then transformed to the current logical DFD.

Current logical DFD
The current logical DFD is derived from the context diagram and event list. The current logical DFD shows the flow of data along the essential functions of the system. Further, a complex system can be modelled as a levelled DFD by the processes of abstraction and decomposition, which describes different levels of DFD's to allow refinement of the modelling process, see Figure 2.

Proposed logical DFD
The most important and difficult step in the formation of DFD is to transform the current logical DFD to the proposed logical DFD. A DFD helps to expose the weaknesses of an existing system and provides valuable opportunities for re-engineering. However, the final solution must still satisfy certain constraints: suggestions from the customers, the compliance of wants and some standards such as ISO9000.

Proposed physical DFD
The proposed physical DFD shows the flow of data among entities such as persons and department within the proposed system.

The final stage is reporting
This includes the current physical DFD, current logical DFD, proposed logical DFD, and a business report. The business report is concerned with the business plan, which should describe the workflow, software configuration, hardware configuration, advantages and disadvantages of the proposed solutions. The descriptions of software and hardware configuration can be omitted if there are no IT related matters in the existing system, and if IT is unlikely to feature in the proposed system. The report should specify the immediate and future re-engineering solutions, Vosniakos and Goitia (1995).

Application of proposed framework

The company concerned is a trading company based in Hong Kong with its headquarters in Europe. The major business of the company is the sale and distribution of machinery equipment systems. Such machinery and equipment includes plastic injection moulding machines, lathes, milling machines, and CNC machines, all designed and manufactured in the Europe. The main office is located in the central district of Hong Kong, and the two warehouses are located in two of Hong Kong's industrial zones. The central office is responsible for general operation administration, and the two warehouses are responsible for the functions of inventory and show rooms.

The domain of the problem of interest is the company's contracts management business process (CMBP). This domain falls between the receipt of the contract of requisition from warehouses and release of an official contract to the suppliers. The contract is the official legal document released from the purchasing department to its suppliers for the delivery of machinery

equipment systems. The contract includes all commercial and technical specifications, and its preparation must go through a rigorous procedure. Before releasing the official contract to the supplier, several activities will take place. These include contract initialisation, checking and approval, from a junior clerk to a senior manager, in the purchasing department.

The CMBP problem was found to be the bottleneck of the whole business process. An average of two weeks was needed for completing this portion of the work, leading to many complaints from customers concerning late shipments. The company's top management decided to acquire new software solutions to improve the efficiency of CMBP related activities.

The project can be divided into four phases:
1 BPM;
2 strategy identification;
3 field implementation of standard software package; and
4 control and evaluation.

It is with the first phase of the project that this paper is concerned. Solutions of business process re-design with immediate and future changes were proposed in the aspects of workflow, software and hardware configurations.

BPM based on DFA consists of three stages:
1 information acquisition;
2 analysis; and
3 reporting.

In this study, a series of questions, see Hauge (1993), are put to key respondents through interviews. DFA is applied to analyse the current situation, and based on the DFDs so generated, re-engineering solutions are

proposed and described in terms of the final physical DFD. To assist implementation of the proposed solution, a detailed report was compiled which includes the specifications of the immediate and future re-engineering solutions.

Detailed information acquisition involved interviews with key personnel. The interviews were conducted on site, and the main area of study was within the purchasing department. The key respondents can be divided into management level, upper level (procurement and EDP manager), intermediate level (buyer and programmer) and junior level (clerk). The information generated by the interviews for the three levels of management provides a basis for next stage of the analysis.

DFA is applied in creating the business process model, and the current situation is studied via the answers collected from interviews. The current physical and logical DFD are generated. After reviewing the current DFD, the problems are identified and analysed and the solutions are proposed. Then, the proposed physical and logical DFDs are drawn. A business plan that summarises the solutions for immediate and future changes is attached. The study of current and proposed situations are divided into three areas consisting of activities and data flow, software and hardware configuration.

Current model
After interviews with the key respondents, information collected is analyzed. The problem domain, as mentioned earlier, is the contract management business process (CMBP) between receipt of contract requisition (CR) from warehouses and release of an official contract (OC) to the suppliers. This forms the bottleneck of the whole business process; Figure 3 shows the physical DFD that describes the current situation.

The current software
The current software system contains a management information system (MIS) called IRS (integrated retail system) that is used for the CMBP. There are two modules, one for the OC and the other for the inventory; the OC process is computerised while the CR process is manual. The IRS system is interfaced to an accounting software and a point-of-sale system. IRS uses a UNIX operating system as the host server and has a terminal at the front end. The host server is a Pentium-based PC computer. There are four terminals used, with two in the EDP department and two in the

Figure 2
Steps in formation of DFDs
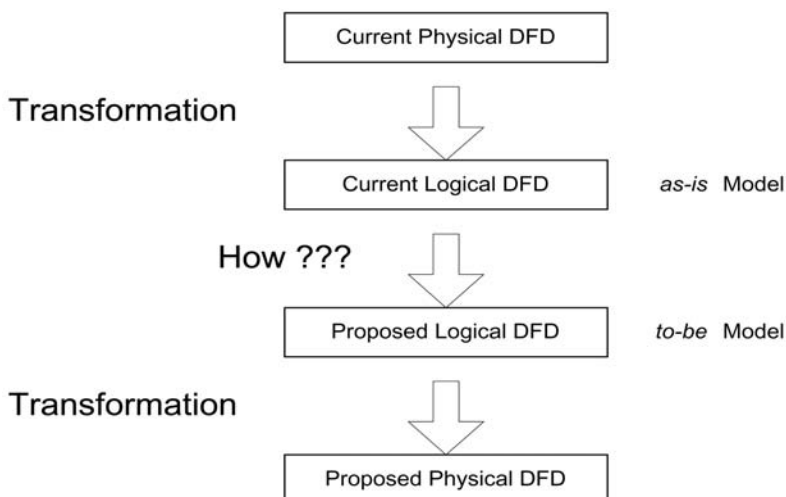
purchasing department. From the above information, the current situation can be manipulated, analysed and partitioned into a context diagram and a set of event lists. Based on the context diagram and the event lists, the physical DFD of the current model can be presented. The next step is to transform the current physical DFD into current logical DFD; Figures 3 and 4 show the zero level of the two DFDs.

Problem identification
The intrinsic aims of the programme are to improve the efficiency of the CMBP. The factors that are causing this problem can be identified by an analysis of the current model. First, is the physical transportation problem between the warehouses and the central office of the documents for CR; it takes about one day to transfer the documents. If the transfer could be done by

Figure 3
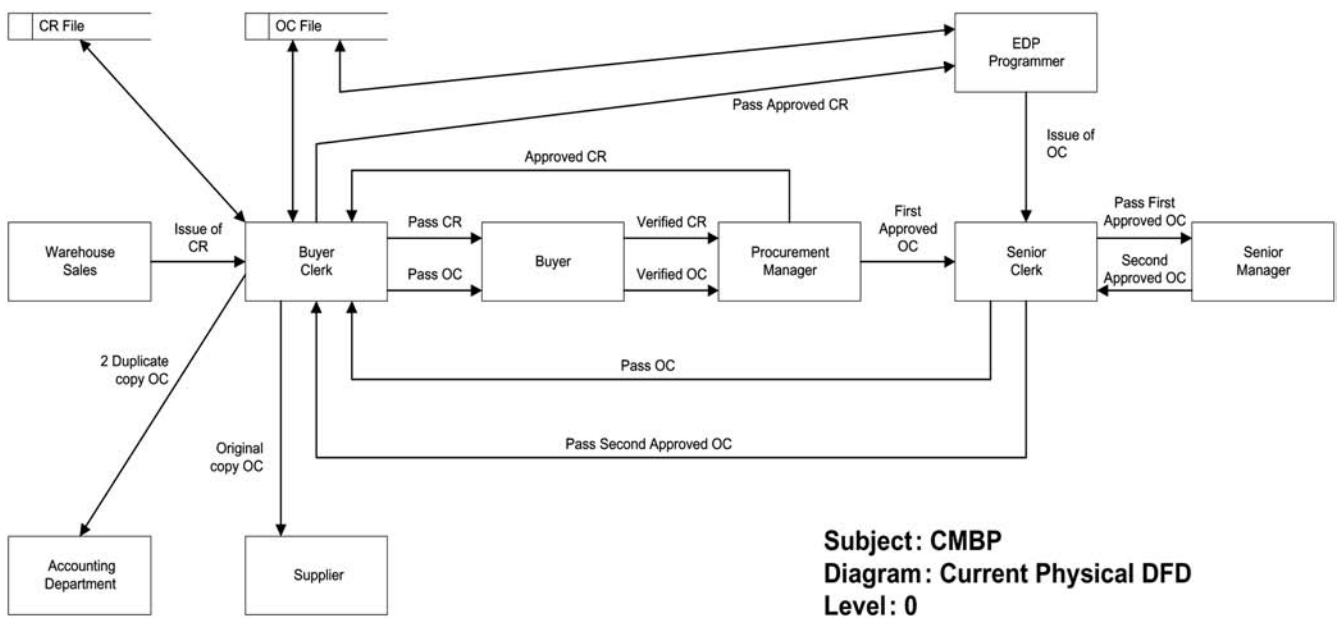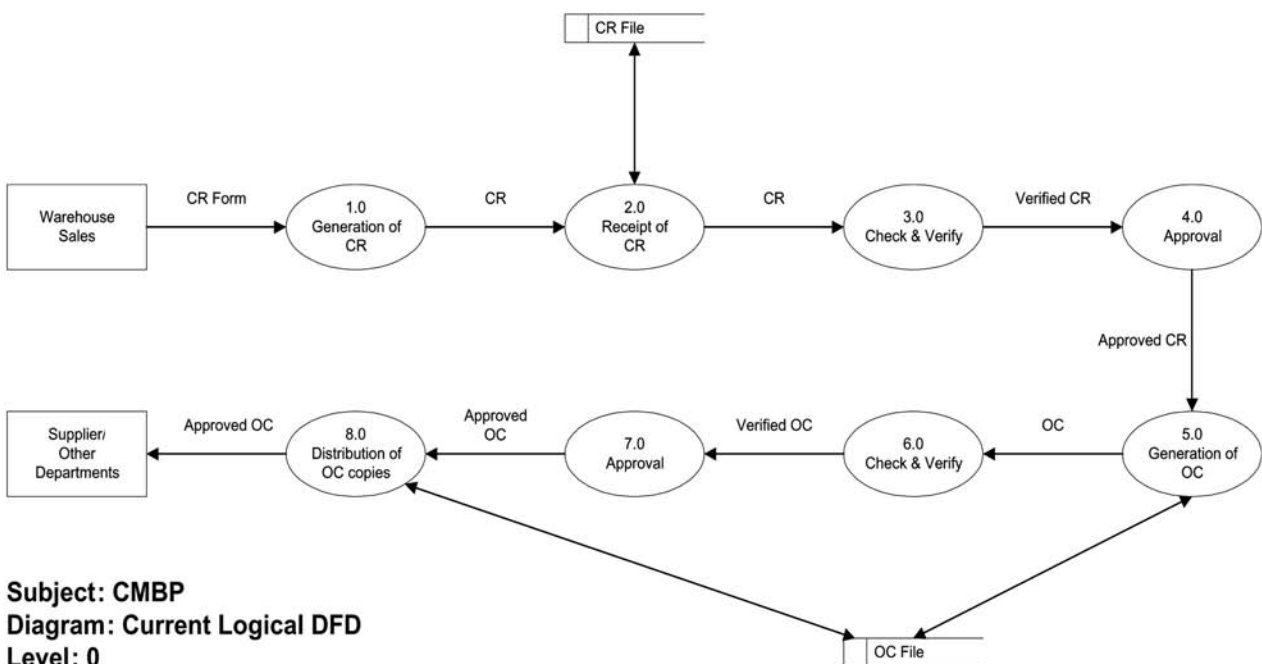Current physical DFD: level 0

Figure 4
Current logical DFD: level 0 (*as-is* model)

electronic means such as networking, time will be saved. Second, the procedure includes too many duplicate checks and approval, for both the CR and OC release. In order to alleviate this second problem, duplicate checking and approvals must be kept to a minimum. Third, there are two separate processes with the problem domain. The first process, CR, is performed annually, while the second process, OC is computerised. Thus, the manual process forms a bottleneck in the current system. The integration and computerisation of the two processes seems an obvious step. Briefly summarising, the solutions should minimise duplicate checking and approval procedures, consolidate and computerise the whole process, and link the warehouse and central office by electronic networking.

The proposed model for immediate and future change must, in addition to simplifying the existing activities and data flow, create a new module for CR, which must be added to the IRS system. A CR can be inputted into the CR module by the sales person in the warehouse via a terminal, which is networked to the central office. The CR module allows the buyers to check and edit the CR, and then the procurement manager to approve the CR. The final approval of the CR is done by the senior manager and automatically recorded by the OC module. A hard copy of the OC is printed in the EDP Department. The clerk in the purchasing department collects the OC and distributes it as usual.

For improvements under future changes, the simplification of activities and data flow is essentially the same as that for the immediate change. However, the software configuration will be significantly upgraded. NovaSoft, an integrated system of document and workflow management solutions, see NovaSoft Web site: www.novasoft.com is recommended. NovaSoft registers with Oracle database and Oracle database interfaces with the IRS system. The CR is inputted into the Oracle database by the sales person from the warehouse. The data from the Oracle database passes to the NovaSoft system to initiate a CR request form. All the buyers checks and management approval of the CR are entirely within the NovaSoft system. Upon completion, the complete CR record in the NovaSoft system will be passed back to the Oracle database, and an OC automatically generates a hard copy from the OC module of the IRS system from the Oracle database.

The report will include the following: the current physical and logical DFDs, see Figures 3 and 4, the proposed logical and physical DFDs for the solution with immediate change, see Figures 5 and 6. The figures show all the flow of data amongst the physical entities, including persons and departments. They also show the flow of data along the essential functions of the system, at both the current and the proposed situations. The solution for immediate and future changes are both shown in graphical representation featuring the remedies required to meet short and long term goals, see Figures 7 and 8. The final business report must also describes the workflow, software configuration, hardware configuration, advantages and disadvantages of the proposed solutions.

Concluding comments

The case study presented was able to demonstrate the application of DFA as the BPM methodology for an SME in Hong Kong, and, at the same time, provided a useful basis for investigating DFA as a suitable BPM methodology for Hong Kong's SMEs in general. Hong Kong's business environment is highly dynamic and provides only tight space in which the SME's may survive and flourish. From a practical viewpoint, the simplicity, cost and efficiency of implementation of DFA enables DFA to compare favourably with other methodologies which are under the IDEF umbrella, see Kappes (1997) and Knowledge Based Systems Web site: www.idef.com for a full exposition of IDEF. It also compares favourably with the SAP/R3 framework, see Kirchmer (1998) and SAP AG Web site: www.sap.com

For many SMEs in Hong Kong, BPM exercises usually focus on business process re-design, rather than enterprise-wide integration of business processes. DFA is sufficient to cover a large number of situations. Business process re-design always calls for full commitment from top-management. Simple procedures involved in DFA can sometimes require controversial measures that must be implemented with greater care. Moreover, implementation of IDEF and SAP/R3 require considerable expertise as well as manpower.

At this stage of development of Hong Kong's SME's, the knowledge possessed by local SME analysts is not at the level of those in the large and multi-national companies. There also seems to be a lack of technical support in Hong Kong, that does not encourage the SME's to consider applications involving enterprise-wide modelling. DFD is one of the tools used in structured system

analysis and design, and is the required
methodology for software development in
both Hong Kong and British government
projects. DFA is possibly the most commonly
used method in Hong Kong's data processing
community, and most IT workers are
familiar with DFD, which is not the case with
IDEF and SAP/R3.

Despite the mentioned positive factors for
DFA, the methodology itself must, of course,
be adequate for performing BPM. BPM
requires the logical DFD to provide a means
of identifying the functional activities of the
whole or part of an enterprise, with the
current logical DFD representing the *as-is*
model, while the proposed logical DFD

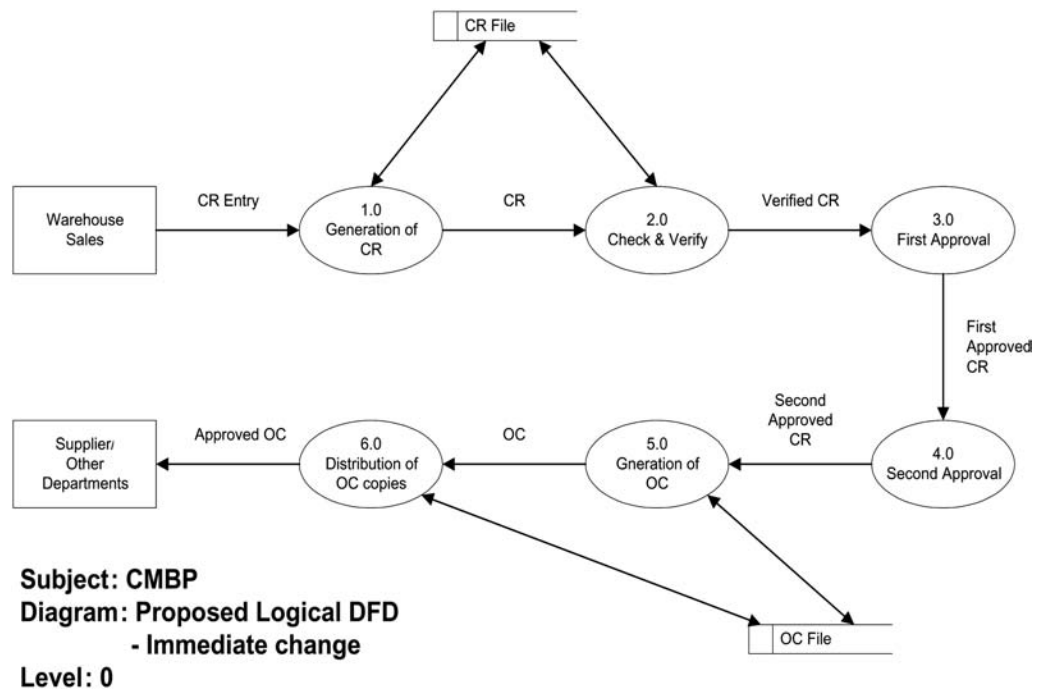**Figure 5**
Proposed logical DFD: level 0 (*to-be* model)
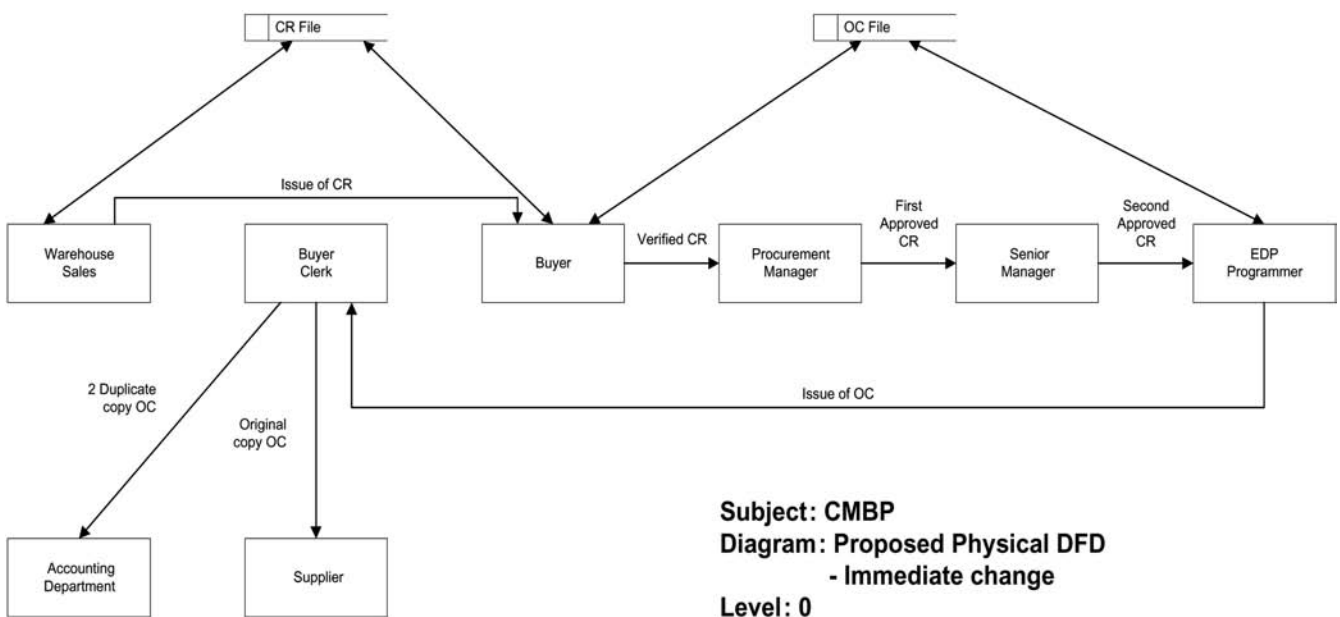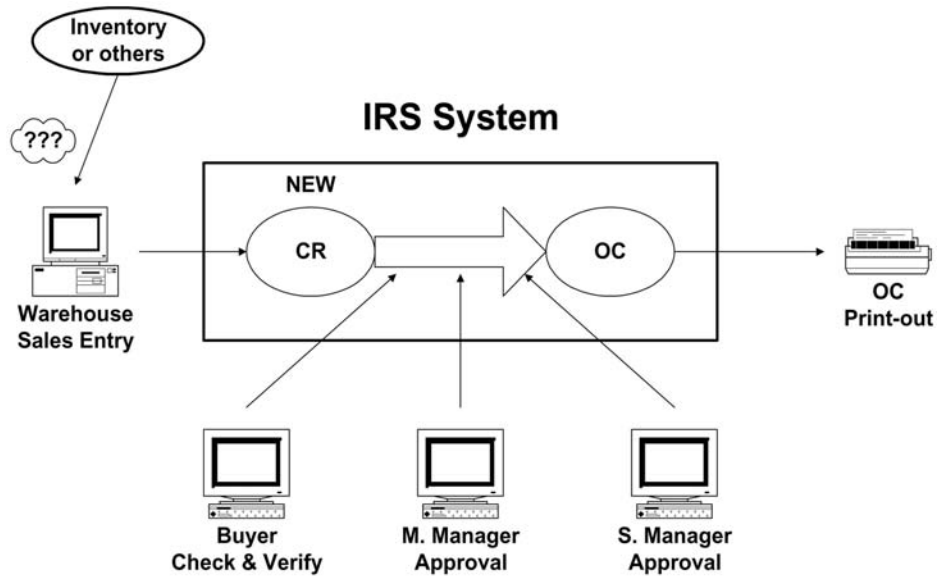

Figure 6
Proposed physical DFD: level 0

Figure 7
CMBP solution for an immediate change

Figure 8
CMBP solution for a future change

representing the *to-be* model. However, the physical DFD cannot totally fulfil the definition of BPM because it only identifies the physical entities but not the functional activities. Nevertheless, it is needed as it is a part in the transformation process of DFD.

As a modelling methodology, DFA has been criticised as having limited capabilities because of its function orientation and lack of precise specification for where and by whom the processes or activities are performed. Difficulties are encountered as the size of enterprise increases. In reality, as a BPM methodology, DFA does not provide a full set of modelling features and methods as outlined in Table I. Further refinements are required in the following areas: first, a detailed study of the basic features of BPM that are to be performed. These include the modelling capabilities, especially their abstraction modelling capabilities (e.g. specialisation and aggregation) and their domain of competency (function, information, resource, organisation, human skills and modelling aspects). Second, the mapping from BPM or named enterprise modelling to enterprise integration must be developed as outlined in Figure 1. Normally, for a business process that communicates with another business processes, two fundamental components are required. These are the integration platform with its integrating infrastructure (IPIS), and a business process model. The former components refer to the support, i.e. software and hardware, which allows communication between business processes. In effect, the above requirement refers to two or more business processes communicating with each other in the same language, and focuses on minimising the risk of misunderstandings. Third, DFA alone may be too weak in some situations such as financial analysis. The use of a sound methodology support such as IDEF with activity based costing (ABC) is seen as an important step in enhancing the capability of the analysis method. Such a methodology aims to seek a support analysis tool for merging with DFA to enhance the overall capability of the analysis.
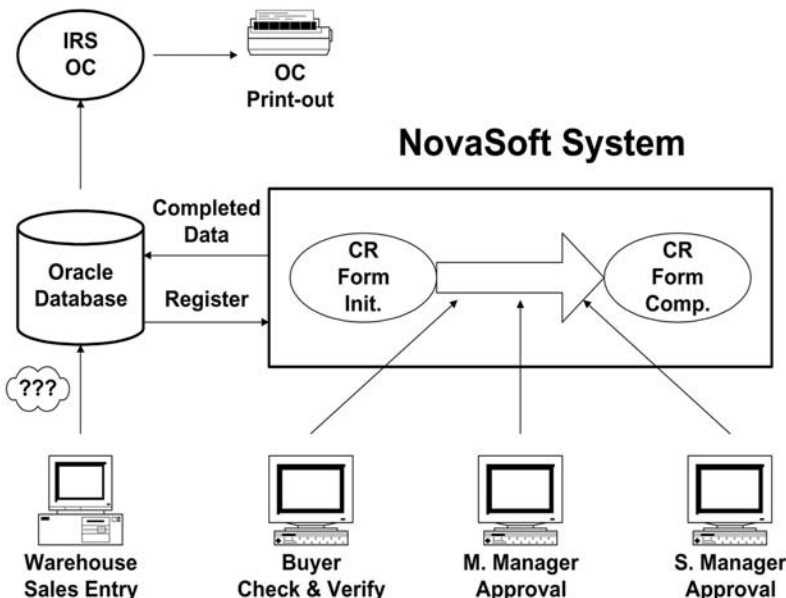
Table I
Evaluation of DFA modelling approach

Modelling features/modelling methods	DFA
Formal constructs/language	No
Abstraction mechanisms	
Specialisation/inheritance	No
Aggregation	No
Classification	No
Modelling views	
Functional/control view	Yes
Information view	Limited
Resources view	Limited
Organisation view	No
Human skills	No
Modelling support	
Modelling method	Few
CASE tools	Many
Modelling levels	
Requirements definition	Yes
Design specification	No
Implementation description	No
Object flows	
Control flow	No
Information flow	Limited
Material flow	Limited
Process modelling	
Event/process triggering mechanism	No
Separation between processes and activities	No
Process/resource decoupling	Yes
Control flow operators	No
Control issues	
Time	No
Exception handling	No
Non-determinism	No
Co-operative activities	No

This paper explored a novel use of the DFA
methodology for BPM in Hong Kong's SME's.
A case example illustrated the essential
procedures involved in the proposed
methodology, and it appears that the
proposed methodology is able to fulfil the
elementary requirement of BPM, i.e.
establishing the *as-is* and the *to-be* models to
generate re-engineering solutions. Software
implementation can also assisted by the
DFD's generated.

We concluded that DFA can be used in the
prosed novel context to undertake BPM
exercises. Other major advantages of the
approach are the reduced cost and efficiency
of implementation, which are, obviously,
important factors to be considered for many
SMEs in Hong Kong and other parts of the
world. However, in terms of a general
modelling methodology, DFA lacks the full
capabilities of the more sophisticated
methods such as IDEF and SAP/R3. At
present, there are not sufficient theoretical
research developments to extend the power
and capability of DFA as BPM methodology.

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