University of Strathclyde
Department of Mechanical Engineering
Energy Systems Research Unit

The Use of Electronic Data Interchange (EDI) In Energy Management

by
Apostolos M. Karatolios

A thesis presented in the fulfilment of
the requirements for the degree of
Master in Philosophy

Glasgow 2000

Table Of Contents

Acknowledgements

This thesis could not have been completed without the help and support of many people and institutions, to whom I am extremely grateful.

My gratitude is expressed to my supervisor Professor J. A. Clarke for his expert knowledge and guidance throughout the course of the project.

I wish to thank Mr Ron Hill of the planning and development department of North Lanarkshire Council for his advice and support.

My thanks are extended to the following members of ESRU for their advice and numerous useful discussions: Dr. P. Strachan, M. S. Evans, Jaemin Kim and J Hand.

Finally, my sincere thanks go to my family for their continual help and support during the course of my studies.

Abstract

This thesis deals with a substantial problem: the lack of reliable and robust information to support the ever more important function of energy management. Specifically, it investigates the use of a communication technology namely electronic data interchange [EDI], known as the computer to computer exchange of information via acceptable standards and communication links to address the problem of data collection and integration.

In recent years technology has progressed at an astounding pace. Computer hardware and software applications have reached a level of sophistication that few people could have foreseen. Consequently, information and the technology used for its exchange are a strategic concern in almost every organisation. Today's energy managers are confronted by an astounding array of issues and quantities of data relating to energy and environment.

The present work addresses approaches to the attainment of a robust and reliable information flow within and between organisations to support effective decision-making.

Electronic data interchange techniques for enhancing the integrity and reliability of information flow are developed and tested within two case studies.

Finally, the future work required to increase the applicability and accuracy of routing electronic data interchange is elaborated in terms of the required integration with other aspects of information technology.

Chapter 1

INTRODUCTION

"Energy management can be defined as the combination and application of business management and industrial organisation methods, to assist the optimal use of energy resources for effective task processing".

"Good information is essential to effective decision-making." [Robert Priddle IEA1999]

1.1 ENERGY MANAGEMENT

The need for energy efficiency, both for economic and environmental reasons, has never been greater. The International Energy Outlook 2000 [IEO2000] predicts that energy consumption will increase by 60% over period 1997 to 2020. Energy use worldwide will continue to grow at an average annual rate of 1.1% and by 2020 the world consumption will rise from 380 quadrillion British thermal units (Btu) in 1997 to 608 quadrillion Btu in 2020 (figure 1).

figure 1.1 *world energy consumption (Quadrillion Btu) 1970 – 2020*

It is the assumption of economic growth (especially in the developing world) that, more than any other factor, is the reason for the anticipated increase in energy demand.

The International Energy Outlook 2000 [IEO 2000] also points out that world carbon emissions are projected to rise from 6.2 billion metric tons in 1997 to 8.1 billion metric tons in 2010 and 10.0 billion metric tons in 2020. In this forecast, world carbon emissions exceed their 1990 levels by 40% in 2010 and by 72% in 2020 (figure 2). Emissions in the industrialised world grow by 1.1 billion metric tons between 1990 and 2020, with nearly one-half of the increment attributed to an increase in natural gas use.

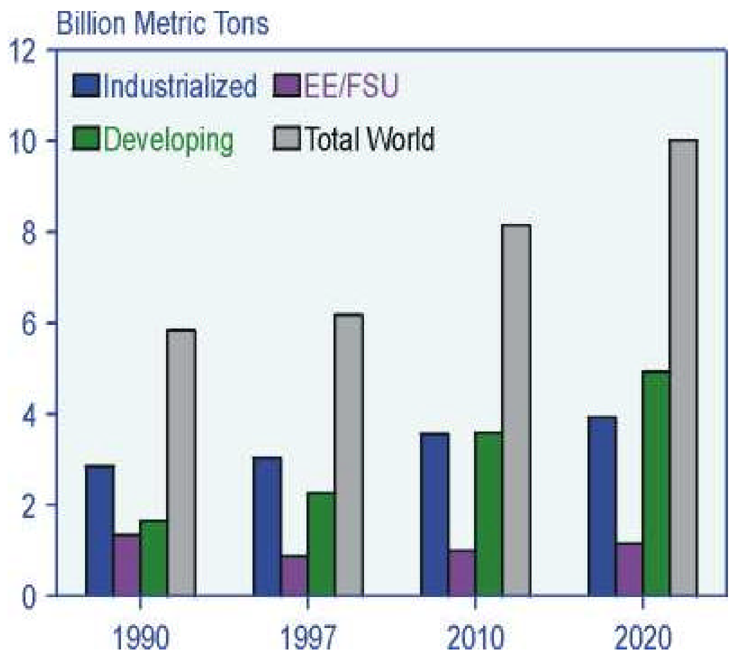


figure 2.2: *World Carbon Emissions by Region, 1990-2020*

Confronting this growing world energy demand raises two questions. Will there be enough energy available, and in what forms? Reassuringly, there appears to be no prospect of absolute shortage, at least for the next twenty or thirty years and probably beyond. Fossil energy resources are still abundant: for example, the cumulative production of natural gas has used only one sixth of the 325 trillion cubic metres of known reserves. Coal reserves are even larger, providing a basis for continuous production for hundreds of years. Known uranium resources, even on the basis of present knowledge, could meet the current level of demand for a period of 8000 years if advanced nuclear technology is developed [IEA 1997].

Consideration of energy in relation to the built environment throughout the world's developed countries reveals that 20 – 55% of all delivered energy can be directly associated with buildings and industry [IEA 1994a and 1994b]. Consequently, new technologies applied to the build environment and industry may be expected to make a significant contribution to a reduction in energy consumption. By raising the efficiency of energy utilisation, it is possible to reduce energy consumption by 10 – 30%, representing a saving of around 3Mtce per year [DTI 1994].

Some progress has been made in recent years as building energy management (sensors, HVAC control equipment) and information technology (IT) systems have evolved to a point where they can support and integrate the activities involved in energy management. With respect to environmental impact and economics, the ability to make well–founded decisions regarding energy consumption and supply is of the utmost importance. This requires some means to assess the current performance and agreed targets against which to judge performance.

1.2 ENERGY MANAGEMENT: TARGETS AND BENEFITS

Energy targets are required:

- to ensure energy is available to satisfy all demands;
- to ensure energy is used and supplied with minimal cost/ environmental impact;
- to ensure energy is not wasted.

The challenge of achieving these targets is the driving force for the development of computer-based energy management tools that enable users to understand how energy is consumed within their properties and how they can improve the use of energy resources for effective task processing.

The Energy Efficiency Initiative, a report published by the IEA [Danish Energy Agency and the Energy Charter 1999], identified four most essential elements of a coherent framework for effective energy management policies.

1. Focus market interest on energy efficiency

   Actions include: fostering voluntary agreements; establishing and enforcing building codes and minimum energy performance standards; integrating energy efficiency in procurement practices; and using government purchasing to stimulate the market for advanced technology.

2. Ensure access to good technology

   Actions include: encouraging the development, adaptation and diffusion of energy efficient technology; improving district heating systems; and expanding the use of combined heat and power.

3. Develop and maintain a supportive institutional framework

   Actions include: integrating energy efficiency in sectoral policies; and ensuring the availability of impartial expertise.

4. Act to ensure continuity

   Actions include: establishing policy clarity; demonstrating leadership; implementing effective evaluation and monitoring techniques; and strengthening international collaboration.

Energy management is the act of reducing the consumption of energy whilst maintaining or improving the standard of service.

1.3 DECISION SUPPORT SYSTEMS

As the energy management function grows in complexity, computer based “information systems” have been developed to support the process. These systems are able to record and monitor energy consumption, and to analyse data in such a way as to highlight any deviation from the normal based on historical trends and patterns. Realistic targets for reductions can then be set.

Eight per cent of an energy manager’s day is dedicated to information receiving, communicating and use in support of a wide variety of tasks. Since information is the basis for virtually all activities performed in an organisation, systems are required to produce and manage it. The objective of such a system is to ensure that reliable and accurate information is available and presented in a useable and understandable form [James A. Senn 1985].

The term "Information System" is formally defined by Niv Ahituv and Seev Neumann [1983] as:

> *'… a set of people, data and procedures that work together. Giving a particular emphasis on systems means that the various components seek a common objective of supporting activities like communication of information, management activities and decision-making.'*

As many organisations today possess one or more of these information systems, they can be considered to have some degree of intelligence. Energy management must therefore cover a broad spectrum of capabilities.

A decision support system provides three functions. Firstly, it accepts data from internal or external sources. Secondly, it acts on data to produce information. Finally, it produces information for the intended users. Examples of the use of information systems can be found throughout the industry. In each case, the nature of the activity, in terms of processing data to provide the information needed by users, is the same, although the procedures may vary. *Emodel* is an application that integrates data processing, graphing and regression modelling. Emodel can determine baseline energy use to determine retrofit savings and help to identify operational and maintenance problems [Energy Systems Laboratory, Texas A&M University 1997]. *Enforma* is an application designed to cost-effectively gather data and convert it into information about building performance [Architectural Energy Corporation, USA 1999]. *Interlane* is designed to meet the energy management needs of commercial and small industrial businesses. When added to an existing meter, Interlane Power Manager provides users with monitoring and control of their energy [TeCom Inc, Florida 1999]. In the UK the *TEAM* system is in widespread use for energy management. The system comprises three windows-based applications for energy accounting, automatic monitoring and contract tariff analysis [Energy Auditing Agency Ltd, UK 1998]. Appendix I summarises the features of the TEAM package.

These applications are currently being deployed in different organisations worldwide to support energy related decision-making. However, issues of sustainability are requiring ever more sophisticated decision support.

1.4 "ADVANCED DECISION SUPPORT SYSTEMS": THE NEED

Although contemporary decision support systems can be effective, they are built on top of a poorly designed data entry model. Therefore they have difficulties to integrate high frequency, multi-aspect data. When applied to the multi-variable issue of sustainability, it is likely that these systems will produce results that are incomplete and therefore likely to mislead. Even the most sophisticated system, will be unable to produce meaningful and robust information in terms of data analysis, if the underlying database is incomplete. Such systems may operate well when applied within the limits of their initial design, but they will not be able to offer multi-variable information support or operate co-operatively with other applications for financial appraisal or geographical information display, for example.

One example of an advanced decision support system is the EnTrack package developed by ESRU - the Energy Systems Research Unit at the University of Strathclyde. EnTrack offers all the functionality of a conventional energy management system for monitoring and targeting whilst undertaking the simulation of energy supply systems and the demand side efficiency measures. The system also allows users to track and analyse building performance at variable frequency and to formulate and implement intervention measures that improve the performance of the entity. Finally, EnTrack theoretically provides an open ended architecture to support integration with new communication technologies for electronic data transfer. This feature of EnTrack will be the subject of the next two chapters.

1.5 INFORMATION EXPLOSION

The noncommittal way by which information is provided through the available data resources (e.g. Internet) has lead to an information explosion. This situation is crucial because a discrepancy between reality and organisational expectations of data reliability and confidentiality has been created. Unfortunately, even advanced decision support systems like EnTrack do not solve the problem of information overflow. This occurs because information explosion results in large and complex databases that are extremely difficult to manipulate and analyse. Consequently, the effectiveness of the information produced is limited. It is therefore necessary to introduce relative order by evolving the basic data entry module of such information systems.

In this research the use electronic data interchange (EDI) to overcome the problems of information explosion is explored. The Electronic Commerce Association [ECA 1998] has defined EDI as: ***"…the computer to computer transfer of information in a nationally standard, pre-determined format".***

A more generic definition of EDI is offered by Emmelhainz (1990): ***"…the inter-organisational exchange of business documentation in a structured, machine processable form".***

Figure 1.3 is showing the main concept of using the Electronic Data Interchange [EDI] communication technology to overcome the barrier of information flow from the source to the system.

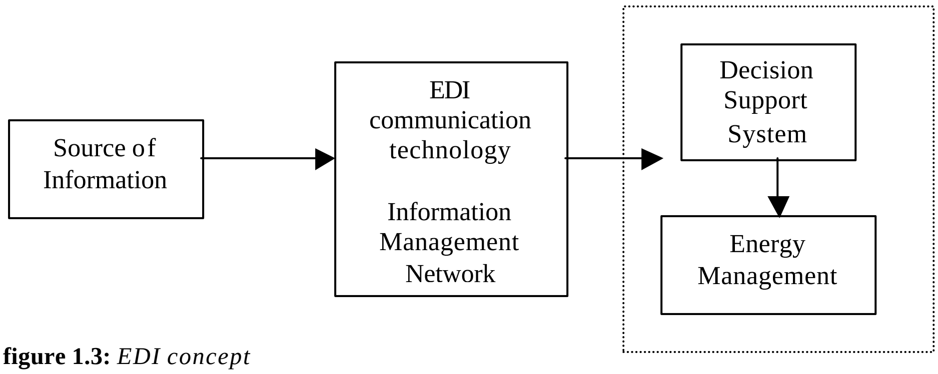


figure 1.3: *EDI concept*

Technically there are three main components that must be addressed before electronic exchange can commence.

Standards: EDI standards define the techniques for structuring data into the electronic message equivalents of paper-based documents. In other words there are standardised methods for describing the components that make up a trading document, e.g. product code, price, name, address etc.

Software: EDI management or translation software is designed to translate messages as they move from standard to internal formats and vice versa. EDI messages between trading partners can move directly to the application software.

Communications: The communications infrastructure required for electronic trading is analogous to the pipe work of the process, that enables messages to flow between trading partners. Different options are available, such as exchange of discs or tapes, private networks etc. However, most UK organisations now engage the services of a third party network operator who operate a VAN (Value Added Network).

The evaluation of the approach that the communication technology uses to enable this kind of interaction is the subject of this thesis.

1.6 OBJECTIVES AND OUTLINE OF THE PRESENT WORK

The present research addresses the following vision of energy management possibilities:

- Advances in computer technology will allow a radical new approach to decision-making in which information technology will play an integral part. New communication technologies based on the Internet will allow the robust and reliable exchange of information.
- In order for advanced decision support systems to be fully utilised by the communication technologies, a number of existing barriers and deficiencies in the existing structure of the IT tools must be overcome.

Consequently, this research work encompassed the following specific objectives:

- to study the requirements of the communication technology [EDI] for data transfer;
- to employ the communication technology [EDI] in conjunction with advanced decision support IT tools for energy management;
- to implement, validate and verify the above when incorporated within different types of user environments.

Outline

Chapter 2 describes one advanced decision support system, with the focus on its database integration, maintenance and analysis features. Chapter 3 identifies the essential features of an EDI enabled approach and describes the structure and development of an EDI taxonomy for data communication between applications. Chapter 4 addresses the issue of applicability of the EDI enabled approach using a number of case studies involving Highland Region Council (HRC), North Lanarkshire Council (NLC) and Strathclyde University in Glasgow. Chapter 5 describes the future possibility of a web-based EDI implementation. Finally, Chapter 6 presents the project’s conclusions and indicates possible directions for further work.

References:

James A. Senn, **Information Systems in Management**, *Wadsworth Publishing Company, Belmont, California (1988).*

Niv Ahituv, Seev Neumann, **Principles of Information Systems for Management,** *WCB/ McGraw-Hill (1990)*

Margarett A. Emmelhainz, **EDI: A total management guide,** *(1990).*

http://www.iea.org/, *International Energy Agency, (energy year outlook 2000).*

http://www.esru.strath.ac.uk, *Energy Links*

http://www.archenergy.com, *Enforma*

http://www-esl.tamu.edu, *Emodel*

http://www.tecom.net, *Interlane*

Bibliography

Karatolios M, A, **Overall Evaluation of the Role of IT in Energy Management**, *ESRU, University of Strathclyde, Thesis (1997).*

Kenneth Bamborough, **Information and information systems for the management of energy in buildings.** *ESRU, University of Strathclyde, Thesis (1993).*

Chapter 2

ENTRACK PROGRAM

The needs for energy sustainability and environmental control, and the traditional approaches have been discussed in chapter 1. It was found that the main disadvantages to decision support of many of the commonly adopted approaches focus on the issues of integrity and containment of information. It was argued that what is required is an advance decision support program capable of maintaining the integrity of the information that is communicated at different level has of abstraction.

This chapter describes a system, EnTrack, which facilitates an integrated approach to communicating information. A review of the system's capabilities is given, followed by a description of possible ways of communicating and integrating data employing electronic data interchange (EDI) methods.

2.1 INTRODUCTION

EnTrack is designed to allow resource managers to track and analyse system performance over time and thereby to formulate effective intervention measures to improve the performance of the entity. In practice, it can also be applied strategically in order to establish broad policy, or tactically in order to investigate particular design and operational changes. It should be noted that although the system has been primarily developed as a building energy tracking tool, employing effective and efficient management of energy, the system can also track information that is not necessarily building or energy related, e.g. water consumption, vehicle fuel data and the like.

EnTrack has been created in a manner that allows the analysis and comparison of supply against demand energy streams in order that similarly matched profiles may be brought together for further evaluation and possible integration.

Additionally, EnTrack can be used to undertake the constant monitoring and integration of information on property and renewable energy schemes, trend analysis and targeting. Finally, EnTrack is GIS[1.] compatible. This offers the ability to match and correlate supply to demand energy streams on a temporal and spatial basis.

2.1.1 EnTrack functionality

EnTrack is a new generation M&T system containing three interrelating program modules for monitoring, prediction and targeting. In conjunction with the provision of these main features, EnTrack has been developed to offer the following additional capabilities:

- a database scoping facility to allow the definition of groups of entities with a similar function or geographical location, for processing as a single entity;
- GIS compatibility;
- the ability to configure specific user requirements such as reporting screens for tariff analysis, project cost evaluation, environmental emissions etc.;
- entity classification by fuel consumption for support of selective resource targeting;
- forecasting based on simulation techniques using regression equations formed from historical fuel consumption data and mathematical models of the various renewable energy technologies;
- a range of target setting aids from simple NPI classifications, through trend analysis to full simulations of future demand against user-specified assumptions;
- demand and supply profile matching for either single or hybrid renewable energy schemes designed for both autonomous or grid connected applications.

[1.] Geographical Information System

2.1.2 Technical characteristics

The system comprises two principal components: a data collection and processing standard, and a software package for the storage, manipulation and analysis of the data in support of fuel use management. The software package is built on top of a progressive database design that provides many advanced data management features [Evans 2000]. Data of any frequency, detail and type may be recorded, and geographical maps can be used to improve effective user interaction. A targeting module can be used to devise consumption targets and to determine appropriate design interventions.

Targeting is enhanced by making use of predictor equations, derived from analysing building performance and characteristics, and from reference to EnTrack's entity classification procedures. The system in its current form utilises a combination of mouse controlled sensitised maps and characters in conjunction with related pop-up menus for system navigational purposes. These provide the means of access to a wide range of analysis and report production facilities. Keyboard interaction is employed for basic data entry.

2.2 ENTRACK ENVIRONMENT

EnTrack operates in graphical, interactive mode via menu driven command selection. The system has a modular structure comprising several interrelated sections as depicted in figure 2.1. Essentially, it is composed of four main modules:

- The Database Maintenance module, on which this research is focused in terms of the system's needs for automatic data importation and integration. This module has a data capture schema covering entity description parameters and fuel consumption. In addition, climate and environmental information are included.
- Data Selection performs database scanning to select and focus on a specific range of data according to the problem defined. EnTrack's flexibility in the selection of information permits the aggregation or desegregation of entities, thus allowing particular aspects of energy management to be explained.
- Modelling provides the possibility to conceive demand/supply targets and to determine appropriate design interventions to attain them. Furthermore, targeting requires the use of predictor equations derived from the stored fuel consumption dates in order to analyse entity performance.
- The analysis and Report module is responsible for the evaluation and the transformation of the selected data into useful information. Data analysis involves graphical reporting, target establishment, classification and comparisons of performances of entities.

The interaction between the four modules can be continuous in order to help the user with the decision making process. In other words, the user analyses the results, changes some parameters of the problem, and executes selections and forecasting in an iterative loop.

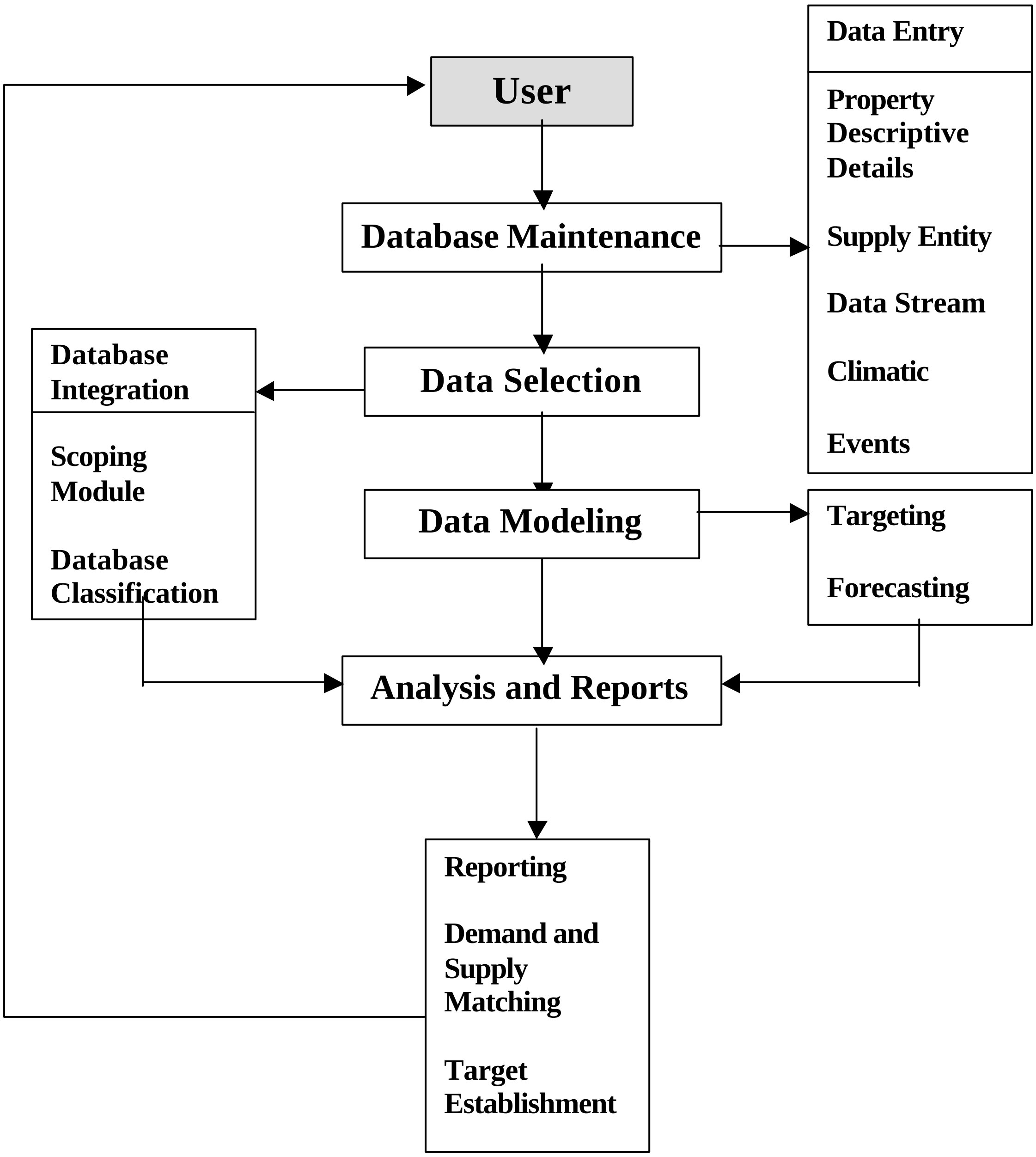


figure 2.1 *Main EnTrack functions.*

2.3 DATABASE MAINTENANCE MODULE

It is stressed that the most important component of any energy management decision support IT tool is the data collection and maintenance module because of its impact on data flow management. Using an inadequately designed and managed data collection system will produce results that are suspect and, more likely, results that are inaccurate and misleading. A most excellent system on data analysis cannot produce meaningful and robust information if the data input is unreliable. In the previous chapter it was stated that EDI constitutes an enabling technology for information flow management in decision support IT systems.

Thus, the purpose of this section is to present the potential of integrating EDI into future decision support tools. A possible way of achieving this is by focusing on the EnTrack system's data entry requirements and examining its internal database structures from the viewpoint of data flow automation.

As illustrated in figure 2.2, EnTrack's database maintenance module comprises four basic data categories. Each category contains a number of databases that are responsible for the availability of information in the data selection and analysis module. These databases are property descriptive details, energy consumption data, both for supply and demand, and climatic data in terms of degree-days.

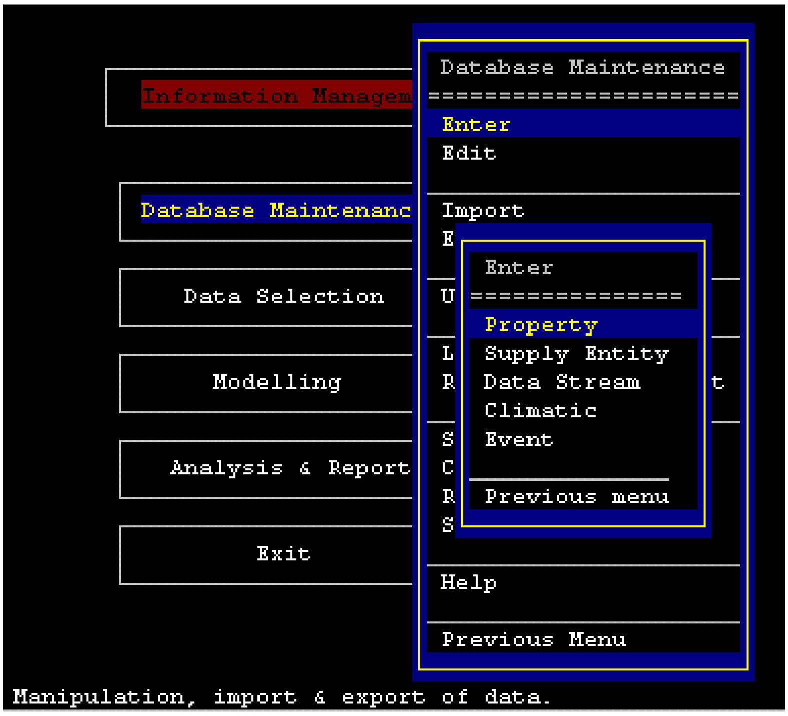


figure 2.2: *EnTrack data maintenance function*

2.3.1 Property descriptive details database

The EnTrack program uses a basic data entry database to store information regarding all the descriptive details of an entity. The purpose of this database is to provide the system with information, such as the reference of an entity or the number of buildings the entity includes. Also, information regarding technical characteristics of the entity (construction materials, thermal transmittance, floor area, volume, exposure etc) as well as details of its geographical location (state, address, post code etc) is included. Finally, information about the types of the control systems regarding the use of energy within the buildings is also available.

Table 2.1 shows the contents of the property descriptive details database. Basically, data fields, which represent data segments of a transaction set [see chapter 3 p.3.2.2], are separated into two categories. The first involves data that is imported by the user once and is common for all the properties that a dataset can handle. The second involves data that is entered by the user and may differ for each property of the dataset.

Reference			user-defined selection		
Code 1			user-defined selection		
Code 2			user-defined selection		
Code 3			user-defined selection		
Code 4			pre-defined selection		
Code 5			pre-defined selection		
Code 7			user-defined selection		
Name			user entry		
Location			user entry		
Post Code			user entry		
Function			user entry		
Building No			user entry	set limits 1-50	
Year Built			user entry	set limits 1700 - 2300	
No Floors			user entry	set limits 1-26	
Exposure			pre-defined selection		
Enclosed Volume (m)			user entry		
Enclosed Area (m^2)			user entry		
Heated Volume (m^2)			user entry		
Heated Area (m^2)			user entry		
Exposed surface area -	user entry				
	Roof		user entry		
	Floor		user entry		
Fenestration - Vert	user entry				
(%)	Horiz		user entry		
Thermal transmittance	Wall		user entry		
(W/m^2C)	Roof		user entry		
	Floor		user entry		
	Rooflights		user entry		
	Windows		user entry		
Energy Control			Thermal	Lighting	Power
Systems -	manual		user entry	user entry	user entry
(YIN)	timeswitch		user entry	user entry	user entry
	timer		user entry	user entry	user entry
	programmable		user entry	user entry	user entry
	BEMS		user entry	user entry	user entry
Control Setpoint	1		user entry		
(Deg C)	2		user entry		
	3		user entry		
Primary Heating			pre-defined selection		
Secondary Heating			pre-defined selection		
Operating Periods			pre-defined selection		
Fuel Type & Usage -	Heating		pre-defined selection I	pre-defined selection 2	
	Water		pre-defined selection 1	pre-defined selection 2	
	Tech Lab		pre-defined selection I	pre-defined selection 2	
	Catering		pre-defined selection 1	pre-defined selection 2	
	Laundry		pre-defined selection 1	pre-defined selection 2	
	Other		pre-defined selection l	pre-defined selection 2	
Fuel Storage -	Oil	user entry	% unturned : user entry	number tanks : user entry	
Capacity	Solid	user entry	% unturned user entry:		
	LPG	user entry			

Table II.1: *Property Descriptive details interface synopsis*

Theoretically, EDI provides the potential to integrate both categories of data fields during the initiation of the dataset. However, the system requirements for dataset initiation are only 10% of the data fields shown in table 2.1, and are summarised as follows:

- **reference number**, where the system refers to a specified entity during processing;
- **building number**, indirect identifier of the meter holder;
- **code 5**, (demand-side, supply-side).

Considering the above, it is more efficient at this stage of development to automatically imported and maintained the second category data segment by EDI because in this case 85% of the data fields will be automatically covered. As a result of this, complex datasets can be remotely accessed and integrated easily into the system.

A similar database has been utilised to hold the supplier's details such as the site type (hydroelectric, photovoltaic etc).

2.3.2 Fuel streams details database

The most important database that EnTrack employs relates to fuel consumption information. This database includes information regarding the energy consumption of an entity and the dates over which this consumption occurred. In addition, the database includes the details on the type of the fuel, the supplier and a reference to the associated entity. Also, information about the source of the energy stream is available (meter name, type and identification, tariffs, meter dials, certification dates etc).

DATA ENTRY	ELECTRICITY		
Reference		pre-defined selection	Essential
Date		user entry	Essential
Type (Fuel Index No)		pre-defined selection	Essential
Source (Energy Stream)		pre-defined selection	Essential
Account		user entry	
Tariff		user-defined selection	
Building No		user entry	Essential
Meter id		user entry	
CRT Date		user entry	
Reading Type		user-defined selection	
Day Meter		user entry	
Day Advance		user entry	
Night/Eve Meter		user entry	
Night Advance		user entry	
Eve/Weekend Advance		user entry	
MD Day		user entry	
MD Night		user entry	
React kVAR		user entry	
Capacity		user entry	
Power Factor		user entry	
Total Units		calculated value	
Cost		user entry	
Cost / Unit		calculated value	

Table II.2: *Fuel streams details interface synopsis*

Table 2.2 illustrates the contents of the fuel streams database in terms of electricity. This database holds a new category of data segment relating to

EnTrack's inbuilt mathematical equations. Although this database of calculated values holds similar data fields as the previously described database, the philosophy of the two categories are different. In this database user entries are imported each time a new set of fuel consumption is recorded by the meters. At this point EDI is considered as a necessary communication media for importing and updating data automatically. The system requirements for dataset initiation are the 20% of data fields marked as "essential" in table 2.2. However, best performance of the system requires all data fields to be associated with the EDI preferences.

Finally EnTrack employs databases for climatic data and environmental data relating to CO_2 emissions. EDI provides the ability to remotely access climate data and to integrate these data into EnTrack in support of data analysis and simulation based studies.

2.4 DATA ENTRY METHODS

In general, decision support systems employ two interfaces for data importation. Data can be populated manually via the keyboard and automatically using a standard format import module provided by the system.

2.4.1 Manual importation

The procedure followed in EnTrack for conventional importation involves meter reading and collection of invoice data, which are then entered into the system via the keyboard. This is realised in EnTrack using the two interfaces shown in figures 2.3 and 2.4. The procedure for manual population of new data consists of two steps.

Firstly, the user is requested to enter the descriptive details of the entity in order for EnTrack to register the new entity under a specified reference number. Most of the descriptive details are populated only once since these do not change over time.

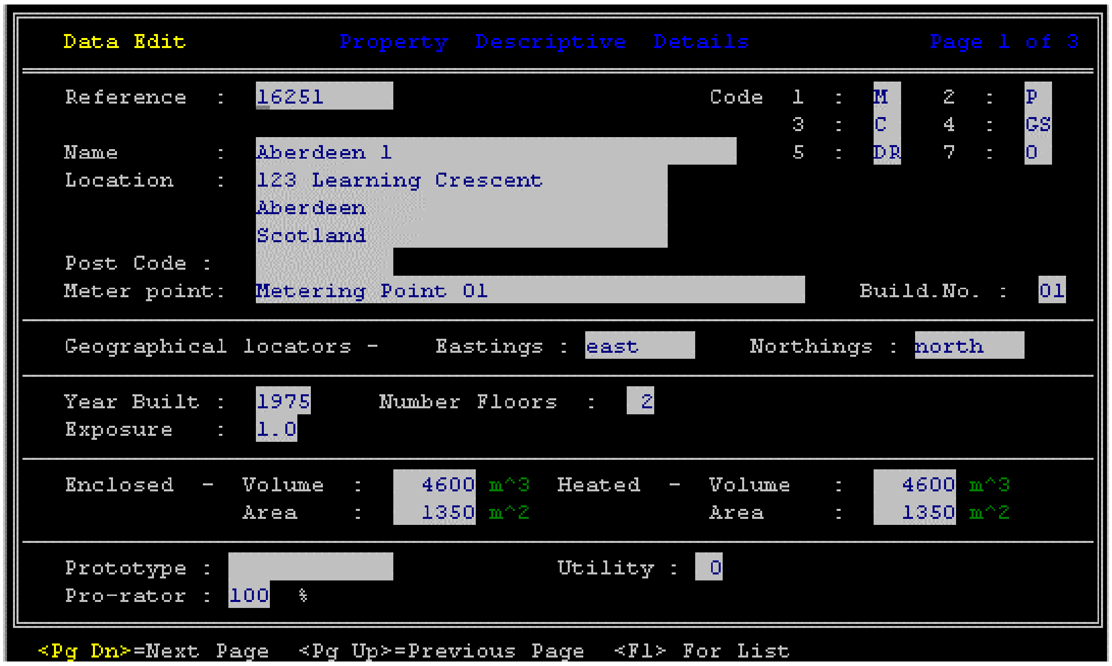


figure 2.3: *Property descriptive details interface*

Secondly, after the descriptive details of the new entity are stored, the user needs to enter the associated energy details by date. Additional information regarding the fuel type, the number of buildings included in the entity and the meters identities are also requested. After each new entity has been entered a system tidy is performed in order to integrate the new data within the system.

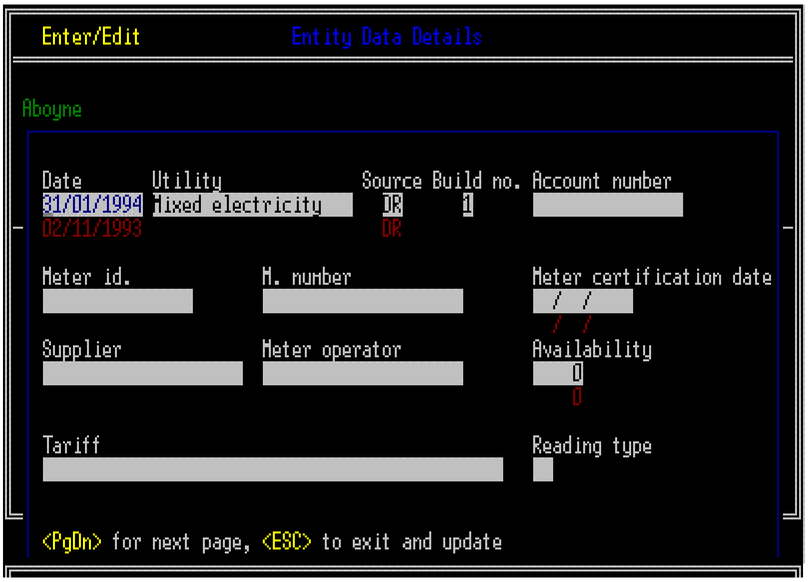


figure 2.4: *Entity fuel data details interface*

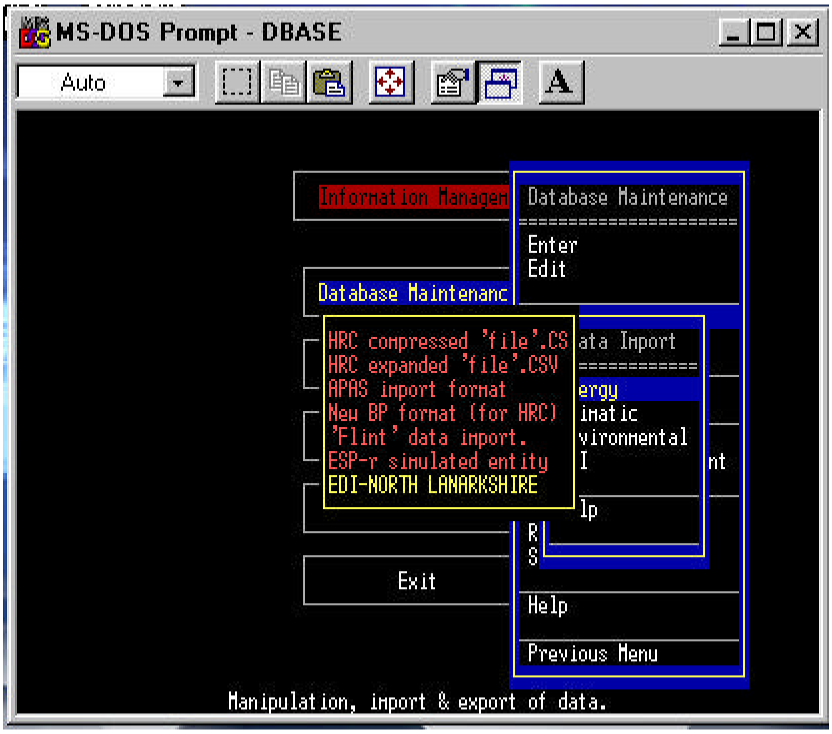


figure 2.5: *Supported suppliers*

2.4.2 Automatic importation

Automatic importation constitutes the doorway by which EDI communicates with the system. In general, the automatic system allows the meters to be connected via data loggers or other suitable interface, allowing the energy consumption to be monitored remotely by other applications. EDI uses its own communication protocols via a pre-defined network.

The method employed by EnTrack in order to automatically import data is based on a generic communication gateway. From this gateway EnTrack asks the user to define the preferences according to which the data will be accessed (provider, transaction type etc)

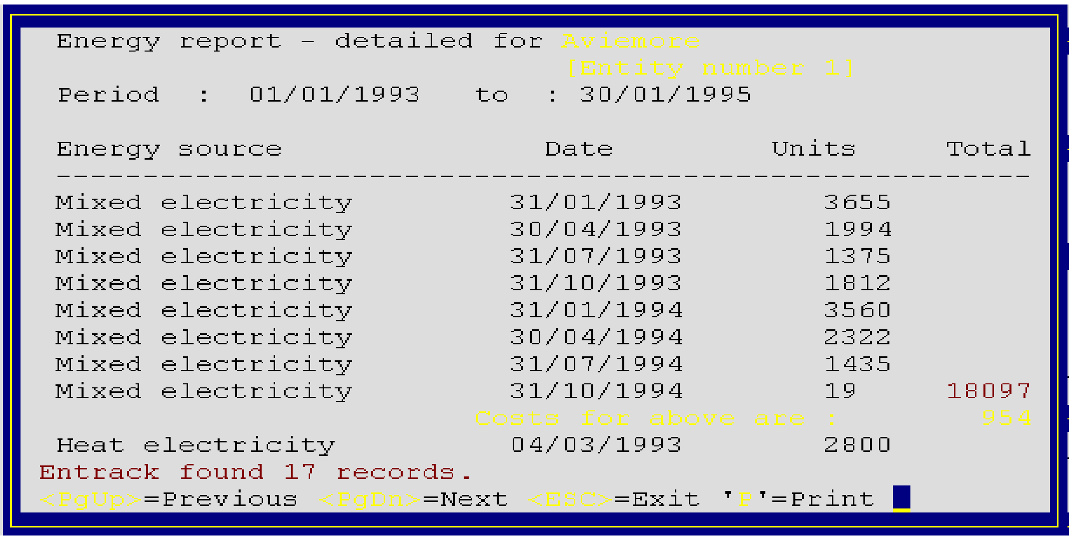
At this stage the user has to choose from a range of text and comma separated file formats for automatic importation of energy data. The procedure consists of two steps. Firstly, EnTrack requires the type of data that will be imported (energy, climate, environmental). The user has to then choose the appropriate file format from a list (figure 2.5). These file formats are preassociated with the datasets that EnTrack manipulates. The second step embodies the internal manipulation of the file for data processing by the EnTrack system. When the importation of data concludes, the user has again to run a system tidy for full data integration. The research into EDI communication technology has revealed that it is possible to obtain from the EDI network, both standard and non-standard energy data files. With the development of a processing routine in EnTrack's engine these files can be completely associated with a current EnTrack database.

2.5 DATA SELECTION

EnTrack has a capability to define specified groups of data with similar functions for collective analysis. This capability is called *data scoping*. These groups can be defined through their common characteristics in terms of dates, functionality, geographical location, fuel type, meter reference etc. However, these data groups must be located within the system's databases. EDI can provide the ability to remotely access other data types. As a result of this the analysis is more robust since there is an interaction of a wider spectrum of data types. After the group of data is defined, the EnTrack processor analyses it, as if it was a single entity. This data scoping facility is supported by EnTrack's flexible database structure whereby a significant number of fields are available for selection to control subsequent complex search procedures.

2.7 ANALYSIS AND MANIPULATION MODULE

EnTrack possesses a flexible reporting facility that can tailor system outputs to a variety of needs. Output presentations are available through a number of textual or graphical reports. Information is available to show the different fuel consumption over a period of time or the amount of gaseous emissions causing environmental impact. Again, EDI provides an opportunity for a more detailed and efficient analysis due to the wider spectrum of data that is available through the network. Furthermore, the user is able to use the scoping facility in combination with remotely accessed databases to determine the range of the entities that will be assessed and the duration over which this assessment will occur. Figure 2.6 shows a sample of written reports produced for a specific entity's electricity consumption.



```
Energy report - detailed for Aviemore
                                [Entity number 1]
Period  :  01/01/1993   to  : 30/01/1995

Energy source                 Date          Units       Total
-------------------------------------------------------------
Mixed electricity           31/01/1993        3655
Mixed electricity           30/04/1993        1994
Mixed electricity           31/07/1993        1375
Mixed electricity           31/10/1993        1812
Mixed electricity           31/01/1994        3560
Mixed electricity           30/04/1994        2322
Mixed electricity           31/07/1994        1435
Mixed electricity           31/10/1994        19          18097
                          Costs for above are :             954
Heat electricity            04/03/1993        2800
Entrack found 17 records.
<PgUp>=Previous <PgDn>=Next <ESC>=Exit 'P'=Print
```

figure 2.6: *Detailed energy report*

2.6 MODELLING AND TARGETING

EnTrack has a modelling module to simulate future demands against user-specified assumptions. This facility enables EnTrack to undertake a trend analysis and set future targets. A targeting module also exists which can be used to devise demand / supply targets and to determine appropriate design interventions to attain them. Targeting is enabled by the existence of predictor equations, derived from historical entity data, and from reference to EnTrack's entity classification procedures. Once more EDI, by enabling the user to remotely access other databases, gives the opportunity of deriving a more enhanced predictor equation since the analysis is based on a greater number entity observations.

In order to display the targeting outcomes, an entity is selected for processing according to the following steps.

- selection of data, used for the production of prediction equations, which is enabled through the scoping facility described previously;

- an automated multi linear regression procedure (figure 2.7).

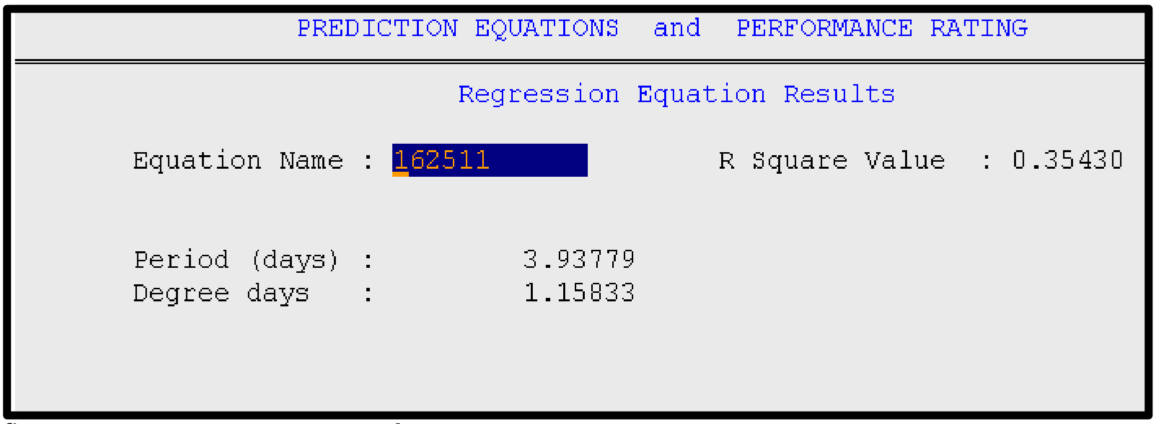


figure 2.7: *Regression equation result*

From the results of the regression analysis EnTrack is able to produce statistics in likely future performances, thus assisting in the setting of targets. The outcome of this targeting exercise may be expressed in different formats as follows:

- scatter graph (figure 2.8);
- bar chart (figure 2.9);
- CUSUM graph (figure 2.10);

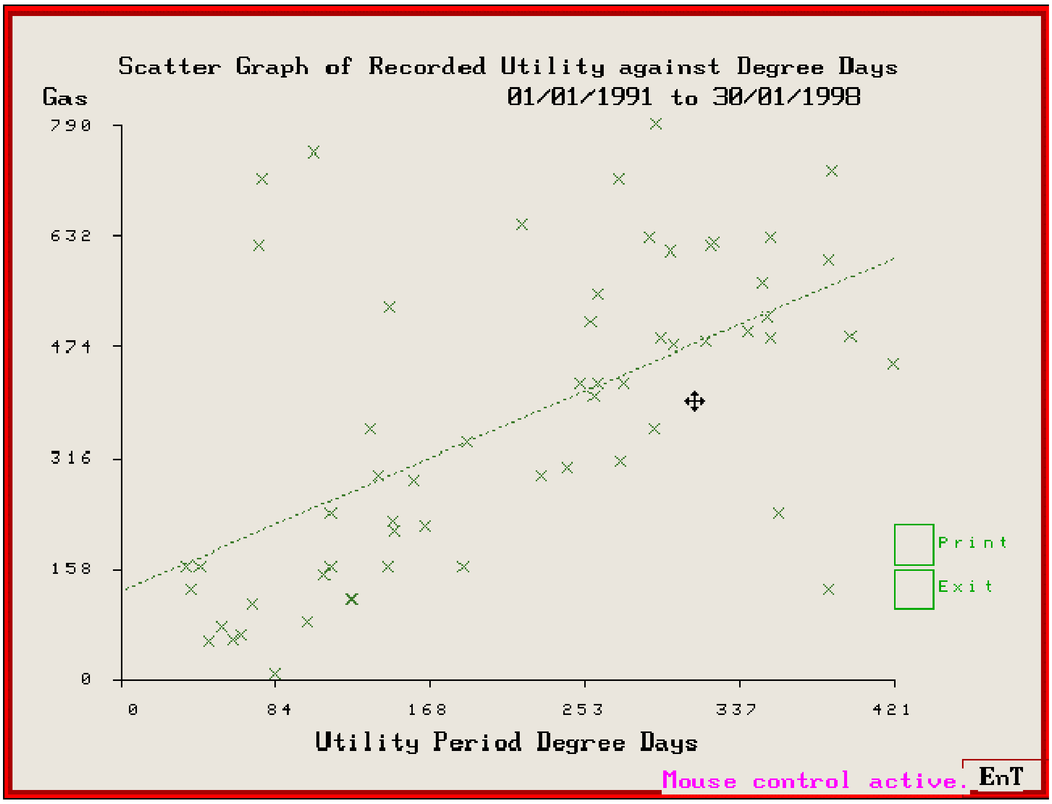


figure 2.8: *Scatter graph of utility recorded upon degree days*

Figure 2.7 show the recorded energy consumption against degree-days to which has been fitted a best fit relationship to represent the entity's performance against climate.

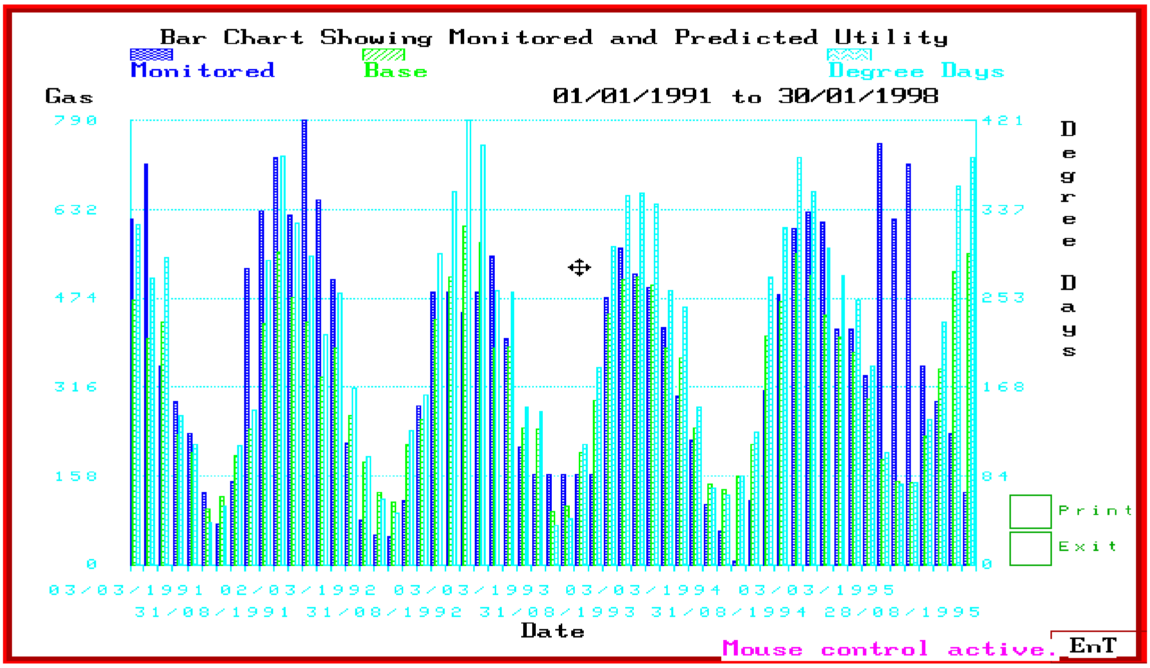


figure 2.9: *Bar chart showing predicted and monitored utility*

In figure 2.9 both the monitored and predicted energy consumption of an entity (or set of entities) is shown over a period of time and in relation to degree-days. In this regard EDI may be used to increase the system's flexibility by supporting the merging of real and simulated data produced by different organisations. This possibility is exemplified in figure 2.9.1 and 2.9.2.

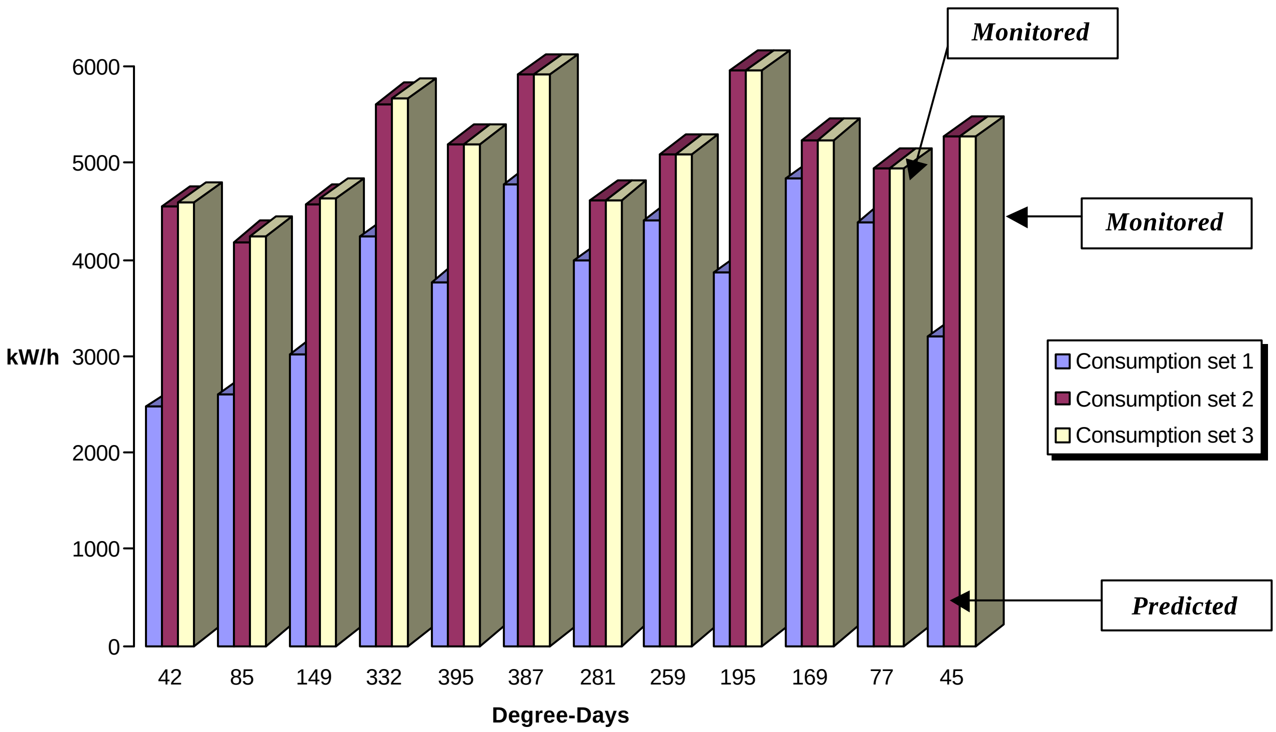


figure 2.9.1: *Energy over climatic variations*

Figure 2.9.1 shows a comparison of the monitored performance of two or more entities against the predicted performance over the climatic variation.

In figure 2.9.2 the percentage of energy use of four monitored and one predicted entity is displayed. This is possible because the user is able to access more than one database via the EDI network.

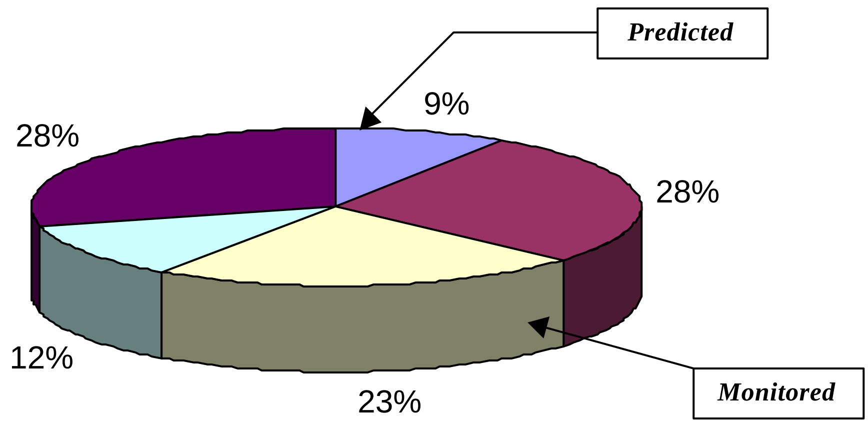


figure 2.9.2: *Energy usage percentage over a year*

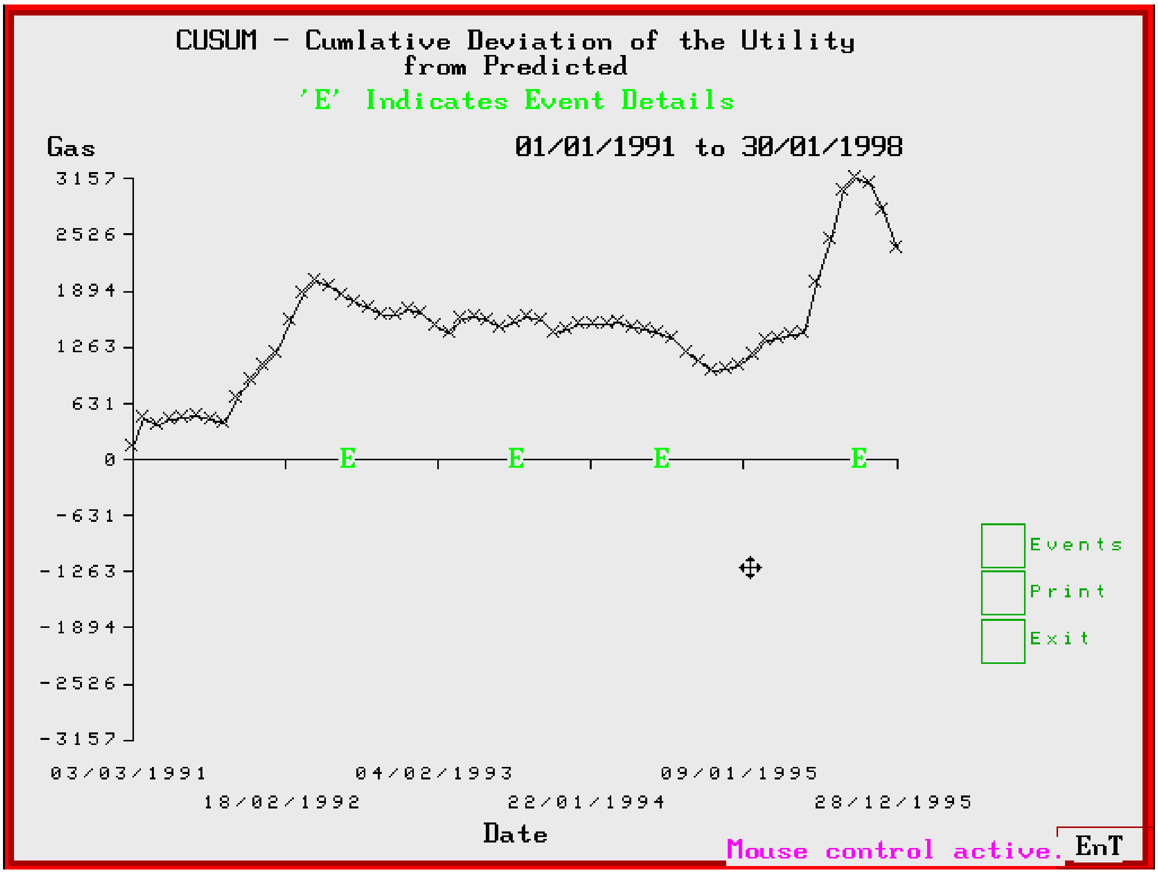


figure 2.10: *CUSUM Graph*

2.8 ENVIRONMENTAL ASSESSMENT

Of particular relevance is the system's ability to transform fuel consumption data to equivalent pollution units thus allowing an assessment of environmental impact. Figure 2.11 shows a report regarding the consumption of electricity of a specific entity over a one-year period. Information is also given on the total CO_2 emissions over a year period. The same information is given in figure 2.12, displayed in graphical format.

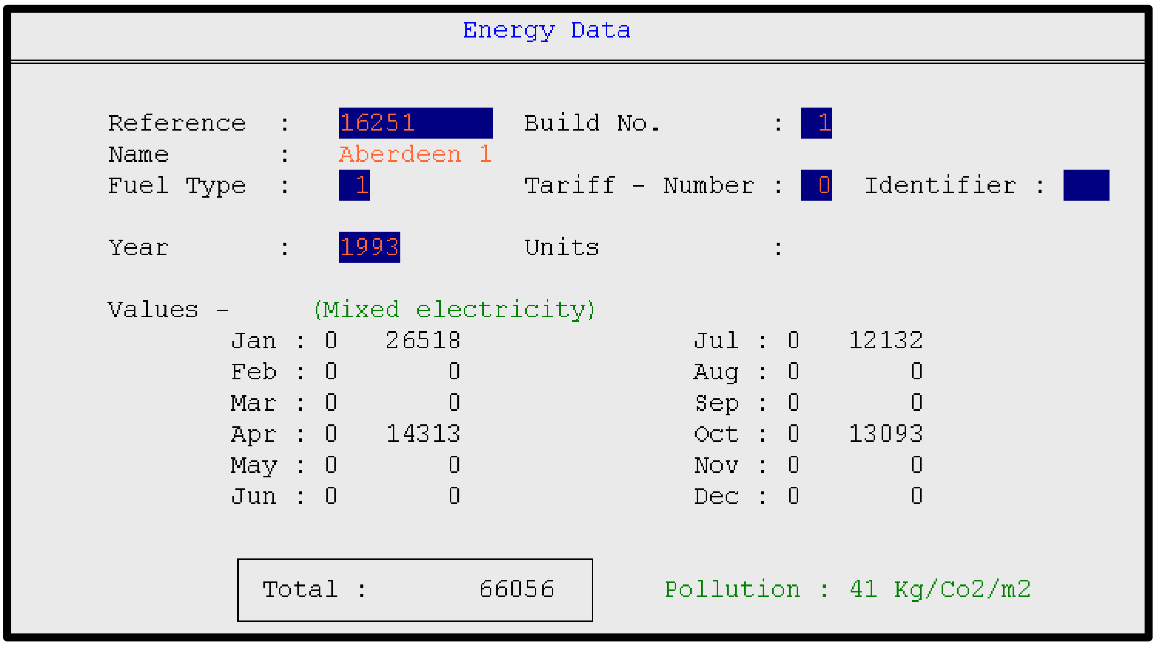


figure 2.11 *Cost of energy and pollution measured value*

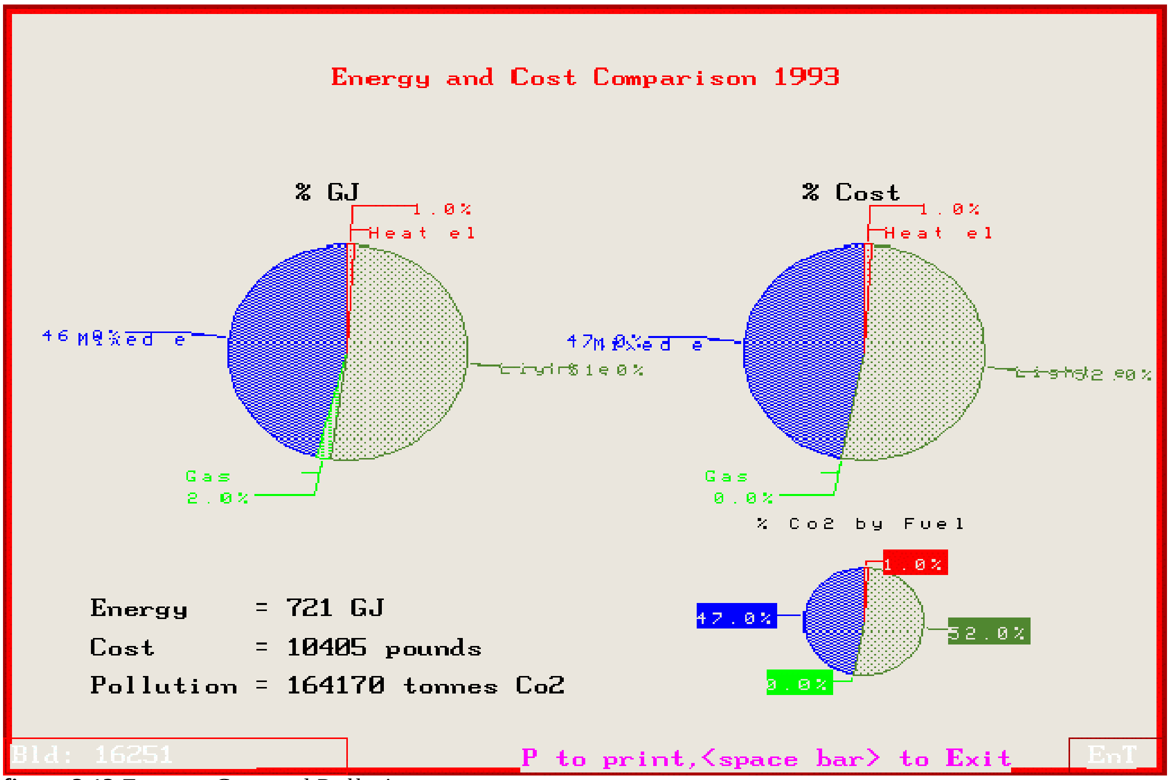


figure 2.12 *Energy, Cost and Pollution*

2.9 ADDITIONAL CAPABILITIES

EnTrack's additional capabilities compared to the standard functionality of conventional monitoring and targeting systems may be summarised as follows. The system has been designed specifically for the management of large property sets and is equipped to deal with a high diversity of entity types. It has a flexible property scoping capability that supports classification by design parameters and / or fuel consumption. The system also possesses a prediction capability that can be used to compare the performance of similar buildings under different climatic influences or to explore the saving potential of alternative design or control intervention.

2.9.1 Demand Side Modelling

In order to assess the potential for the integration of demand and supply-side energy streams, quality data on the consumption of electricity, gas, oil, solid fuel etc is required.

Once installed within EnTrack, these data will allow the determination of peak and base load characteristics together with frequency and magnitude of fluctuations across the site. This will provide an early identification of abnormalities within the consumption profile that, in turn, will permit remedial or corrective actions to be implemented.

The importance of acquiring data of a suitable quantity and quality is paramount in order to enhance the quality of any subsequent analysis. This can best be achieved through the provision of fuel consumption data from the relevant utility in electronic format (this may correspond to half hourly meter readings if the size of supply justifies it in cost saving terms) and through the installation of additional and automatic sub-metering where appropriate.

EnTrack's scoping facility will then permit the aggregation of entities in support of renewable energy matching studies [Born 2000].

2.9.2 Demand to Supply Matching

An example of EnTrack's capabilities in relation to demand to supply matching is shown in figure 2.13. This example illustrates a survey of Scottish schools, where a normalised performance for the schools in kWh/m^2 per year is derived. On the supply side, renewable energy resource estimates may be provided either in terms of technical feasibility, or against economical and/or environmental constraints. Temporal supply-demand matching is also possible where shortfalls and surpluses may be identified. Potential sites for renewable energy development may then be assessed according to a predetermined range of selection factors and socio-economic and environmental "value assessment factors".

2.10 CONCLUSION

This chapter has described the functionality of the EnTrack system, and its capability to perform efficient data analysis and produce useful and reliable information for supporting decision-making in energy management. EnTrack comprises an open architecture system for energy management and contributes to the bridging of the gap between raw data and useful information. However, the quality of the analysis, and consequently the reliability of the information produced, depend on the way that new data is introduced to the system. Systems like EnTrack require reliable and secure data from appropriate but diverse sources. A first attempt at understanding how EDI may effect data control has been established.

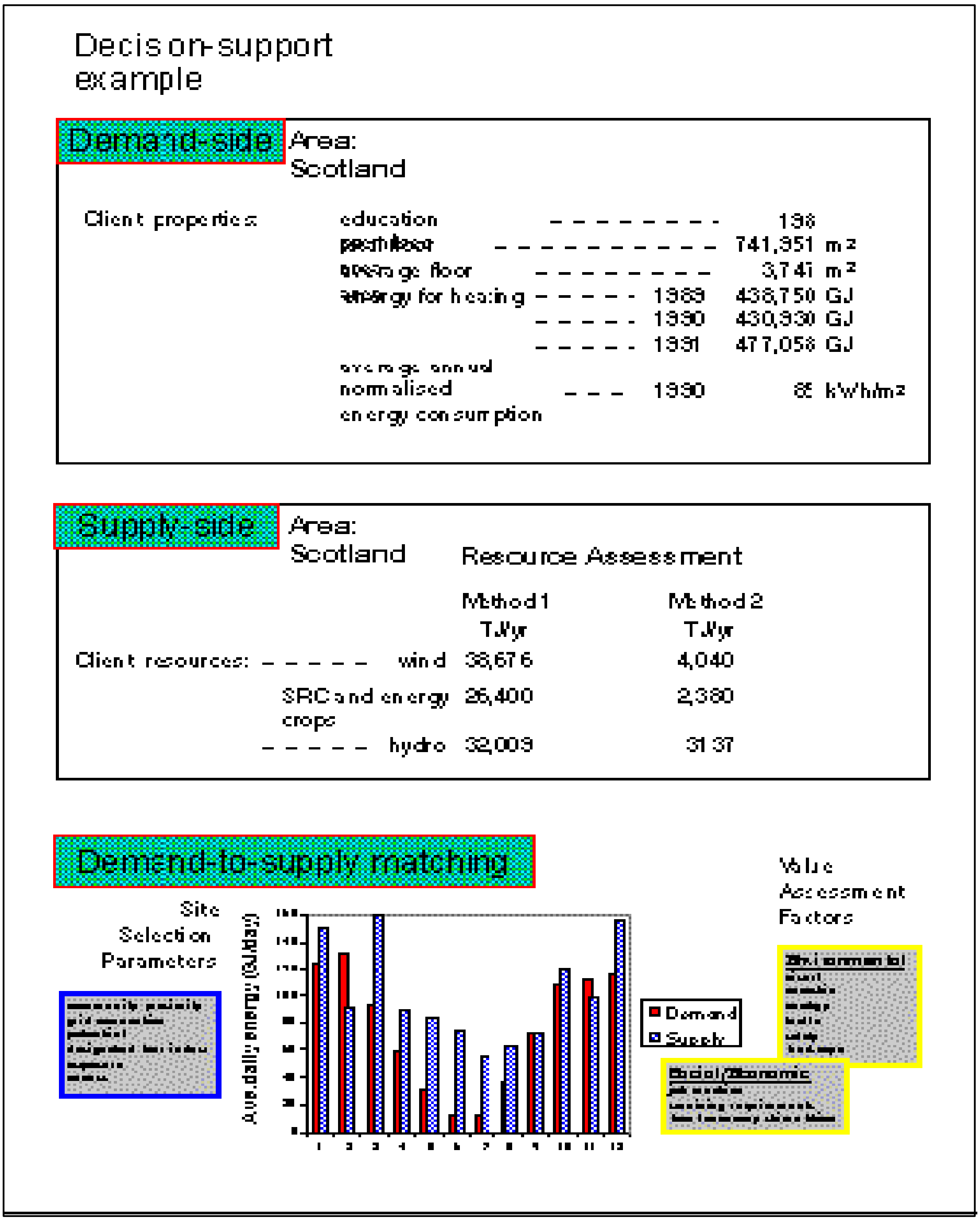


Figure 2.13 *Demand to Supply Matching*

References:

Evans S Mark, **Energy Management in Diverse Estates,** *Thesis (2000).*

Born Francesca, **Aiding Renewable Energy Integration through complementary Demand-Supply Matching,** *Thesis (2000)*.

Bibliography:

Clarke J A, Evans M, Grant A D, Lindsay M, Morgan J, **The EnTrack System in Energy Management**, *ESRU, University of Strathclyde, Technical Report (1995).*

Karatolios M, A, **Overall Evaluation of the Role of IT in Energy Management**, *ESRU, University of Strathclyde, Thesis (1997).*

Chapter 3

APPROACHES TO EDI

The need for advanced decision support information systems in energy management has been established (Chapter 1), and an example of such system capabilities has been discussed (Chapter 2). It was found that the main disadvantages and inadequacies of the commonly adopted energy management decision support systems focus on the issues of information explosion. It was argued that what is required is a technology capable of controlling, managing and transmitting data at any required level of abstraction, in a fully automated manner and in support of different user requirements.

This chapter describes the possible implementation flavours of a communication technology which facilitates such information exchange, namely EDI. This is followed by a description of the theory of the possible information exchange methods that may be employed.

3.1 INTRODUCTION

3.1.1 Internet: the dilemma

Figure 3.1 shows the increase in capacity of the Border Gateway Protocol (BGP) over time (1989 – 2000) [CAIDA 1999]. The BGP protocol is the current exterior routing protocol in the Internet that carries routing information. It uses a path vector protocol that allows the selection of the best path for routing the information. The size of the BGP table is proportional to the amount of information flow.

Despite the fact that the Internet is an enabling technology in terms of a new possibility to retrieve or distribute information to the existing options (oral by personal contacts and telephone, in writing via fax or mail, in a textual or visual form via television etc), it does not solve the problem of the overflow of information. On the contrary, the noncommittal way by which information is provided through the Internet does not ease the search for specific and qualitative information. The Internet on its own cannot be considered as a reliable solution to the necessity of bringing order to the large amount of available information.

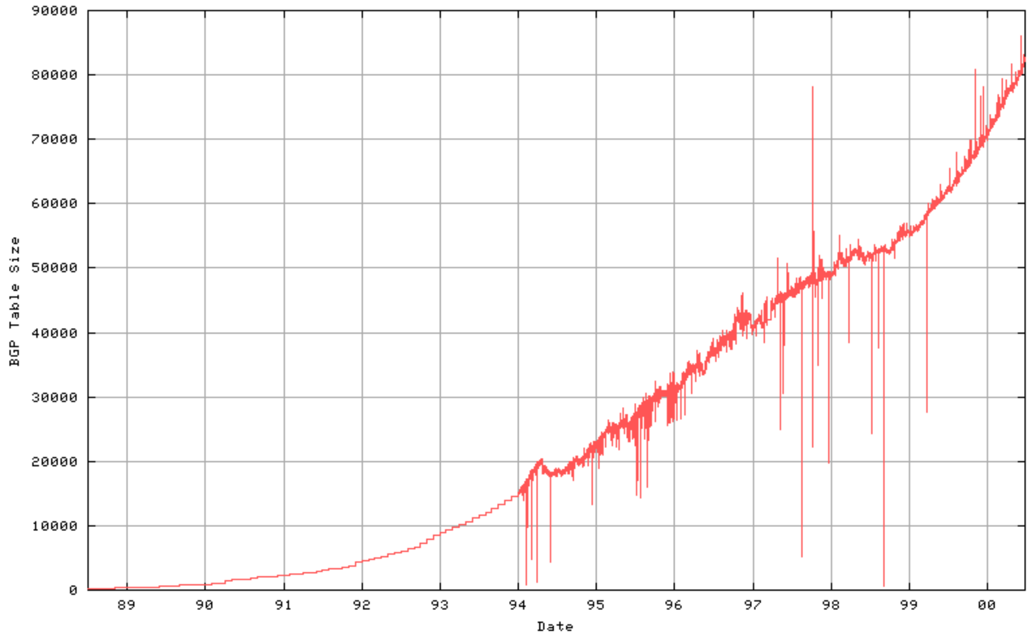


figure 3.1 *Border Gateway Protocol (BGP) table size*

3.1.2 EDI: the alternative route

During this research the possibility that electronic data interchange (EDI) could be used to solve the problem of information overflow between applications has been examined. It was found that EDI was able to support the exchange of information between incompatible computers without the need to resort to the Internet's protocols and routers. EDI was developed when organisations realised that in order to remain responsive and competitive, they needed information faster because the efficient processing of information is vital to their planning and control functions. However, it has been realised that EDI is not a revolutionary concept. As the power of computing and telecommunication has grown, EDI technologies have evolved as a natural data carrier, replacing the paper document. Nor is EDI a new concept or a new practice. It has existed for over two decades in Europe and North America in industry sectors, with products or services having a short shelf life but a high unit price.

In the early 1970's, large companies pioneered electronic business communication. With thousands of stores and suppliers to contend with, these organisations not only generated but processed mountains of paper. As a result of this, and in order to electronically communicate between them, suppliers were forced to address the standardisation of electronic business communications. In 1978, the United States Electronic Data Interchange Standard, known as X12, was developed [EDI Aware 1995]. Furthermore, in 1986, OFTP protocol (ODETTE[1] File Transfer Protocol) over the X.25 network, which is the most common protocol used for EDI file transfer throughout Europe, has been established [EDI-Hellas 1997]. (Details of the X.25 network diagnostic error messages and infrastructure are given in appendix III and appendix IV respectively). ScottishPower has used the OFTP protocol in order to establish an EDI connection with their customers and suppliers. This choice was made because of the advantage of this protocol in exchanging billing information and energy related documents. Its features include:

- *File restart*. If a communication session is lost partway through a file transmission, the file will be picked up from a recent 'check-point' when a new communications session commences [Halsall 1997].

- *On-the-fly compression*. Data can be compressed by the sending system, and automatically un-compressed by the receiving system [Halsall 1997].

- *End-to-end acknowledgements*. When a file is received by the destination system, an acknowledgement can be sent back to the sending system, proving that the file was received. This is known as an End-To-End Response (EERP) [Hughes 1998].

- *Security*. Passwords are exchanged in both directions during the start up of an OFTP session and the session aborted if either is not recognised by the opposite system [Sklar 1998].

[1] (Organisation for Data Exchange by Tele-Transmission in Europe)

- *Flexibility*. There are standards for running the OFTP over an X.25 network.
- *Widespread support*. Most European VANs and many of the major EDI users support communications with their trading partners using OFTP.

3.2 EDI METHODOLOGY

During this research different approaches on the EDI implementation have been studied. Basically, two ways of implementing EDI have been identified: the standard approach, which uses **structured** message formats and the non-standard approach, in which there is no need to establish message standard. This method has been characterised as an **unstructured** (or bespoke) approach. However, it is concluded that both approaches use the same EDI implementation methodology.

The EDI methodology for data transfer between two systems involves five main processes:

- extracting data from a computer system;
- translating the data into a transmittable format;
- transmitting the message;
- translating/interpreting the message at the receiving end;
- downloading the data in the receiving computer application.

3.2.1 Preparation of electronic documents

Extracting data from the system by means of preparing the electronic documents is the most demanding part of implementing EDI. From a number of methods available to generate the electronic documents, this research has identified three main categories that varying according to the application. These are summarised as follows:

- Users may manually transcribe data from their printed reports into a software package from where it can be communicated electronically to their customers. EDI software packages that require only a modem and a PC allow users to generate entry forms, permitting them to enter information via the keyboard.

- Alternatively, users may have access to commonly used database products, or spreadsheets, from where they can export data for their EDI transactions. It is also possible with inexpensive commercially available PC software, to read electronic report files from other applications, and re-format them into data files that can be used by EDI packages.
- For businesses that have existing application systems, regardless of the platform, they can consider having the applications enhanced to generate output in a format that is easily translatable. This approach necessarily requires custom software development. With custom software, enhancements may be done internally if such expertise is available, or it can be developed on a contract basis.

3.2.2 Outbound translation

Translating data is a fairly complex procedure involving the encoding of the transferring files in a standard message format. Although the philosophy of EDI is to exchange structured files in a standard format, it is a fact that some organisations are using their own non-structured (bespoke) flat file format. However, in order to exchange these files using EDI, their translation into a pre-defined standard message format is essential.

ScottishPower uses both TRADACOMS and UNEDIFACT standards for different types of files. TRADACOMS is an EDI message standard developed by the ANA (e-centre UK) in the UK. However, its use is being reconsidered as the date fields within it hold a six-character date rather than eight characters, which gave use to issue for the Year 2000 compliance. UNEDIFACT syntax was introduced by the United Nations in 1986, and is becoming the worldwide basis for international trading.

The message standard associated with EDI is a common format with a defined structure. The content, quantity and position of all elements that compromise a document can be defined using the standard. The terminology associated with the standard is given in figure 3.2 in relation to the structure of a typical form used in such application environments. Each page relating to a document is known as a *transaction set*. This comprises a number of *data segments* each of which corresponds to a line, box or table on the form. A data segment is made up of one or more *data elements*. The overall format used is shown in figure 3.3. Defined character strings signal the start and end of each component part and the individual data segments/elements have separators associated with them [Halsall 1997].

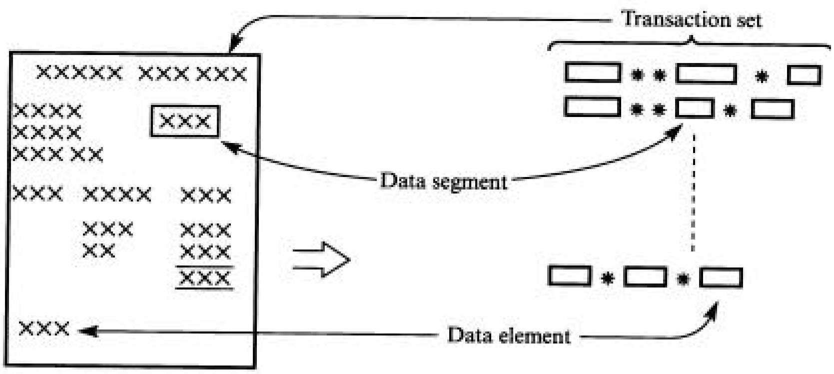


figure 3.2: *form encoding*

The encoding rules are relatively simple and the character set is limited. The translation to a standard format can be accomplished by internal systems or it can be done by a separate package of software. Regardless of the means chosen for translation, the end result of the process will be an output file generated in a specific format that any subscriber to the standard can understand.

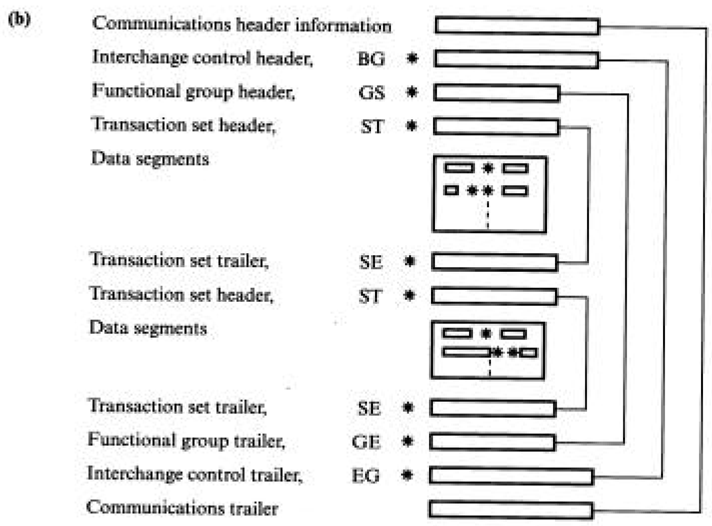


figure3.3: *overall document*

3.2.3 Communication of information

The way that data is transmitted can be a function of the number of users. In a one-to-one EDI relationship, transmitting data can be achieved via a modem connection. However, this would become impractical with more than just a small number of receivers. Even if the main user had an extensive private network available, successful transmission would require that all receivers be linked into the network. Providing this kind of connection to the sender's computer poses a serious security problem. However, EDI users do not have to rely on either of these alternatives. They can turn to third-party network services, commonly referred to as "Value Added Networks" or VAN. Appendix II summarises the main features and characteristics of the VAN network service. ScottishPower is using a VAN provided by GEIS (General Electric Information Systems) called Tradanet.

This research considers that VAN provides an answer to the pressing problem of security. It allows trading partners to be secure in the knowledge that they can trade information, but at the same time avoid giving information away. Neither party has access to the other's systems, but can still freely exchange agreed-upon information. In addition, a full service VAN can provide other services, including translation, standards compliance checking, and EDI software to ease the implementation process.

3.2.4 Inbound translation

This process is the reverse of outbound translation. Once the files have been placed in the electronic mailboxes by the VAN, the receiver can retrieve them at their convenience. The next step in the process is to "de-map" the file, and translate it into the specific format required by the receiver's applications. Since a standard format has been used, the user will be able to first recognise which company the transaction is from, and then which type of transaction it is. When translation is complete it can be made usable in any desired format as required by the receiver's internal applications.

3.2.5 Processing electronic documents

End-users with a highly automated process may route the information directly into their system and act upon it without intervention. Alternatively, the user may do little more than print reports. In either case, and regardless of the scale, EDI can be successfully implemented. The final step in the process may be to transmit an acknowledgement transaction back to the vendor to close the loop.

3.3 EDI SOFTWARE

Of the three components that make up the EDI triangle, standards, software and communications, this research highlighted the fact that it is the software that contributes the greatest number of variables and must therefore be carefully selected to accommodate the way EDI systems are used. The research also showed that, in terms of basic functionality, an EDI software package must be able to perform two fundamental tasks. It must incorporate a facility to allow data to be entered and encoded into an EDI standard format. Conversely, for incoming messages the software must allow data to be decoded and entered into an in-house format. These two features define EDI software.

The choice of software is of crucial importance to the effectiveness of an EDI-enabled system. The process of software selection cannot, however, be made in isolation from the rest of the EDI system and should be viewed in parallel with intrinsically related business and technical issues.

3.3.1 EDI Software Selection Factors

From the study of EDI network requirements, the following software selection factors have been identified:

Ease of upgrade*:* As an EDI trading relationship matures there is likely to be a requirement for enhancement of the existing system. This may arise as a result of additional messages, changes to existing messages or standards, addition of new trading partners and their individual messaging requirements, inclusion of additional network connections or an increase in the number of business applications to be integrated.

Network connectivity*:* Some EDI software packages are restrictive since they do not allow users to be connected to all of the major EDI networks. This is the exception to the rule since most of the popular packages have multi-network connectivity.

Multi-standards capability*:* In cases where a supplier is faced with a situation in which two or more trading partners require EDI messages to be transmitted using different standards, the software must be able to accommodate this need.

3.4 AREAS OF DEVELOPMENT

3.4.1 Accuracy of information

The premise of this project is that the issue of information flow accuracy is of utmost importance and, if disregarded, will greatly reduce the precision of decision-making and, ultimately, the application of effective energy and environmental management.

The contention is that the accuracy of the information derived from data analysis can only be increased and optimised if all relevant aspects, features and characteristics of a system are automated during the data collection and integration process. This requires tools that adopt a fully integrated approach, and integrates data selection criteria and data transfer. It is observed that EDI technology is able to solve the information flow problem by interconnecting systems for automatic data transactions using standard communication protocols.

3.4.2 Extending applicability

Although the data collection and integration issues are tractable, problems arise when trying to automate the transaction because of structural incompatibility. However, different types of EDI deployment can be beneficial in overcoming this data incompatibility barrier.

To summarise, EDI can be implemented by a standard *structured* approach or by an *unstructured* approach. Furthermore, applications and types of EDI technology may be classified into three categories:

- *initial data selection criteria*, where no communication protocols are necessary;
- *data transfer and integration*, necessitating the establishment of communication protocols and translation modules;
- *ambitious and highly conceptualised interconnection network,* where full configuration of EDI technology is needed.

It is evident that the potential of EDI in controlling information flow has never been greater. This is a key issue facing the energy management community.

3.5 CONCLUSION

The present chapter has identified the main approaches to EDI technology and has detailed the structure and development of an EDI taxonomy for sustainable and controlled information flow between applications.

The following chapters discuss issues relating to the implementation and testing of the EDI approach.

References:

EDI-Hellas S.A., **http://www.edi-hellas.gr**, *EDI-Hellas (1996).*

U.K. EDI Awareness Centre, **http://www.edi.wales.org.,** *Issue 4 (1994).*

Lawrence E. Hughes, **Internet E-mail: Protocols, Standards, and Implementation,** *Lawrence Hughes (1998).*

Bernard Sklar, **Digital Communications. Fundamentals and Applications,** *Prentice Hall (1998)*

Fred Halsall, **Multimedia Communications: Applications, Networks, Protocols, and Standards,** *Addison-Wesley (1998)*

Bibliography:

European Construction Institute, **Data Transfer and EDI: An Introduction**, *European Construction Institute Paperback (1998).*

Steven Marks, **EDI Purchasing: The Electronic Gateway to the Future,** *Pt Pubns Paperback (1997).*

Albert J. Marcella Jr., Sally Chan, **EDI Security, Control, and Audit**, *Artech House Publishers (1996).*

Mike Hendry, **Implementing EDI (Artech House Telecommunications Library)**, *Artech House Publishers (1993).*

Phyllis Sokol, **From EDI to Electronic commerce: A business Initiative**, *McGraw-Hill Book Company (1995).*

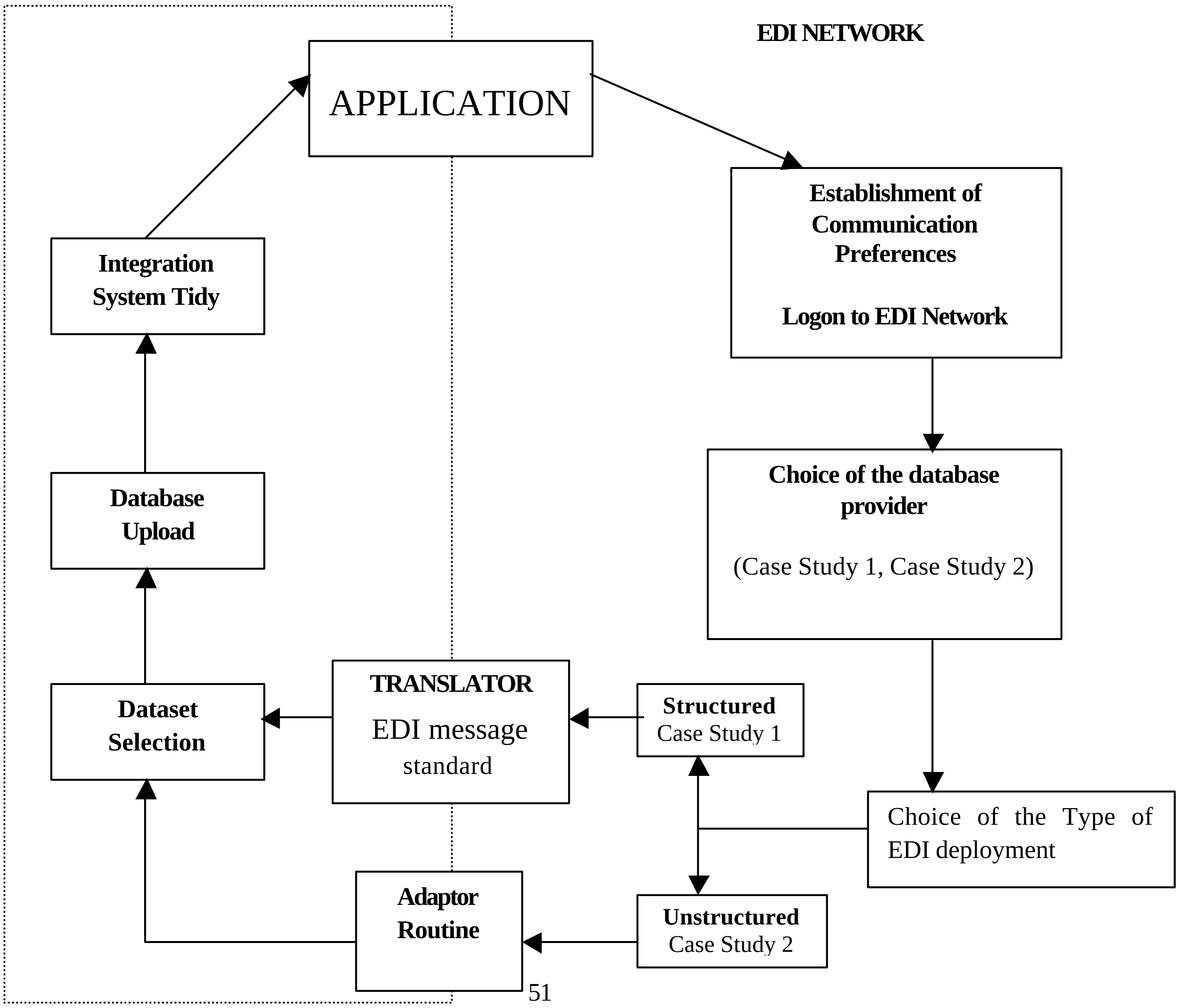
APPLICABILITY

This chapter identifies the main phases of EDI technology deployment. The new communication technology pointed out in this present work is assessed in terms of its applicability in real world issues.

4.1 APPLICABILITY

4.1.1 Levels of abstraction and applicability

Different EDI interconnection environments do not require the same level of modelling abstraction. However, the required level will depend on the type of the transferring files. Files are commonly structure defined, but there is also the prospect for unstructured file definition. This depends on the agreement of the users according to the type of data (invoices, tables, figures, statistics, databases etc). A schematic representation of the EDI network was established as follows:



In this chapter the assessment of EDI applicability will be undertaken in phases as shown in figure 4.1:

Phase 1: Initial design stage appraisal involving the provider of the EDI interface. At this stage, no decision has been taken regarding systems regulation and attributes. The provider may wish to dictate, for example, what kind of information will be available or the frequency of the transmission.

Phase 2: Focuses on an in-depth study of the EDI interconnection. Experts at this stage will be concerned to ascertain the optimum configuration of the network for data transmission. Studying the requirements, they will establish the format of the file and choose the communication preferences to be employed (protocols, networks, servers). Finally, this phase includes the choice of the software that the EDI provider will use to host the interconnection.

Phase 3: The final stage before the initiation of the system is the decision on the form of the file, structured or unstructured. This decision involves all EDI users of the interconnection. At this stage the end-users has to decide if there will be further internal processing of the incoming data before use within their own systems.

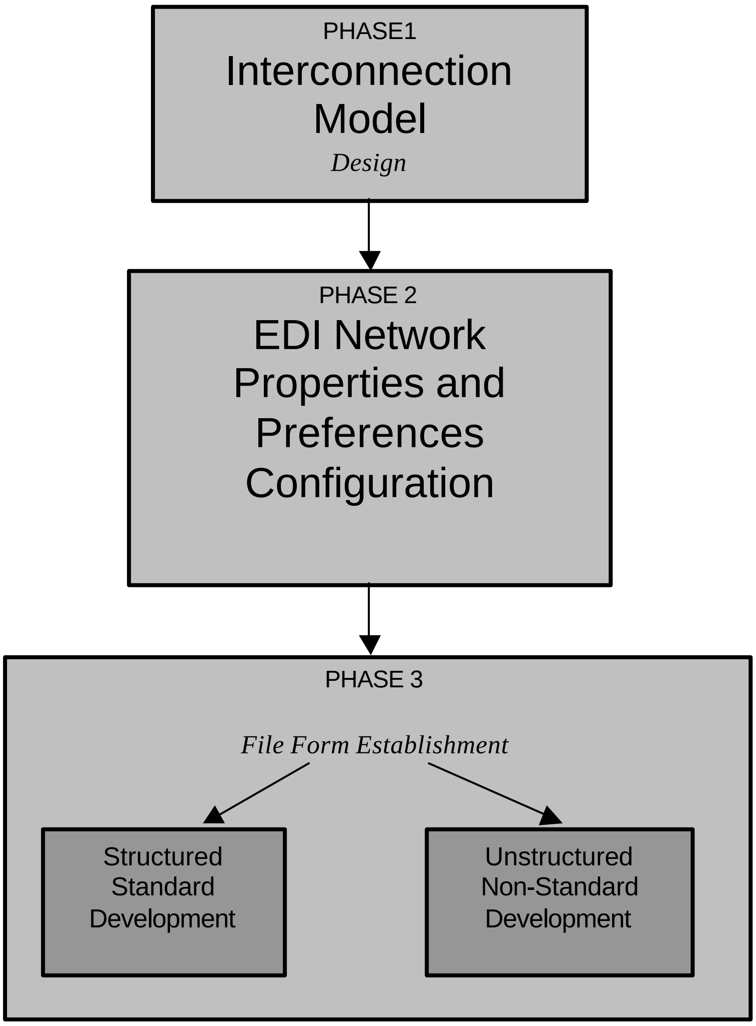


figure 4.1: *application development phases*

4.2 CASE STUDIES

The use of EDI in data transmission, and its suitability for controlling and managing data, is demonstrated within two case studies.

- A structured standard development of an EDI network for data transmission (invoices and energy consumption data) involving *ScottishPower* and *North Lanarkshire Council* (NLC).
- An unstructured, non-standard development of an EDI network interconnecting Highland Region Council (HRC), Glasgow City Council (GCC), the Energy Systems Research Unit (ESRU) of Strathclyde University and ScottishPower.

These case studies are used to conclude on the advantages and disadvantages of the different types of EDI interconnection.

4.2.1 Case Study 1

4.2.1.1 Application first phase

This section presents the initial stage design from ScottishPower of the EDI network. ScottishPower uses the EDI network to provide billing information, invoices and energy consumption data to their customers across the U.K. For the purposes of this research, only the connection between ScottishPower and NLC was examined. However, the network properties and preferences are the same with any of the end-users; only the type of the transferring files varies according to the needs of the end-user.

The way that ScottishPower had intended to implement the EDI network is shown in figure 4.2. ScottishPower decided to use the X-tra software, designed by their software development department, for business application and for data translation and communication.

The model adopted allows the end user to employ the same software for data retrieval and management.

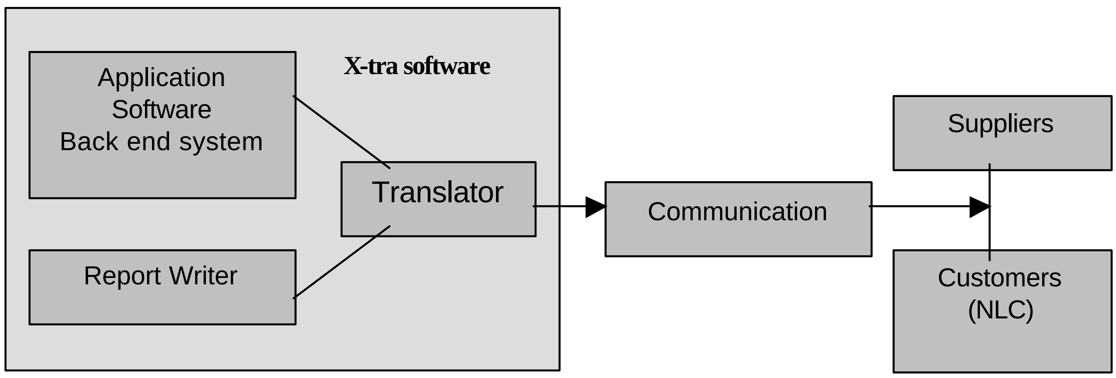


figure 4.2: *EDI network*

4.2.1.2 Application second phase

Phase two constitutes the stage where the configuration of the network takes place. The initial concern is the establishment of the communication protocols.

ScottishPower uses the OFTP protocol over an X.25 network. ScottishPower has selected this protocol for two substantial reasons. Firstly, it is a well-known protocol in Europe, and consequently it is supported by many products. Secondly, according to pre-described features [see p. 3.1.2], it constitutes one of the most popular transfer protocols for energy related documents.

The OFTP protocol helps to avoid duplication of data since the *file restart* feature continues the transmission of data from the recent "check point" in the case of a communication session error. Meanwhile, the *end-to-end acknowledgement* feature eliminates the possibility of transferring the same data twice. *Security passwords* facilitate the confidentiality of energy data and finally *data compression* accelerates the transfer process when substantial data amounts are involved. For these reasons the OFTP protocol is widely used for EDI data transfer.

ScottishPower uses a standard format for billing invoices as well as energy documents. Consequently, the decision was made to establish a message standard [see p. 3.1.2] for file transactions. The choice to adopt a structured EDI brought a number of benefits, which are summarised as follows:

- all users to employ the same software with ScottishPower;
- all users adhere to ScottishPower's document format;
- all users have to subscribe to a value added network indicated by ScottishPower.

The software chosen by ScottishPower to implement this network is X-tra. This product is aimed at providing an interface for manipulating and communicating data.

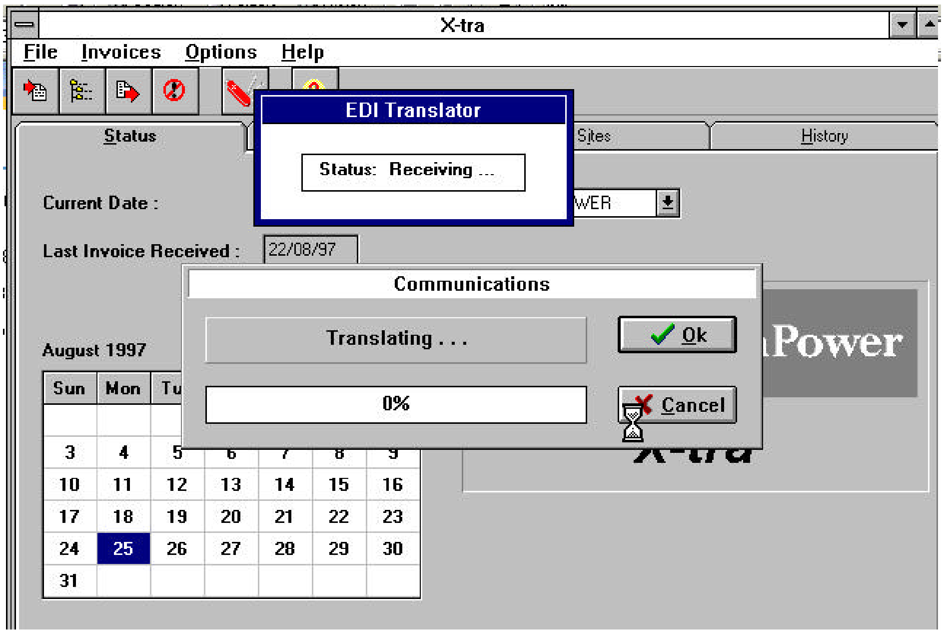


figure 4.3: X-*tra's user interface (EDI translator)*

Figure 4.3 shows X-tra's EDI translator, through which an energy file is translated into a pre-defined format. Furthermore, the translated file is communicated to the end user by utilising the communication protocols (figure 4.4).

However, ScottishPower's X-tra software is misleading in flexibility. It is a typical desktop application that will operate comfortably on its own merits within the limits of the design. It cannot, however, allow the user to interact whenever data transfer problems occur.

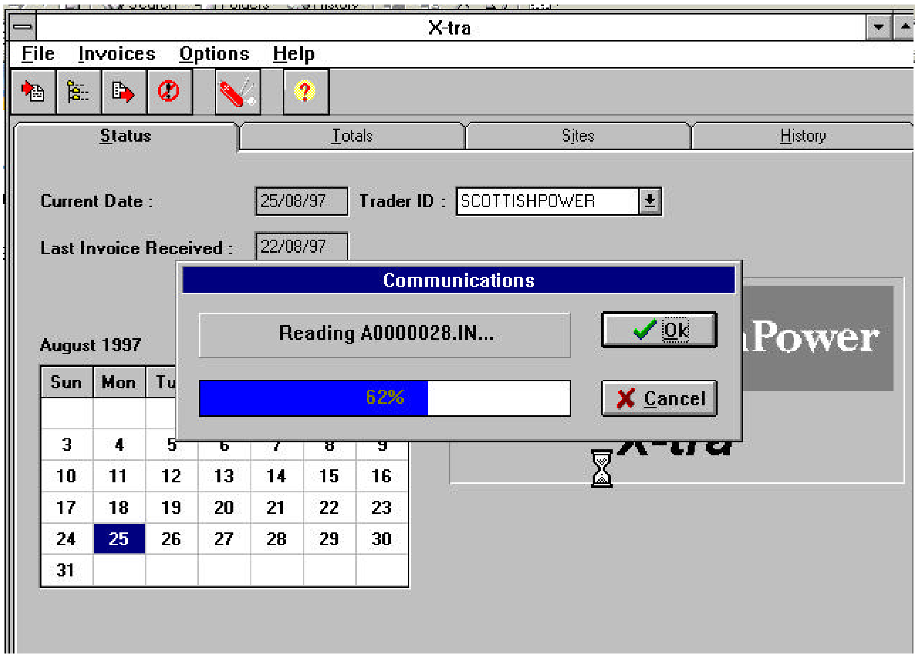


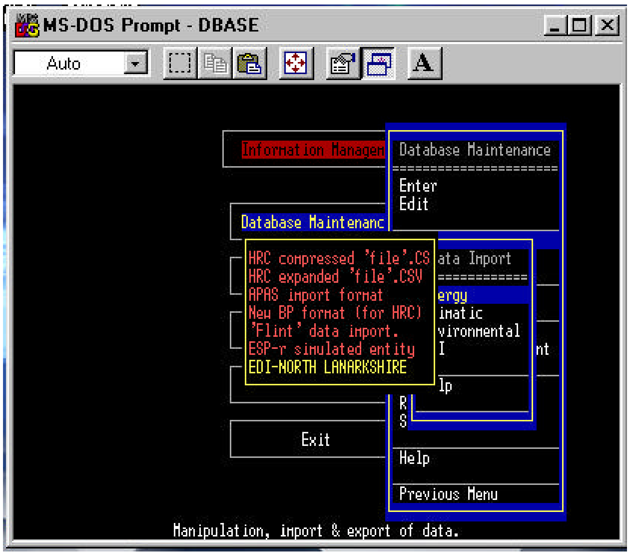
figure 4.4: *X-tra's user interface (file communication)*

The last step in the second stage of the EDI schema implementation is for ScottishPower to subscribe to a Value Added Network on which all the transferred data will be routed.

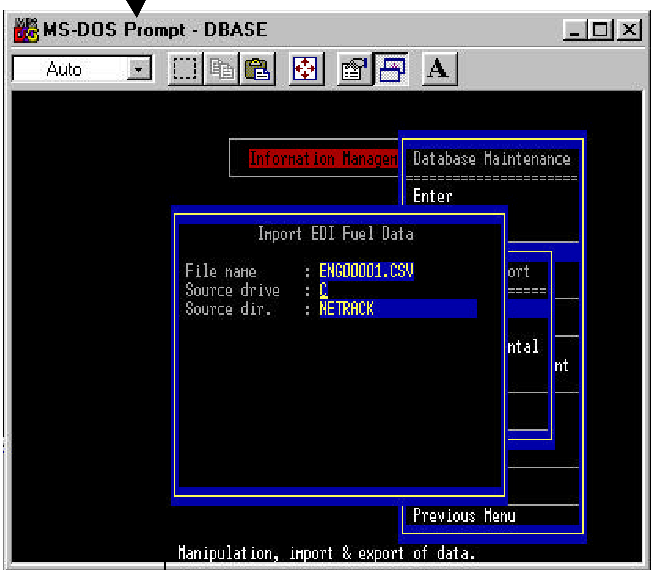
4.2.1.3 Application third phase

In this phase the EDI network is configured and the end-user subscribe to the network. North Lanarkshire Council's (NLC) Planning and Development Department is a subscriber to ScottishPower's EDI network. NLC is more interested in the transfer security in terms of confidentiality that the structured file interchange provides rather than the flexibility of transferring more than the pre-defined files that the unstructured file exchange provides. NLC's decision seems to be correct since it is more interested in transferring standard electricity invoices and the monthly energy consumption of their properties than in building a decision support facility They subscribe as users of the X-tra software for the purposes of inbound translation of the incoming data.

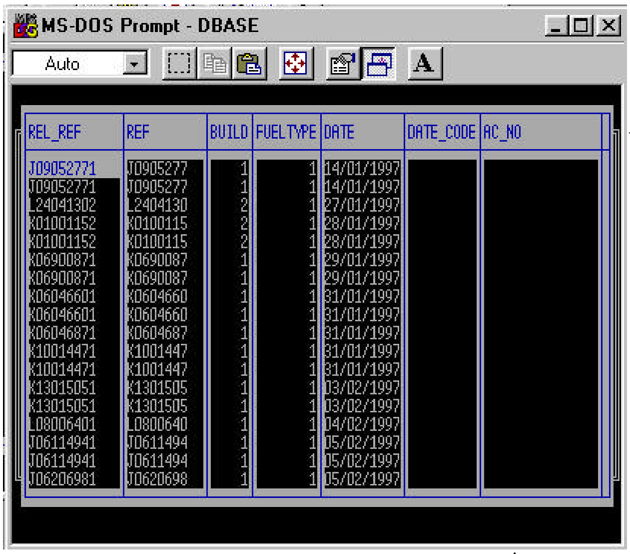
NLC also addresses issues regarding building energy management. For this purpose the X-tra software is inappropriate because it is unable to analyse data and derive effective and reliable energy information. EnTrack, as described in chapter two, is a primary tool for decision support in energy management and NLC has employed it for such reasons. The involvement of EnTrack into the pre-described network is established as follows:



The location of the file is given in order to initiate the transferring procedure

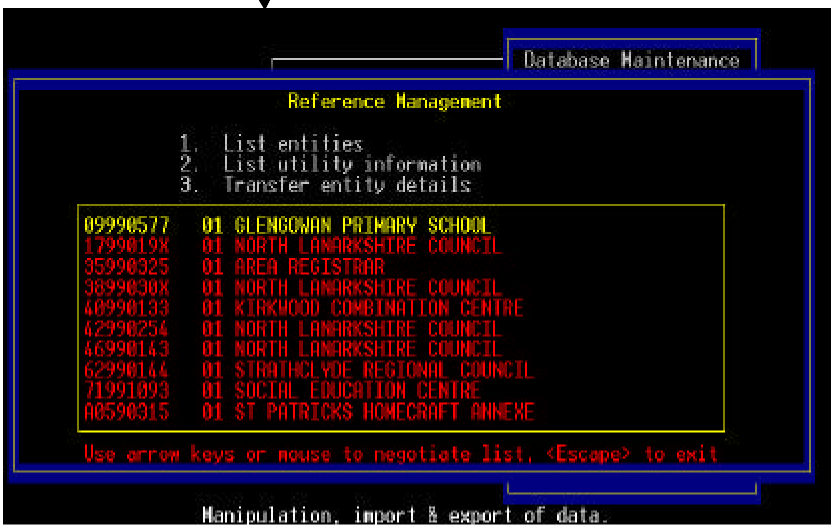


The user chooses the dataset in which energy data will be transferred from the EDI network.



REL_REF	REF	BUILD	FUELTYPE	DATE	DATE_CODE	AC_NO
J09052771	J0905277	1	1	14/01/1997		
J09052771	J0905277	1	1	14/01/1997		
L24041302	L2404130	2	1	27/01/1997		
K01001152	K0100115	2	1	28/01/1997		
K01001152	K0100115	2	1	28/01/1997		
K06900871	K0690087	1	1	29/01/1997		
K06900871	K0690087	1	1	29/01/1997		
K06046601	K0604660	1	1	31/01/1997		
K06046601	K0604660	1	1	31/01/1997		
K06046871	K0604687	1	1	31/01/1997		
K10014471	K1001447	1	1	31/01/1997		
K10014471	K1001447	1	1	31/01/1997		
K13015051	K1301505	1	1	03/02/1997		
K13015051	K1301505	1	1	03/02/1997		
L08006401	L0800640	1	1	04/02/1997		
J06114941	J0611494	1	1	05/02/1997		
J06114941	J0611494	1	1	05/02/1997		
J06206981	J0620698	1	1	05/02/1997		

Energy data has been processed and has been incorporated into EnTrack's fuel database.



Data has been transferred and maintained by EnTrack's system tidy function.

EnTrack is now able to analyse the new energy data.

Figure 4.5 shows the schematic representation of the EnTrack's link to the EDI network.

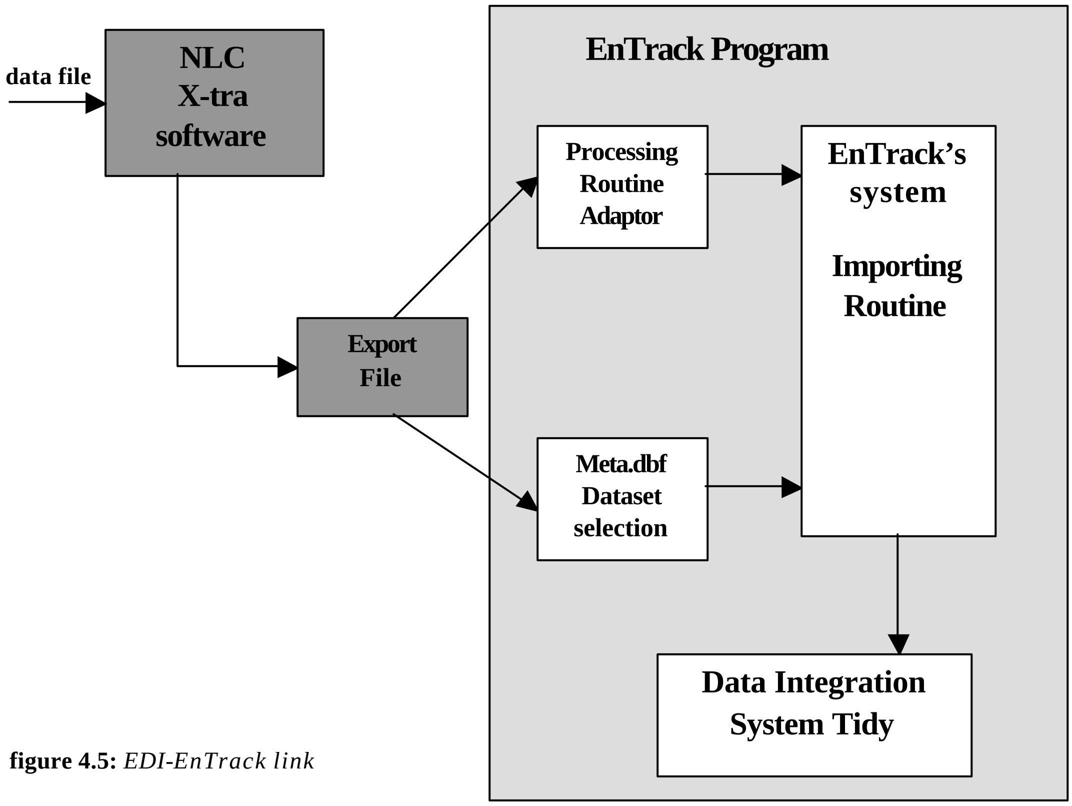


figure 4.5: *EDI-EnTrack link*

The procedure for integrating the incoming EDI message in EnTrack involves three basic steps:

Firstly, the EDI message is processed by a routine in EnTrack with which a separation of data fields unnecessary for the system occurs. This process ensures that incompatible data is avoided during the transfer and that energy consumption is not related to different time periods.

The second step involves the primary integration of the EDI message within the EnTrack system. Existing databases are updating their data elements according to the incoming information. The whole EDI transfer is released with a minimum of 12 sets of data. This has normally been based on the 12 months of the year with the data being collected on a monthly cycle. However, EDI system is able to carry out higher frequency data transfers as soon as is appropriate to the complexity of the system. At this stage data is ensured of their quality since neither incompatible nor insufficient data has been transferred. The final step is established by the system's tidy function whereas the secondary and final data integration is secured.

4.2.1.4 Meter identification error

After importing fuel use data using X-tra, some errors were concerning fuel and property incompatibility. When a property was called up for reporting, its electricity consumption was incorrect (when compared to the initial pre-processed data). It was subsequently discovered that there was a number missing from the X-tra export file which gives the meter identification number. This happened as a result of a change to the procedure for handling meter identification. Figure 4.6 shows EnTrack's metering breakdown.

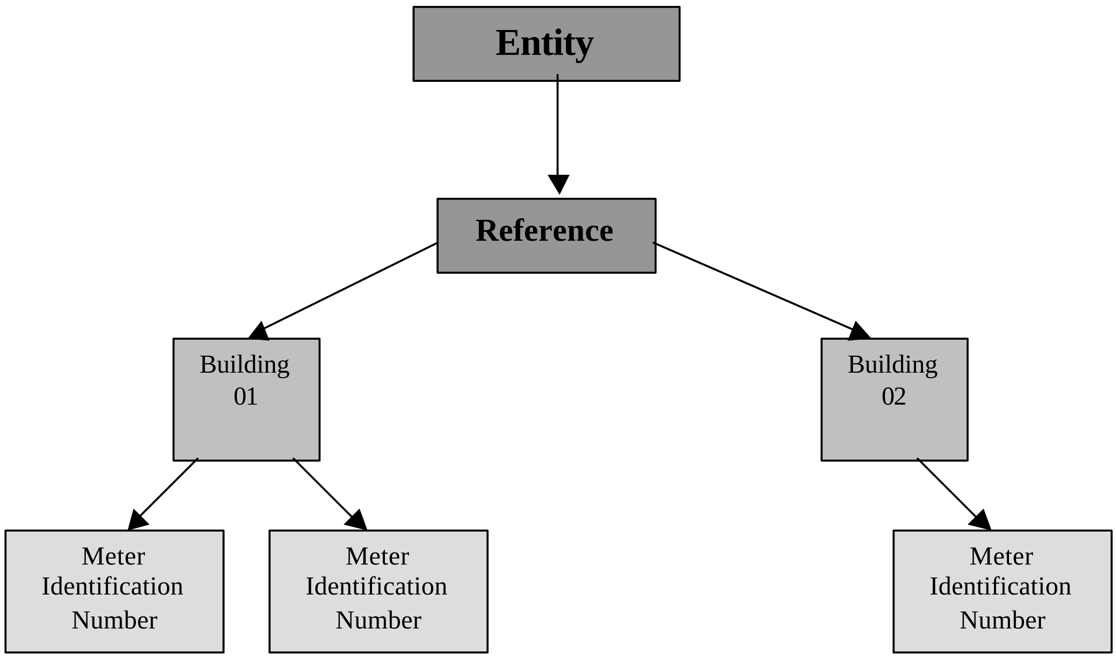


figure 4.6: *entity hierarchy*

According to this structure, each entity has a reference number from which use as more buildings may be accessed. That is, the entity might have several meters and each meter might have several tariffs.

North Lanarkshire Council's export file was missing the meter identification numbers. This problem could only be fixed by asking ScottishPower to modify the format of the EDI exchange file. This proved to be a time consuming task which highlighted the problem of adopting a structured approach where the utility controls the exchange format.

4.2.2 Discussion

Employing this kind of EDI network interconnection gives use to several immediate advantages:

- ***Speed.*** The moving of information between computers is achieved rapidly and with little or no human intervention. Facsimile transmissions work well for small documents, but for several hundred pages, this is not a feasible solution.
- ***Accuracy.*** Using an EDI network the major drawback of requiring re-entry into the system is overcome. Information that passes directly between computers without having to be re-entered eliminates the chance of transcription error.
- ***Security***. Using structured file format means that the possibility of transferred files being intercepted is unlikely because passwords are exchanged in both directions during an OFTP session.

However, security cannot be considered as an immediate advantages in the X-tra's link with EnTrack because the OFTP session is not available for this link.

Although these benefits are convincing, actual acceptance and implementation of EDI is less prevalent than might be expected because the technological complexity of EDI presents a number of major barriers as follows.

- ***Expense.*** Computers and their business application systems are complex and expensive. EDI requires that information technology be extended beyond core functions. So while there are substantial savings to be gained from the use of EDI, the cost of re-designing and deploying software applications to integrate EDI into the existing infrastructures is high enough to offset the anticipated advantages.

Network complexity. The need for an extensive telecommunications capability introduces a second major barrier to the widespread implementation of EDI. Beyond the computer itself, a basic requirement of EDI is to transmit and receive information to and from a wide variety of customers or suppliers. This required a heavy investment in computer networks.

4.2.3 Case Study 2

4.2.3.1 Non-Standard Development

Although the philosophy of EDI is to standardise messages and processes, it is a fact that small organisations may have non-standard requirements, which are not going to change in the near future. Common examples are:

- HRC is a user that will not send standard EDI messages, but instead uses their own proprietary flat-file format;
- Glasgow City Council uses an application system that is only partially configured. So, some messages must be turned into a readable report and printed out, instead of being passed electronically;
- a given type of message may need translating twice, for example into the main EDI translation software, and then into another application for processing;
- ScottishPower deploys different message types that need to be routed to different applications depending on the data contained therein.

In order to study the non-standard development of the EDI network a desk case study has been undertaken. The virtual nature of this case study will be enabled by the implementation of an EDI network model capable to test and verify the unstructured EDI data transfer using a central client server. However, the configuration of this model will be based on the already tested network preferences used in the physical development of the structured EDI network in case study 1.

4.2.3.2 Non-standard EDI model

The second case study of EDI development involves three different organisations (utility, local authorities and institution). The main concern of these organisations is the exchange of energy consumption data for building energy management and control.

Before the initiation of the EDI network, the following arguments have to be considered:

- the network partners are using different decision support systems;
- energy data incompatibility between their applications;
- different file formats.

Consequently, the need for a non-standard EDI interconnection via an unstructured file format is essential. This connection is described as a corporate EDI gateway implementation, often referred to a "Multi-level" implementation. Figure 4.7 shows practically how this interconnection was visualised during this research.

All the end-users of this kind of networking are interconnected to the server via an application adapter. The adaptor is the essential media in order for the user to communicate files. It is developed by the users in order to download and upload information into their backend systems by converting the data into the format accepted by the backend system. The server is used as a mailbox to download and upload information. This model allows transactions to be transmitted between the users mainly by using XML (Extensible Markup Language). It is believed that XML is a powerful data representation standard for digitised information delivery and formatting. XML documents are easily converted to other XML documents simplifying backend integration.

Additionally, XML separates the data from the presentation style. This allows the presentation to be tuned to wide variety of output devices [W3C XML 1999].

Practically, there are two ways of interconnecting in such a network. Either the user is connected directly to the server (GCC, ScottishPower) via its own adapter, or, in the case where a set of users is employing the same application, the connection can be established via a common adaptor (HRC, ESRU). In a situation like this, it is possible for users to arrange a flat file format transaction (comma separated or text format) through the server. A typical example can be the use of EnTrack's standard export facility (CSV format) for data transfer between Highland Region Council and ESRU.

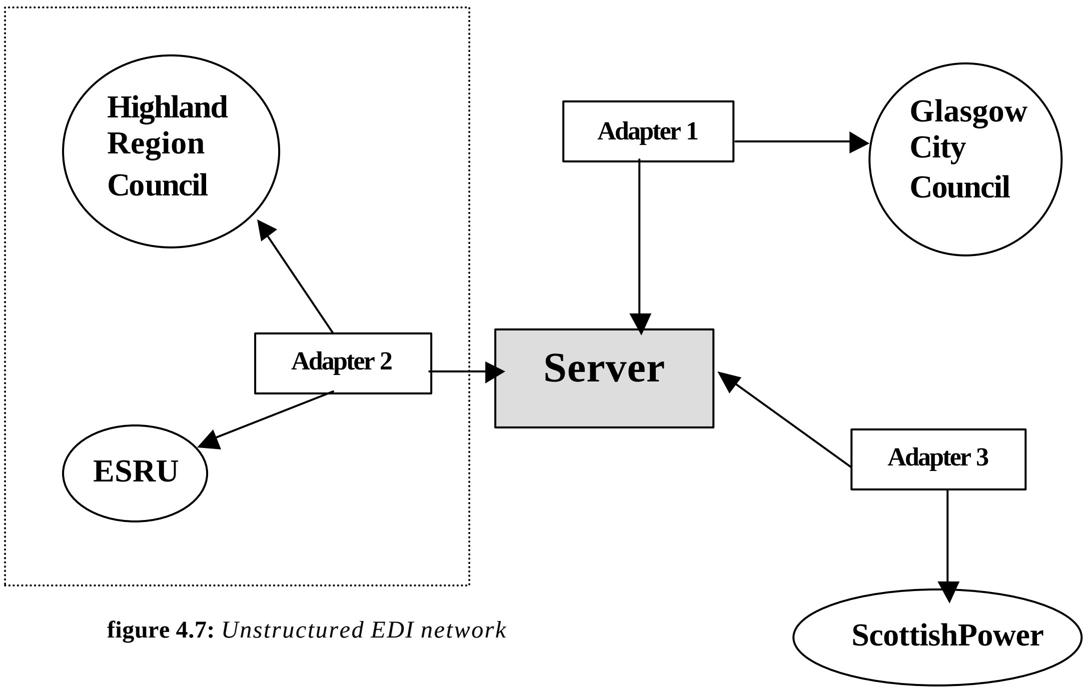


figure 4.7: *Unstructured EDI network*

4.2.3.3 Network communication configuration

As in the first case study, the initial concern for the users is to establish their communication protocols with the server. The research on this kind of EDI implementation showed that the communication protocols must represent a wide spectrum of gateways. The OFTPPlus over the X.28 network seems to be the optimum solution. OFTPPlus supports all features of the OFTP protocol and is capable of running many concurrent communications sessions (40 or more is normal in several installations). However, the most suitable protocol for this kind of networking is considered to be the XML Protocol, which allow two or more users to communicate in a distributed environment using XML as its encapsulation language. Solutions developed by this protocol activity allow a layered architecture on top of an extensible and simple messaging format, which provides robustness, simplicity and interoperability.

For the reason that the exchange file format is unstructured, there is no need to establish any EDI message standards. In addition, the translation software is not necessary in this non-standard connection, if the end-users employ internal applications that support functions that the EDI software enables. An example of such functions is the data routing and management to allow data flows to be robust. It is a fact that data is processed through flows, which may have more or less functionality as required. Software must be able to translate incoming data from the server to the end-user's application formats. Nevertheless, this is not always necessary because it is possible that end-users are using the same application. In this case, HRC and ESRU are two users that are both using both EnTrack for energy management purposes. On the other hand, ScottishPower and Glasgow City council are using different BEMS applications.

4.2.3.4 Data confidentiality

The configuration of the interconnection pointed out above raises the issue of data confidentiality. Data can be accessed by everyone in the collaborating organisations even though one organisation might want to restrict access to use of the other organisation. This is a major drawback of a non-standard, multi-level interconnection. However, this situation can be overcome by internal actions that the users can employ. An example of this situation is where ScottishPower or Glasgow City Council own the data as energy consumption for their properties, just do not wish to grant access to a 3rd party. A possible solution is to publish only scrambled data on the servers; for example, the data might be published in groups of the individual consumptions not directly associated to each building. However, the total consumption will still represent the correct amount of energy. The capabilities of EDI exchange are expected to be high enough to offset the matter of data confidentiality.

4.2.4 Discussion

This case study has raised a number of questions relating to non-structure EDI deployment. Speed and accuracy are two universal advantages of EDI networking, which are independent of the file form at (structured or unstructured). However, non-standard EDI networking deployment raises one more major advantage:

> ***Flexibility*****:** The fact that there is no need for a standard file format definition enables users to exchange different type of files according to their needs.

Notwithstanding these benefits, the technological complexity and expense of EDI networking are two major barriers. In addition, data confidentiality is a serious consideration when establishing an EDI network.

4.3 CASE STUDIES CONCLUSION

In this chapter the applicability of an EDI networking for transferring data has been tested. The main objective was to examine the use of EDI in controlling and managing the transfer of data in order to avoid information overflow and, consequently, the acquisition of unreliable data. From the two case studies, it was concluded that EDI is a promising communication technology for achieving the pre-mentioned objectives. However, the drawbacks that this type of information exchange involves (network complexity, expense and lack of confidentiality) are still significant. Nevertheless, it seems that it is more important for an organisation to secure the reliability and the robustness of its incoming data, which an EDI network provides, despite the fact that several constraints still exist. The next chapter approaches the problem of network complexity and expense by introducing a web-based Internet EDI model that provides value-added functions.

References:

http://www.w3.org/XML *W3C XML Page.*

Bibliography:

W. Buchanan, **Advanced Data Communications and Networks**, *Stanley Thornes Paperback.(1998)*

Fred Halsall, **Data Communications, Computer Networks and Open Systems**, *Addison Wesley (1998).*

W. Hughes, **Internet E-mail Protocols, Standards, &Implementation**, *Lawrence (1998).*

http://www.wisc.edu/arch/issues/edi.html, *Information Technology Architecture.*

Bernard Sklar, **Digital Communications Fundamentals and Applictions**, *Prentice Hall (1998)*

Andrew S. Tanenbaum, **Computer Networks (third edition),** *Prentice Hall (1996)*

Chapter 5

INTERNET BASED EDI

This research has shown that EDI can help to automate and streamline a business by eliminating or simplifying clerical tasks, speeding information transfer, reducing data errors, and eliminating business processes. Although EDI has been successfully employed in specific retail industries and in some large enterprises, it has not been widely adopted. The primary barriers to widespread acceptance of EDI are the costs of implementation and the costs of communication, which is frequently done using value-added networks. In this chapter two web-based Internet EDI models are introduced, representing a web server dependent and a more generic solution, respectively. In these models, users conduct transactions using ***Java-capable*** *browsers instead of traditional EDI software, thus eliminating the costs of VANs and EDI –related applications.*

5.1 INTRODUCTION

Electronic Data Interchange (EDI) has been presented as an electronic means for companies to exchange data in a structured and computer processable format. It has been showed that the primary barrier to the acceptance of EDI is cost; which includes the cost of implementing EDI software and the cost of communication. In general only large organisations can afford to utilise EDI to conduct data transactions with their customers because EDI, in most cases, requires a value-added network to support mailboxing, protocol conversion, implementation assistance, auditing and other value-added services. These services can be costly. Because of this, many medium and small companies prefer to use traditional non-automated means (mail, fax, telephone etc) to communicate data rather to employ EDI.

After a detailed analysis of EDI communication preferences this research proposes an alternative route to the deployment of EDI. With the popularity of the Internet, an Internet enabled EDI offers a low-cost alternative that is especially suitable for cost sensitive applications. An internet-based EDI model that enables companies to engage low-cost EDI business transactions over the Internet is therefore proposed. The model offers end-to-end integration that automates the flow of data between network users and internal systems.

5.2 CURRENT EDI INFRASTRUCTURE

Although the traditional EDI infrastructure has been presented in previous chapters, it is necessary for the purposes of this chapter to present a summary of the current EDI infrastructure.

Energy management organisations have various applications for different purposes, running on different system platforms. Different types of suppliers require also different message formats. The most common EDI infrastructure uses multiple EDI translators to translate the various types of flat files generated by their in-house applications into EDI formatted documents and to transmit the data to their EDI-enabled users on a store and forward basis via a third party VAN (figure 5.1).

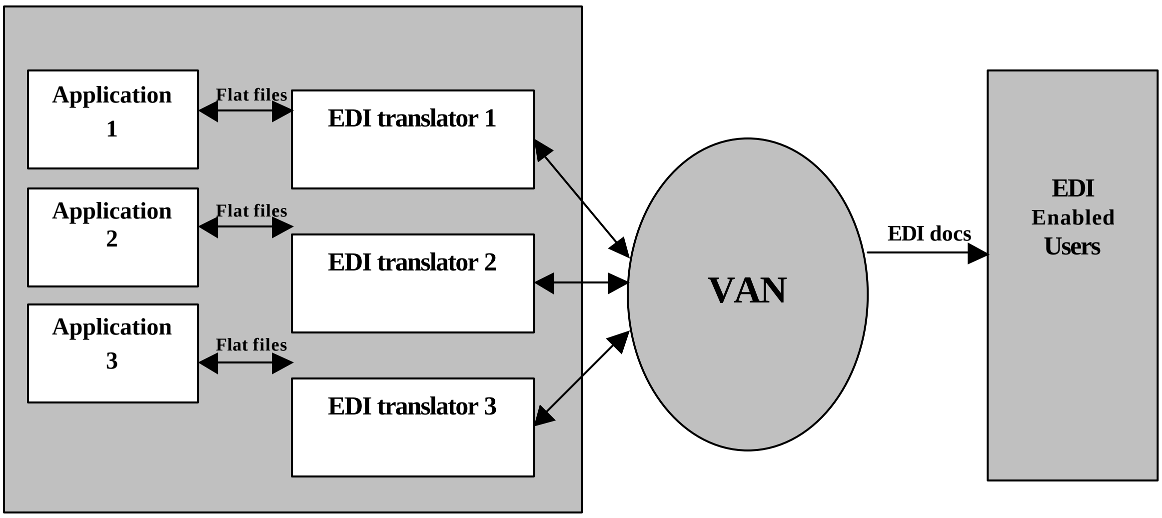


figure 5.1: *EDI infrastructure*

5.3 PROBLEMS WITH THE CURRENT EDI INFRASTRUCTURE

Despite the many benefits of EDI and the fact that the quality and price of computers and communications equipment have improved significantly over the past two decades, many organisations are still reluctant to adopt EDI.

During this research two major hindrances in implementation of the EDI network have been pointed out: **expense** and **network complexity.** It is believed that these main obstacles are responsible for the disappointing uptake of EDI:

- lack of management awareness of the strategic benefits and opportunities EDI may bring;
- the difficulty of evaluating the tangible benefits of EDI;
- lack of top management commitment to the EDI implementation process;
- concern with the high cost of EDI hardware, software and value-added network subscriptions;
- difficulty in justifying the investment in EDI.

5.4 INTERNET BENEFITS

The aim is to fully exploit the Internet's promise as a low cost information transport mechanism with standardised formats and protocols. The Internet offers broad connectivity that links networks around the world, supports point of use infrastructures, and offers a platform-independent means of exchanging information. With worldwide connections, the Internet can dynamically link users to any organisations even though no previous transactions exist. It is estimated that by 2002 80% of the EDI transactions will be exchanged via the Internet [Reilly, Block 1997]

5.5 FIRST PROPOSED MODEL (SERVER DEPENDENT)

A web-based EDI model is proposed that adopts the "intelligent gateway" concept, using a central EDI server site (hub) system to perform bi-directional transactions. In this model Java-capable browsers allow users to conduct EDI-like data transactions using the Internet without pre-installing EDI software. This eliminates the costs of VANs and the costs of traditional translation software. The architecture of the proposed model as depicted in figure 5.2, consists of two parts: the server site (hub) and the supplier site.

5.5.1 Business Documents Flow

Billing orders and invoices constitute the majority of data transactions among the EDI network users. The hub site's backend system generates the appropriate files that must be transmitted to the user. As shown in figure 5.2, an EDI translator converts the proprietary-format document file generated by the hub site's proprietary backend system, for a particular user, into an EDI file.

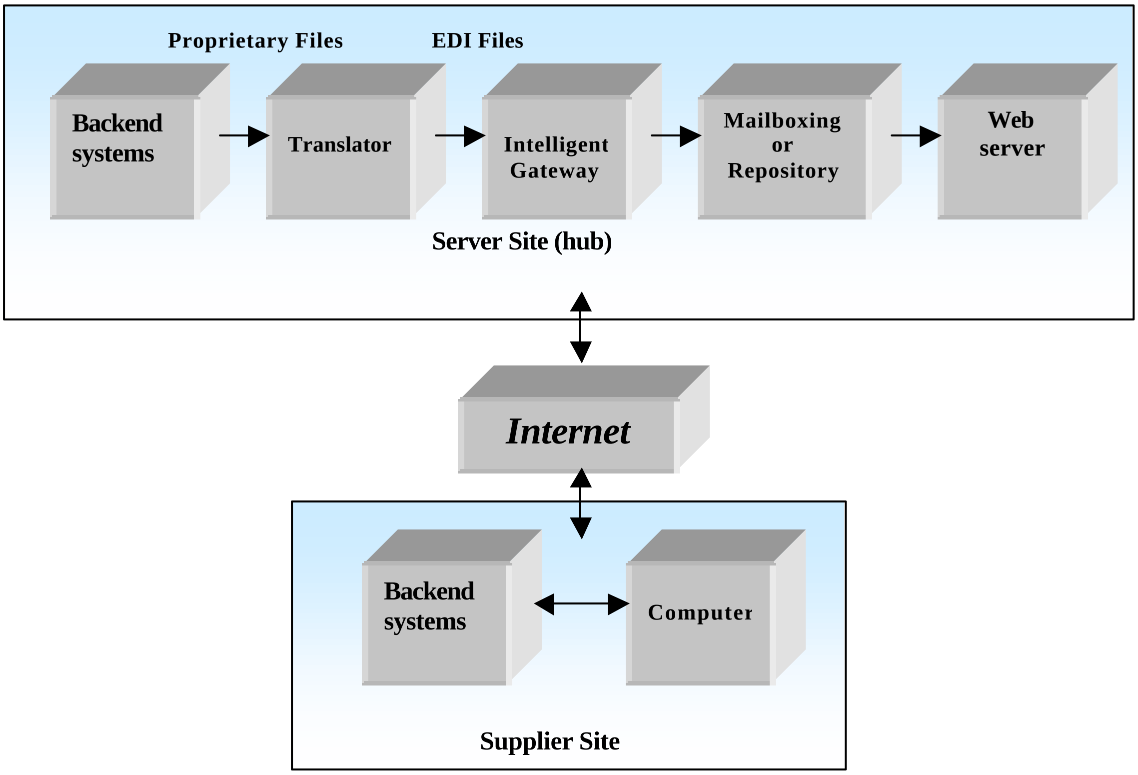


figure 5.2: *New EDI infrastructure*

This EDI file is then placed into a mailbox or repository system via a reliable delivery gateway. The repository system then sends a notification to the appropriate user. On receiving the notification, the user invokes a Web browser to login to the webserver, download and view the file. Together with the EDI file, the web browser also downloads Java Applets. These Applets translate EDI files into a form-based content that is displayable through the browser. In addition to the translation and display of EDI files, these Applets transfer data that can be exchanged with the user's backend systems.

The user can prepare a reply document either by entering information manually in the browser or by using a backend system to generate a reply document, which is transferred into the browser by the adapter. The Java Applets then send the prepared document back to the Web server. On the web server side, the document is received and deposited into the file repository system. From this repository, the file is sent via the intelligent gateway into the hub's backend system where normal processes are followed in order to assign the incoming file with the internal systems of the EDI user.

5.6 BASIC COMPONENTS

5.6.1 Backend Systems

The backend system in the hub site generally contains an application system, such as EnTrack or X-tra, and its underlying database to store and operate on this data. These applications have their own internal proprietary data format. To conduct business activities with the network users, the backend system generates documents in the proprietary format and accepts reply documents from the end users. As the backend system only recognises its own proprietary format, it requires a translator to convert documents.

The supplier may have its own backend system to manage their activities and generate reply documents. To automate the processes of incorporating the downloaded EDI documents into the supplier's backend system, an adapter is provided.

5.6.2 Translator

A large organisation typically exchanges data with many trading partners who require either different standards (e.g. X12, EDIFACT) or paper documents. In general the translator in an EDI-enabled hub takes the responsibility of firstly converting the sender's data format to a variety of formats and secondly translating various incoming document formats into the proprietary format. The proposed model does not require any of the paper formats.

5.6.3 Mailboxing or Repository

Mailbox services are the core component of VANs with many value-added services built on top of mailboxing. The proposed model currently utilises any database for the mailboxes and uses a web server to list and serve up documents and applets. The hub creates and maintains mailboxes for each spoke, with each mailbox containing an inbox and an outbox. The inbox stores the EDI documents delivered by the hub to the user, while the outbox saves the reply EDI documents from the user. By utilising the access control facilities provided by the database, the proposed model maintains the mailbox and allows each user to access only its own mailbox.

5.6.4 Webserver

The webserver provides authentication by requiring that a supplier enter a valid user id (identifying the supplier) and password to log on into the system. After logging on, a supplier only accesses its own mailbox and the Applets and has only read privilege for the incoming documents. Web servers also have the SSL (Secure Socket Layer) encryption capability.

5.6.5 Adapter

The adapter is used by the suppliers to import documents into their backend system by converting the document into the format accepted by the backend system.

5.7 SUPPLIER REGISTRATION

Each user goes through a one-time registration via the Web. During the registration, the user requests a user id and enters their e-mail address (used for notification) and other vital information (company name and contact phone number etc) and picks from a list of supported backend systems.

This registration process requires an administrator of the server to assign a password and run a script to add the new supplier, providing any additional information required, such as the supplier ID to be used for particular EDI messages. The script will mail the password to the supplier, set up the supplier user id, enter the supplier information into the supplier list and set up the necessary authorisations.

5.8 DISCUSSION

For many organisations, the pre-described Internet EDI model offers an alternative solution that is less expensive yet offers many of the VANs advantage:

- it enables suppliers to conduct automated EDI transactions with the large enterprise using only a Java-capable Web browser, without installing any EDI software or setting protocols.
- it allows the main user (hub) to utilise their existing EDI system to conduct automated EDI transactions with the suppliers (spokes) that are not EDI-enabled;
- it can coexist with the traditional VAN-EDI that large enterprises are already using;
- it provides security services such as login security, access control and SSL transport;
- it provides end-to-end integration that automates the business flow between the hub and the spokes;
- it supports Internet EDI.

5.9 SECOND PROPOSED MODEL (GENERIC SOLUTION)

The second web-based model constitutes the development of an *engine* for generic communication of data, based both on EDI principles and on the Internet network. In order to accomplish this engine other programs and client-server systems have to be provided.

JDBC [Buchanan 1998] is the main application for the development of this engine. JDBCTM is a Java trademark Application Programming Interface (API) for executing SQL statements. (As a point of interest, JDBC is a trademarked name and is not an acronym; nevertheless JDBC is often thought of as standing for Java Database Connectivity.) It consists of a set of classes and interfaces written in the Java programming language. JDBC provides a standard API for tool/database developers and makes it possible to write database applications using a pure Java API.

Furthermore, the ODBC Driver Manager as well as the ODBC driver itself has to be associated with the JDBC application. The design of JDBC is based on that of ODBC, a standard way of accessing SQL-compliant databases. ODBC simply provides a method of connecting an application to a data source. Its significance is that it strives to be open to as many kinds of applications and sources as possible, and does so fairly successfully.

However, the key point for the accomplishment of this engine is to design a JDBC-ODBC bridge for database access referred as “intelligent gateway”. The JDBC-ODBC bridge is a JDBC driver that implements database connection operations by translating them into ODBC operations. To ODBC, it appears as a normal application program. The Bridge implements database connectivity for any database for which an ODBC driver is available. This kind of bridge enables database access wherever ODBC compliance occurs. However, it is possible to use a pure Java JDBC driver instead of the bridge and the ODBC driver. This completely eliminates the client configuration required by ODBC. It also eliminates the potential that the Java VM could be corrupted by an error in the native code brought in by the Bridge (that is, the Bridge native library, the ODBC driver manager library, the ODBC driver library, and the database client library).

Finally, a smart importation engine has to be designed and applied internally into the DBMS system of the organisation. The whole functionality is displayed graphically in figure 5.3.

5.9.1 Engine functionality

The system described in the schema of figure 5.3 comprises the complete vision of the generic communication engine.

The first step is for a user to grant access to the on-line databases via the ODBC Driver. This can be accomplished using of a Java program (JDBC Driver Manager) developed for managing the communication link. Since the connection has been established, the following step is to design and build an internal importation engine. Java's JDK (Java Development Toolkit) can be useful in this situation as well. Firstly, a module on which the user can select the type of the file that will be imported has to be accomplished. File selection is in terms of its file extension. Secondly, another module will be responsible for the manipulation of data. The user must be able to access the information (fields) from the imported database and drag them into the reception database. Finally, the third module will process and integrate the new database into the main system's databases. This entire engine can be developed using Java's JDK and API, which supports the building of user friendly and robust interfaces.

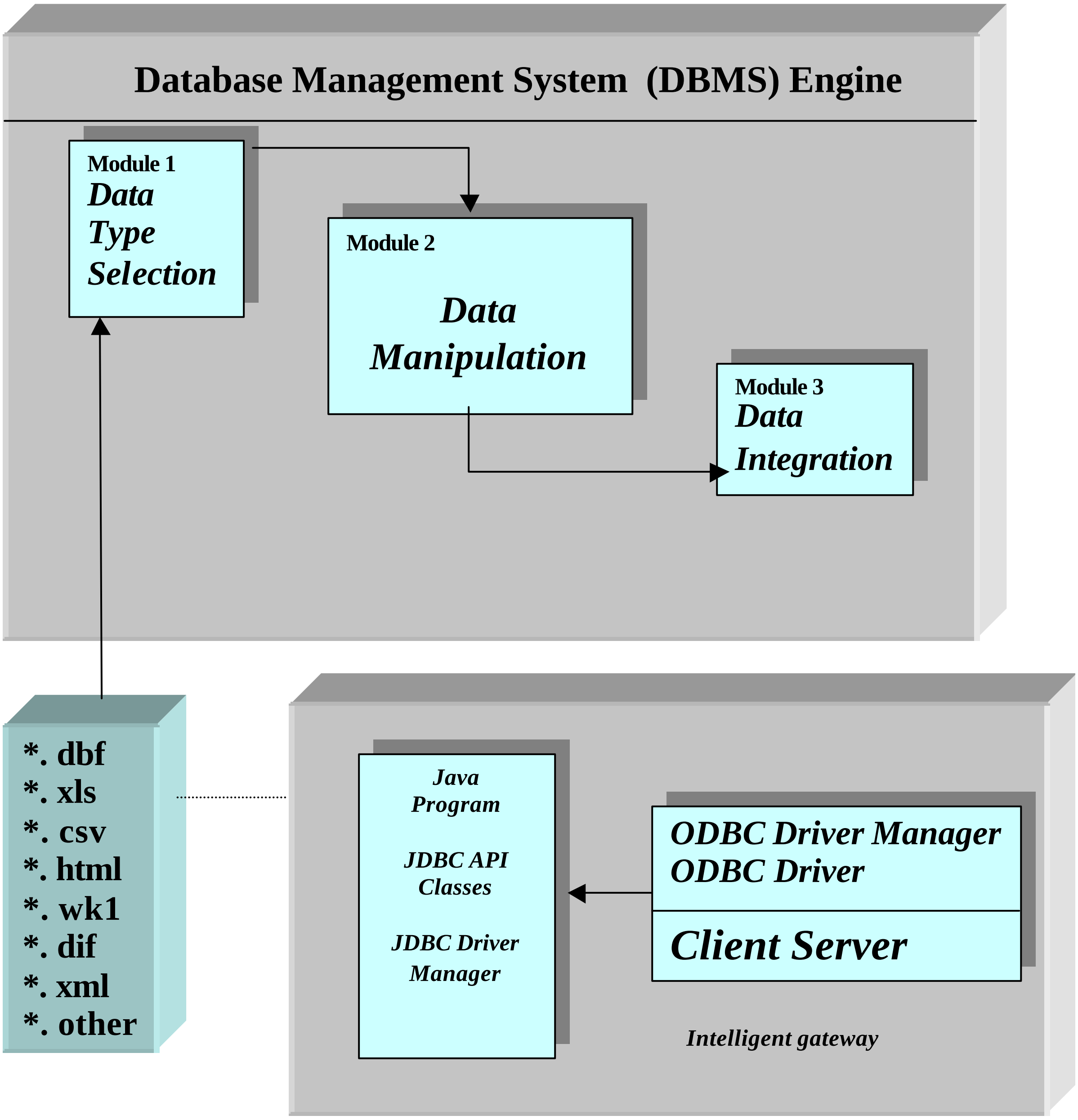


figure 5.3: *Database Access via the JDBC/ODBC bridge*

5.9.2 Outcome

Although the engine has nothing to do with the EDI network itself, the idea of the system described above is based on EDI communication principles. It is considered as the evolution of EDI networking towards a more generic type of transaction. *Easy deck access* and the *independent message type* are considered to be the advantages of this system.

The deployment of this generic solution for data access and communication will enable the transmission of databases to the user application in a way that is independent from the number of end users and the type of the network. The EDI router has been replaced from a client server using ODBC drivers. This introduces the advantage of inexpensive and simple networking.

In conclusion, the following areas should be considered for further research in order to implement the above.

- Research the set of classes and interfaces written in the Java programming language, as well as in a particular area of JDBC that provides a standard API for tool/database developers and makes possible database applications development using a pure Java API.
- Research on the design of JDBC based practically on the ODBC's standard way of accessing SQL-compliant databases.
- Re-engineering of the user system's databases for association of the new data communication module.

Comment

Although traditional EDI has had some success in specific industries, especially large enterprises, it has not been widely adopted by companies. The substantial barrier is the costs associated with EDI implementation and VAN services. The Internet is a ubiquitous public network that provides many advantages over VANs, including low cost worldwide connectivity, platform-independence, and ease of use.

References:

Reilly and J. Block, **"Next Generation Electronic Commerce Processes and Systems",** *Garnter Group Electronic Commerce Strategy, (1997).*

William Buchanan, **"Mastering JAVA",** *Macmillan press ltd, (1998).*

http://www.w3.org/XML *W3C XML Page.*

Bibliography:

C. Smith, G. Spieler, A. Terhune, **"EDI: At the Crossroads of Evolution or Extinction,** *Vol. 1, No. 11,(March 1996).*

Chapter 6

CONCLUSIONS

The need for a capability to electronically transfer data into advanced decision support systems has been demonstrated. Having defined the practical objectives (data accuracy, reliability of information, effective energy management and confidentiality), the main goal of this work was to develop/enhance the electronic data interchange (EDI) technology within energy management. The solutions adopted facilitate the electronic data transfer and database integration at an appropriate level of abstraction.

In this chapter, a general discussion of this work is presented and the requirements for future work introduced.

6.1 CONCLUSIONS

Optimisation of decision-making in energy management has assumed greater importance not only for reasons of energy efficiency but also for environmental impact. The noncommittal way information flows from the available sources to support decision-making within organisations is ad hoc and non optimal.

In order to improve this situation, and provide effective and efficient support for energy management, advanced decision support systems can be employed. However, while such systems can provide assessments of energy usage, there are limited facilities for the effective acquisition and intelligent integration of multi-variable information.

The main goal of this work was therefore to investigate the automatic communication and integration of information from disparate data sources into the decision support system in order to facilitate high integrity information flow. It was argued that the only way to respond to information explosion is to provide a technology that supports the automatic transfer of data, namely electronic data interchange (EDI).

Based on a review of technologies for information control and EDI, the following objectives were set:

- to study the requirements of EDI technology for data transfer;
- to employ EDI in conjunction with an advanced decision support tool for energy management (EnTrack);
- to implement, and test a prototype system within different user environments.

Following on from the literature review, the requirements for data transfer were established and the main types of EDI technology categorised.

The database maintenance module of the EnTrack program was then extended by adding of an EDI feature. An additional dataset for North Lanarkshire Council was then established using EDI. A number of conclusions were then drawn:

- the time required to create and update databases is dramatically reduced;
- the required level of human interaction has been significantly reduced;
- the information flow is accurate, robust and reliable;
- the quality of transferred information has been assured in terms of its compatibility and sufficiency.

The use of the two types of EDI technology (structured and unstructured) were explained and subsequently demonstrated by means of two practical case studies. Accordingly, their applicability were assumed as follows:

- Where two users are connected, the standard structured EDI is preferred.
- With a multi user environment, unstructured EDI is considered to be more flexible.
- Structured EDI is a reliable way of network development in terms of data confidentiality.
- Both EDI types present constraints regarding network complexity and expense.

6.2 FUTURE RECOMMENDATION

The present work is merely a step towards an envisaged intelligent, integrated information exchange and management network, and work remains to be done in the area of electronic data interchange. Several areas of future research have been identified:

- Creation of templates for fuel use exchange.
- Creation of standard EDI exchange protocols.
- User support for fast track EDI implementation.

…From the above, it is clear that the objectives of this study have been fulfilled and that the work is a step in the direction of accomplishing the reality of electronic data interchange. With the continuous advances in communication technologies and increasing computer-processing power, the prospect for reliable and robust information transfer in energy management is promising. It is hoped that the present work will generate new thoughts and encourage further developments in the area of electronic information exchange in energy management…

Appendix I

TEAM SOFTWARE

I.1 TEAM software

It is not intended to carry out a detailed operational analysis of this software, as this would entail a complete implementation of the system to achieve but to summarise the functionality offered to users. This overview is intended to act as a benchmark from which to evaluate the relative merits of more intelligent decision support systems in terms of their applicability to energy management. The following overview is based on a combination of demonstration and literature review.

The TEAM system is made up from three separate windows-based systems, each of which can be separately purchased and will operate independently of the other two:

- the **energy accounting** package analyses data and information from invoices or meter readings;
- the **automatic monitoring** system is designed to interface with BEMS, data loggers and other automatic recording equipment;
- the **contract tariff** analysis has been specifically developed to accept half hourly metered and invoice data for the evaluation of the 100kW electricity contacts.

I.2 Energy Accounting

The energy accounting software is the main component. It is built up of a number of modules which, when added to the main database, provide more rigorous analysis and presentation tools for the user. The software has been created around a standard database that has been developed into a reasonably professional interface for the first time user to operate. The modules making up the complete energy accounting package are listed as follows:

- main database;
- graphical and statistical analysis;

- CUSUM;
- reporting module;
- tariff analysis
- weekly database analysis;
- environmental auditing.

I.3Automatic Monitoring System

The automatic monitoring system is a completely separate software package to the energy accounting system. This package has been designed primarily to accept the large amounts of data produced through BEMS sub metering as frequently as on a half hourly basis. It can also accept inputs from many other data collection systems.

Although it is simply called the automatic monitoring system, this is in reality a complete monitoring and targeting package. The claim is that the benefit of this type of system over conventional M&T software is that because it handles data more frequently than the manual input systems, it is therefore able to identify problems sooner after their occurrence, effectively reducing the risk of escalation and consequently maximising any cost saving potential.

However, this developed desktop type of system will operate comfortably on its own merits within the limits of the design, some of which will provide some basic file transfer techniques and some of the functional windows commands such as “cut and paste”. It does not provide the ability to configure links in terms of communicating information with other programs or a transparency between functions such as detailed financial appraisal of projects or even GIS systems.

Appendix II

VALUE ADDED NETWORK (VAN)

II.1Value added networks (VAN)

One of the key components of EDI is the communications medium used to enable the electronic transmission of business documents, between a large number of different organisations throughout the world. In the early days of EDI, organisations such as the Article Number Association evaluated the most appropriate means to support electronic communications between companies.

As a result of their deliberations, it was determined that the use of magnetic tapes or disks for the exchange of data was limited in potential and would inevitably cause problems when the volumes of data exchange grew. They also decided that direct communications links between organisations would be difficult to manage in large numbers. They therefore determined that the way forward was to use a VAN (Value Added Network) to support the communications requirements of industry and commerce.

II.2 The Major VANS

The result of this initial EDI activity, driven by the ANA, was that ICL was asked to develop an EDI service. This service known as TRADANET has become the most widely used VAN in the UK. Subsequently, ICL set up a joint venture company with GEIS (General Electric Information Services) to focus on the electronic messaging services business. This company, INS, is now completely owned by GEIS, between both companies they claim to support the largest community of EDI users in the world.

Another VAN which was originally UK based was Istel. It has developed a substantial user community initially in the automotive and engineering sectors. Global communications company AT&T then acquired it. Thus both of the early market leaders in EDI are now part of international organisations offering global messaging services.

The other main contenders in the UK market are BT and IBM. IBM has had a presence in the market for some time and in particular has established a niche for itself in the insurance business. More recently the company's presence has developed in other industry sectors and in particular, it has developed its European base of users.

The last major player to enter the market was BT. It's presence within the messaging business was also enhanced by its acquisition of Tymnet. Tymnet was one of the leaders in the US marketplace and gave BT a source of EDI products and services from which to evolve and expand into other markets including the UK.

All of the above companies are expanding their market presence in an increasingly wide variety of industry sectors.

In addition there are some smaller organisations that offer function services in particular industries e.g. AutoLink and DIALnet. These are often targeted at the smaller companies.

II.2 Benefits of a VAN

It was clear from the outset that any organisation, committed to EDI, would have a requirement to communicate with a large number of different organisations, whether these are suppliers or distributors. The function of the VAN therefore was to provide a single channel to facilitate this type of communication.

The VANS support links to their networks for all of the main computer hardware and software operating environments. When you join a VAN you need only be concerned about your link to the network whether it be from a PC, mini or mainframe computer. What your customers or suppliers use to connect to the network need not to be concerned at all, as the VAN will take care of all these individual connections to their services.

Until recently, there was a limiting factor, in that there were no connections between networks. As a result, the early development of user communities tended to focus around a particular VAN. In the retail sector the most widely used VAN is the INS TRADANET service, the automotive industry on the other hand developed around the AT&T Easylink network. If an organisation had trading partners on different networks it had no option other then to join more than one.

Now all of the networks support interconnections with each other. It is possible, therefore, to join one network and communicate with trading partners on any of the networks via these interconnections. It should be noted, however, that the current nature of these interconnections means that the full end-to-end Audit Trail capabilities of VANS outlined below do not exist when you send data across more than one network.

In addition to providing the benefits of a single communications link to multiple trading partners VANS fulfil the following functions:

Mail boxing: At its core the VAN is essentially an electronic post office. It receives electronic messages which may be orders, invoices etc., reads the addressing information contained in the EDI envelope surrounding these messages and posts them into the mailbox of the recipient.

All of this can be accomplished within a matter of seconds ensuring that critical business documents can be received by trading partners within minutes.

Audit Control: It will be obvious from the above that it is essential for the VANS to provide the end user with a full audit trail, so that users have information at their disposal with which to manage their use of such services. These facilities are now generally available as a function both of the networks themselves and the software packages that are available for connection to the networks. As previously stated, however, detailed end-to-end audit is not available via most of the available network interconnections.

In general there can be no doubt that the overall levels of security maintained by the VAN operators is very high and that sending important business documents electronically is much more secure than using paper based systems.

Appendix III

X.25 CAUSE CODES

III.1 X.25 Cause Codes

A cause code indicates an event that triggered an X.25 packet. The cause code can only appear in entries for CLEAR REQUEST, REGISTRATION CONFIRMATION, RESET REQUEST, and RESTART packets. Possible values for the cause code can vary, depending on the type of packet. Because the REGISTRATION exchange is not supported, those cause codes are not documented in this section.

Table A1 describes the meanings of cause codes for CLEAR REQUEST packets.

Table A1: Cause Code Descriptions for CLEAR REQUEST Packets

Code (Hex)	Code (Dec)	Description
00	0 (or 128 to 255)	DTE originated
01	1	Number busy
03	3	Invalid facility request
05	5	Network congestion
09	9	Out of order
0B	11	Access barred
0D	13	Not obtainable
11	17	Remote procedure error
13	19	Local procedure error
15	21	RPOA out of order
19	25	Reverse charging not accepted
21	33	Incompatible destination
29	41	Fast select not accepted
39	57	Ship absent

Table A2 describes the meanings of cause codes for RESET REQUEST packets.

Table A2: Cause Code Descriptions for RESET REQUEST Packets

Code (Hex)	Code (Dec)	Description
00	0 (or 128 to 255)	DTE originated
01	1	Out of order
03	3	Remote procedure error
05	5	Local procedure error

07	7	Network congestion
09	9	Remote DTE operational
0F	15	Network operational
11	17	Incompatible destination
1D	29	Network out of order

Table A3 describes the meanings of cause codes for RESTART packets.

Table A3: Cause Code Descriptions for RESTART Packets

Code (Hex)	Code (Dec)	Description
00	0 (or 128 to 255)	DTE restarting
01	1	Local procedure error
03	3	Network congestion
07	7	Network operational
7F	127	Registration/cancellation confirmed

III.2 X.25 Diagnostic Codes

The diagnostic code provides an additional hint as to what, if anything went wrong. This code can only appear in entries for CLEAR REQUEST, DIAGNOSTIC, RESET REQUEST, and RESTART packets. Unlike the cause codes, the diagnostic codes do not vary depending upon the type of packet.

Table A4 describes the meanings of possible diagnostic codes.

Table A4: Diagnostic Field Code Descriptions

Code (Hex)	Code (Dec)	Description
00	**00**	No additional information
01	01	Invalid P(S)
02	02	Invalid P(R)
10	**16**	**Packet type invalid**
11	17	Packet type invalid for state R1
12	18	Packet type invalid for state R2
13	19	Packet type invalid for state R3
14	20	Packet type invalid for state P1
15	21	Packet type invalid for state P2
16	22	Packet type invalid for state P3
17	23	Packet type invalid for state P4
18	24	Packet type invalid for state P5
19	25	Packet type invalid for state P6
1A	26	Packet type invalid for state P7
1B	27	Packet type invalid for state D1
1C	28	Packet type invalid for state D2
1D	29	Packet type invalid for state D3

20	**32**	**Packet not allowed**
21	33	Unidentifiable packet
22	34	Call on one-way logical channel
23	35	Invalid packet type on a permanent virtual circuit
24	36	Packet on unassigned LCN
25	37	Reject not subscribed to
26	38	Packet too short
27	39	Packet too long
28	40	Invalid GFI (General Format Identifier)
29	41	Restart or registration packet with nonzero LCI
2A	42	Packet type not compatible with facility
2B	43	Unauthorized interrupt confirmation
2C	44	Unauthorized interrupt
2D	45	Unauthorized reject
30	**48**	**Timer expired**
31	49	Timer expired for incoming call
32	50	Timer expired for clear indication
33	51	Timer expired for reset indication
34	52	Timer expired for restart indication
35	53	Timer expired for call deflection
40	**64**	**Call set up, clearing, or registration problem**
41	65	Facility code not allowed
42	66	Facility parameter not allowed
43	67	Invalid called address
44	68	Invalid calling address
45	69	Invalid facility length
46	70	Incoming call barred
47	71	No logical channel available
48	72	Call collision
49	73	Duplicate facility requested
4A	74	Nonzero address length
4B	75	Nonzero facility length
4C	76	Facility not provided when expected
4D	77	Invalid ITU-T-specified DTE facility
4E	78	Maximum number of call redirections or deflections exceeded
50	80	Miscellaneous
51	81	Improper cause code for DTE
52	82	Octet not aligned
53	83	Inconsistent Q bit setting
54	84	NUI (Network User Identification) problem
70	**112**	**International problem**
71	113	Remote network problem
72	114	International protocol problem
73	115	International link out of order
74	116	International link busy
75	117	Transit network facility problem

76	118	Remote network facility problem
77	119	International routing problem
78	120	Temporary routing problem
79	121	Unknown called DNIC
7A	122	Maintenance action

X.25 PACKET SWITCHED NETWORKS

IV.1 Introduction

X.25 Packet Switched networks allow remote devices to communicate with each other across high-speed digital links without the expense of individual leased lines. Packet Switching is a technique whereby the network routes individual packets of HDLC data between different destinations based on addressing within each packet.

IV.2 X.25 structure

The protocol known as X.25 encompasses the first three layers of the OSI 7-layered architecture as defined by the International Standards Organization (ISO) as follows:

Layer 1: The Physical Layer is concerned with electrical or signalling. It includes several standards such as V.35, RS232 and X.21bis.

Layer 2: The Data Link Layer, which is an implementation of the ISO HDLC standard called Link Access Procedure Balanced (LAPB) and provides an error free link between two connected devices.

Layer 3: The Network Layer, which provides communications between devices, connected to a common network. In the case of X.25, this layer is referred to as the X.25 Packet Layer Protocol (PLP) and is primarily concerned with network routing functions and the multiplexing of simultaneous logical connections over a single physical connection.

The user end of the network is known as Data Terminal Equipment (DTE) and the carrier's equipment is Data Circuit-terminating Equipment (DCE). The X.25 PLP permits a DTE user on an X.25 network to communicate with a number of remote DTEs simultaneously. Connections occur on logical channels of two types:

Switched virtual circuits (SVCs) - SVCs are very much like telephone calls; a connection is established, data are transferred and then the connection is released. Each DTE on the network is given a unique DTE address that can be used much like a telephone number.

Permanent virtual circuits (PVCs)- PVC is similar to a leased line in that the connection is always present. The logical connection is established permanently by the Packet Switched Network administration. Therefore, data may always be sent, without any call set up.

To establish a connection on an SVC, the calling DTE sends a Call Request Packet, which includes the address of the remote DTE to be contacted.

The destination DTE decides whether or not to accept the call (the Call Request packet includes the sender's DTE address, as well as other information that the called DTE can use to decide whether or not to accept the call). A call is accepted by issuing a Call Accepted packet, or cleared by issuing a Clear Request packet.

Once the originating DTE receives the Call Accepted packet, the virtual circuit is established and data transfer may take place. When either DTE wishes to terminate the call, a Clear Request packet is sent to the remote DTE, which responds with a Clear Confirmation packet.

The destination for each packet is identified by means of the Logical Channel Identifier (LCI) or Logical Channel Number (LCN). This allows the PSN to route the each packet to its intended DTE.

X.25 relies on the underlying robustness of HDLC LAPB to get data from node to node through the X.25 network. An X.25 packet makes up the data field of an HDLC frame. Additional flow control and windowing are provided for each Logical Channel at the X.25 level.

Maximum packet sizes vary from 64bytes to 4096 bytes, with 128 bytes being a default on most networks. Both maximum packet size and packet level windowing may be negotiated between DTEs on call set up.

X.25 gives you a virtual high quality digital network at low cost. It is economical for the same reason that it is usually cheaper to use the mail than to run your own postal service: there are tremendous savings to be made if multiple parties share the same infrastructure.

In most parts of the world, X.25 is paid for by a monthly connect fee plus packet charges. There is usually no holding charge, making X.25 ideal for organizations that need to be on line all the time. Another useful feature is speed matching: because of the store-and-forward nature of Packet Switching, plus excellent flow control, DTEs do not have to use the same line speed. So you can have, for instance, a host connected at 56kbps communicating with numerous remote sites connected with cheaper 19.2kbps lines.

X.25 has been around since the mid 1970's and so is pretty well debugged and stable. There are literally no data errors on modern X.25 networks.

X.25 does have some drawbacks. There is an inherent delay caused by the store-and-forward mechanism. On most single networks the turn-around delay is about 0.6 seconds. This has no effect on large block transfers, but in flip-flop types of transmissions the delay can be very noticeable. Frame Relay (also called Fast Packet Switching) does not store and forward, but simply switches to the destination part way through the frame, reducing the transmission delay considerably.

Another problem for the networks is a large requirement for buffering to support store-and- forward mechanism. One of the reasons that Frame Relay is so cost effective is that storage requirements are minimal.