Theories Underlying Approaches to Systems Modelling

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Contents

1. Learning outcomes check list for the session

This handout makes the following assumptions concerning your knowledge / skills:

- You are aware of some of the techniques of Modellers such as Object, or Entity Relationship Diagrams, State diagrams and Business Process Re-engineering.
- You have carried out a practical exercise using the above techniques.

For details of the two above topics see
chapter 11 http://www.robin-beaumont.co.uk/virtualclassroom/contents.htm.

This handout aims to provide you with the following skills and information. After you have completed it you should come back to these points ticking off those you feel happy with.

Learning outcome	Tick box
Provide a definition for Holism and Organicism	❑
Provide a definition of emergence	❑
Describe in short paragraph the general aims of General Systems Theory (GST) were	❑
Be aware of the patterns movement	❑
Be able to list the basic characteristics of any system derived from the findings of GST	❑
Provide a definition for the concept of teleology	❑
Be aware of the aims of Systems Modelling now	❑
Explain the main approaches to systems modelling taken today	❑
Be aware of the four sociological paradigms that can be applied to organisations and systems modelling	❑
Name and provide an example of a top down objective approach to systems modelling	❑
Name and provide an example of a top down subjective approach to systems modelling	❑
Name and provide an example of a bottom up subjective approach to systems modelling	❑
Name and provide an example of a bottom up objective approach to systems modelling	❑
Be aware of the problems with the 'objective' approaches	❑
Be aware of Frege's Sense and Reference concept	❑
Be aware of Wittgenstein's Rules of Correspondence	❑
Be aware of Austin's Performance meaning concept	❑
Be aware of the problems of mapping a model onto a computer system	❑
Be aware of the consequences of the objective paradigm for Database development	❑

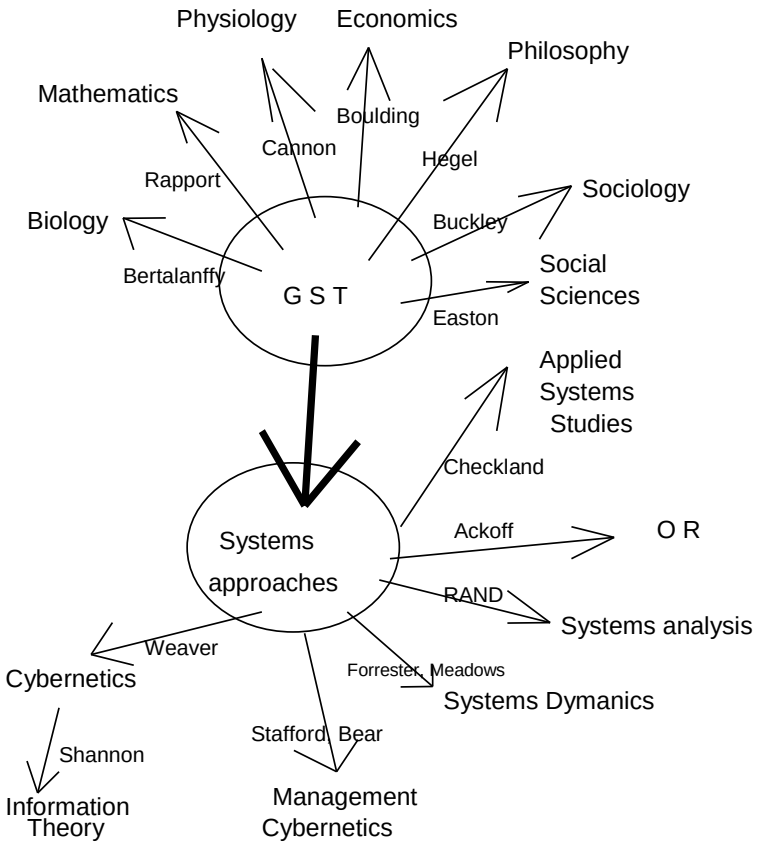
2. Introduction

This handout describes the various approaches that are taken to systems modelling showing how they are, to a certain extent, a reflection of a philosophical stance adopted by the modellers.

3. Systems Modelling - Early History

The concept of systems modelling can be traced back to at least the times of ancient Greece (Checkland 1981), however it is only within the 20th century that the concept of 'systems' itself has been considered. The impetus for the analysis of systems per se was the development of two theoretical movements, firstly the search for unifying principles, and secondly the result of the adoption of the theory of **Holism** by some notable academics (i.e. the book by Smuts in 1928 called Holism and Evolution). This produced the General Systems Theory (**GST**) movement in the 1930's / 40s for details of which see Bertalanffy 1968 (p12, p19-23). At the same time as GST was being formulated **Cybernetics** and **Organicism** (a particular kind of Holism) developed and a decade latter **Information theory** and **Game theory** had a similar influence upon GST. The invention of computers made possible the development of most of these specialist areas including GST. Computers have also provided an alternative method to mathematical modelling - **Simulation** - to investigate models and have been the driving force in developing **Systems Engineering**. This term means a number of things of which probably the most succinct definition is that of Bertalanffy 1968 "Systems Engineering i.e. scientific planning, design, evaluation, and construction of Man-machine systems." (p91). In particular Systems Engineering often consists of two distinct stages, that of **Systems Analysis** and **Systems Design**. Nowadays these last two terms often refer to the development of a computerised Information System (**IS**) and the modern term, **Systems Modelling,** includes both these phases.

Systems Theory - Main Divisions



The diagram opposite shows the range of influences GST had upon a whole range of areas.

The GST approach envisioned by Bertalanffy was a very different thing from that practised by modern Systems Modellers. It used different techniques, had a different purpose and, to a large extent, had a different philosophical foundation. This change is largely the result of many of the complex and difficult aspects being removed to make it workable, unfortunately this streamlining has, I believe, lost several very important aspects.

The section below looks at Bertalanffy's vision while subsequent sections look at various modern approaches to systems modelling.

Adapted from Open University courseT243 Block 1 p.23

3.1. GST and Bertalanffy

As suggested by the name, GST was a theoretical activity that attempted to discover unifying principles for all systems often by way of using complex mathematical models. In other words, "the structural similarity of such models and their isomorphism in different fields" (Bertalanffy 1968 p13) The society for General Systems Theory Research (SGSR) was set up in 1950 and subsequently GST was taken up by a large number of disciplines. While this search has been rather disappointing several basic characteristics have been suggested including:

- Holism / Emergence
- Closed / Open
- Communications
- Processing / Function
- Structure
- Purpose / Goal
- Hard / Soft
- Hierarchy/ Centralisation / Control
- Connectivity (Mechanistic or Organismic)

Based on Jordon 1968

While many of the above characteristics can be found in the modern day process of systems modelling some of them, as well as other aspects of GTS, have all but disappeared. Such aspects are the teleological, and organismic principles that support a generally anti-mechanistic viewpoint of which each will now be discussed.

Anti-mechanistic viewpoint

Bertalanffy was a prodigious writer and an excellent publicist. He believed GST offered a model which was a replacement or extension to the mechanistic viewpoint. He disliked the mechanistic (in his period considered to be Cybernetic) approach and stated it many times:

"...Progressive mechanisation - the individual becoming ever more a cogwheel dominated by a few privileged leaders, mediocrities and mystifiers who pursue their private interests under a smokescreen of ideologies" (Bertalanffy 1968 p10 quoting Sorokin 1966 p558)

" 'Organisms' are not machines; but they can to a certain extent become machines, congeal into machines. Never completely, however; for a thoroughly mechanized organism would be incapable of reacting to the incessantly changing conditions of the outside world" (Bertalanffy 1968 p213)"

The mechanistic world view, taking the play of physical particles as ultimate reality, found its expression in a civilisation which glorifies physical technology that has led eventually to the catastrophes of our time. Possibly the model [read GST model] of a world as a great organisation can help to reinforce the sense of reverence for the living which we have almost lost in the last sanguinary decades of human history." (Bertalanffy 1968 p49)

Teleology

He felt that **teleology** (directed behaviour) was very importance, and not addressed by the mechanistic viewpoint:

"notions of teleology and derivativeness appeared to be outside the scope of science, and to be the playground of mysterious, supernatural and anthropomorphic agencies; or else, a pseudoproblem, intrinsically alien to science, and merely a misplaced projection of the observer's mind into a nature governed by purposeless laws. Nevertheless, these aspects exist, and you cannot conceive of a living organism, not to speak of behaviour and human society, without taking into account what variously and rather loosely is called adaptiveness, purposiveness, goal-seeking and the like." (Bertalanffy 1968 p45)

One aspect of teleology he considered was **finality**, that is the state to which a system is 'aiming' towards:

"It has been maintained for a long time that certain formulations in physicis have an apparently finalistic character. This applies in two respects. Such teleology was especially seen in the *minimum principles of mechanics*. Already Maupertuis considered his minimum principle as proof that the world, where among many virtual movements the one leading to maximum effect and minimum effort is realised, is the 'best of all worlds' and work of a purposeful; creator. Euler made a similar remark: 'Since the construction of the whole world is the most eminent and since it originated from the wisest creator, nothing is found in the

world which would not show a maximum or minimum characteristic'. A similar teleological aspect can be seen in Le Chatelier's principle in physical chemistry and in Lenz's rule of electricity. All these principles express that in case of disturbance, the system develops forces which counteract the disturbance and restore a state of equilibrium; they are derivations from the principle of minimum effort. Principles homologous to the principle of minimum action in mechanics can be construed for any type of system"

"The conceptual error of an anthropomorphic interpretation is easy seen. The principle of minimum action and related principles simply result from the fact that, if a system reaches a state of equilibrium, the derivatives become zero; this applies that certain variables reach an extremum, minimum or maximum; only when these variables are denoted by anthropomorphic terms like effect, constraint, work, etc., an apparent teleology in physical processes emerges in physical action". (Bertalanffy 1968 p75-6).

Bertalanffy discusses different types of finality (p77-79) including the idea of 'fit for purpose' however detailed discussions are outside this short introduction.

Organicism

The final aspect of GTS which I would like to present is that of Organicism, called by the famous philosopher Bertrand Russell the 'concept of organism' (Bertalanffy 1968 p67). Organicism is an extension of holism. Holism basically states that the sum of the parts is greater than the simple summation of each. Organicism however takes this further and states that all systems (including non living ones) behave like living things, literally organisms, whose parts lose their nature, function, significance, and even existence when removed from their organic interconnection with the rest of the organism (Bullock, Stallybrass & Trombley 1988 p390).

Bertalanffy once again was a pains to stress that his interpretation of Organicism did not imply some metaphysical component, and demonstrated mathematically how the concept can, and does, exist in the real world. This is in contrast to Vatalism (see: http://www.xrefer.com/entry.jsp?xrefid=344934) in which there is a belief of a vital metaphysical force.

Organicism embraces concepts such as Holism and **emergence. Emergence** is simply the development of a new characteristic at a higher level than appeared lower down, for example consciousness or 'the mind'. For a description of Holism see http://www.swif.uniba.it/lei/foldop/foldoc.cgi?holism and Organicism see http://www.swif.uniba.it/lei/foldop/foldoc.cgi?organicism

Self-organised Systems – continuing Bertalanffy's ideas

Both Teleological and Organicism ideas have been incorporated into the more recent discipline of 'self-organised systems'. Examples of this include the behaviour of sand to form piles (see http://zinc.hpac.tudelft.nl/home/thijssen/sand/sandpile.html), behaviour of ants (See Langston's Ant web site: http://www.math.umd.edu/~wphooper/ant/ or http://www.go2net.com/people/chaper/java/Langston/) and the behaviour of flocking birds (see http://www.red3d.com/cwr/boids/). An excellent article introducing these concepts appeared in the magazine PcPro, July 2001, p216 – 223.

Exercise 1 (4 hrs):

Spend some time reading about the concepts discussed above, you do not necessarily need to use the web links various paper dictionaries etc. provide excellent review articles. .

Patterns

Most of the grand plans of GST have now been largely forgotten. Although they do live on in such 'areas' as Process manufacturing and the Health care arena with developments such as the Good European Record project and the NHS Healthcare model (http://www.standards.nhsia.nhs.uk/hcm/Index.htm) or the COSMOS Clinical Process Model (http://www.sm.ic.ac.uk/medicine/cpm.htm unfortunately this link is now broken and the model is not available anywhere else).

A related recent development is that of the '**pattern**' concept. **Patterns** are generic models that can fit a number of situations. Fowler 1997 contains a collection of Patterns (he was also involved in developing the COSMOS model). He also has a web site which contains links to the patterns homepage (see abstract below).

"Patterns describe common ways of doing things. They are collected by people who spot some repeated themes in designs they come across. They then take each of these themes and describe them so that other people can read the pattern and see how to apply it. An important part of a pattern is that it is much more than a model. A pattern must also include the reason why it is the way it is. It is often said that a pattern is a solution to a problem, and the pattern must make the problem clear and explain why it solves the problem and in what circumstances it works and in what cases it would not work.

There is a significant movement of people who are interested in documenting patterns. The patterns community sponsor conferences and have produced quite a number of books. Patterns are important because they are the next stage beyond understanding the basics of a language or a modeling technique. Patterns give you a series of solutions and also show you what makes a good model, and how you go about constructing a model. They teach by example." [Abstracted from Martin Fowlers web site: http://www2.awl.com/cseng/titles/0-201-89542-0/techniques/patterns.htm]

Exercise 2 (1 hr):

Investigate the NHS Healthcare model web site (details given in the section above).

3.2. Time line

The table below provides the main stages in the history of modelling:

Systems modelling		Key events
Philosopy		1925 Whitheads 'Organic mechanism'
		1948 Russells rejection of Organicism for a mechanistic view
Biology	-	Cannon 1929 'homeostasis'
Cybernetics		Wiener 1949
Information theory		Shannon & Weaver 1949
Sociology	-	Parsons Functional analysis of organisations (1949)
Psychiatry		Whitehead, Woodger, Coghill, Köhler (gestalt theory) (Bertalanffy 1968 p208)
Systems Theory		GST Society 1950, OR Society 1950, RAND corp.
1970s	-	Add the human element to the process - The Humanistic Rebellion:
		Mumford (Birmingham UK)
		Checkland (Lancaster UK) - soft systems
1980s	-	Development of computer support ('Tools') for the process CASE, ICASE, METACASE
		Accelerator, System architect, Oracle
1990s	-	New method of modelling - Object orientation
		Business Process Re-engineering
1990's		Mathematically verifiable approaches - Formal methods(?)
2000's		Self-organised behaviour, Genetic programming, Intelligent software agents etc. to enable modelling of biological systems

While some of the above concepts will be discussed in this section. Details of others can be found by following the links from the main contents page of the web site. http://www.robin-beaumont.co.uk/virtualclassroom/contents.htm

Back to contents

4. What is Systems Modelling Now?

Nowadays Systems modelling can be thought of as the practical implementation of GST. It has the following characteristics:

- Has a 'system' as the starting point
- Produces a 'model' of some sort
- Has a defined process ('structure') = methodology
- Uses defined methods ('techniques') during the process
- Often the first process in developing a computer system

For example you might hear someone say "A systems analyst investigated the local hospital using methodology X their final report contained a vast number of Data Flow Diagrams, Entity Relation Diagrams, not forgetting the massive Data Dictionary"

Unfortunately there is not just one methodology or a standard set of techniques to carry out systems modelling. This is probably partly due to the financial incentive to sell methodologies and techniques along with the computer support for them. Traditionally a number of consultancies/ companies developed all inclusive, very prescriptive methodologies with approved training programmes. This all inclusive approach is now generally frowned upon by modellers who are being encouraged to use their own experience selecting a set of techniques they feel happy with alongside a non inclusive methodology. (For an example of one such approach see details of the Unified Modelling Language at http://www.robin-beaumont.co.uk/virtualclassroom/contents.htm) This has been called the tool bag or tool Kit approach to systems modelling (Benyon & Skidmore 1987).

A methodology can be thought of as a road map of what to do when. Whereas a technique or **tool is a particular activity within it.** In the following sections a number of methodologies and techniques will be discussed.

Exercise 3: (30 mins)

From the understanding you have about modelling, create two lists, one of techniques or tools and another of methods with which you are already aware.

5. The main approaches to systems modelling

There have been several attempts to classify the approaches taken to systems modelling (Wood-Harper & Fitgerald 1982; Episkopou & Wood-Harper 1986; Jayaratna 1986; Klein & Hirschheim 1987; Hirschheim, Klein & Lyytinen, 1995). Wood-Harper & Fitgerald 1982 believe that the various approaches can be classified into two paradigms, whose that fit the **Scientific** (similar to Bertalanffy's mechanistic concept) or those that fit the **Systems** paradigm. This dichotomy is also presented by Klein & Hirschheim 1987 who call it the **Objective** / **Subjective** dichotomy.

Episkopou & Wood-Harper 1986 provide a framework to help modellers decide which approach is most suited in any given situation based upon the characteristics of the Problem Owner, Problem Solver and Problem Content System (environment).

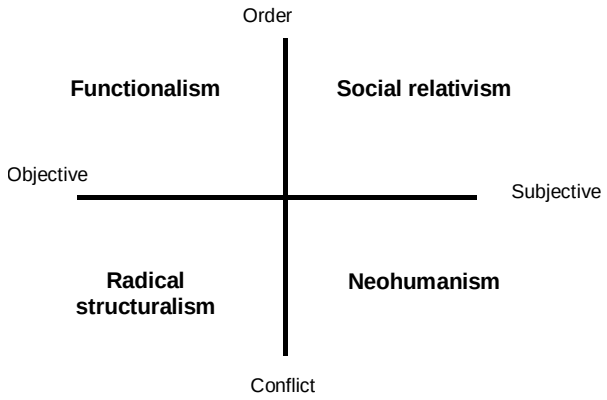
Hirschheim, Klein & Lyytinen, 1995, in a detailed book about the Philosophical foundations of Information Systems Development, extend the dichotomy to form a grid. Interestingly the same grid appears in Mumford et al. 1985 where it is attributed to M C Jackson (University of Hull consultancy work for OU on systems and system methodologies - unpublished).

Much of the information below is taken from the Hirschheim et al book.

Their grid is based upon the work of Burrell and Morgan 1979 who suggested it when applying sociological paradigms to the analysis of organisations. In addition to the Objective / Subjective dimension an **Order** / **Conflict** dimension is added. Representing the two main thrusts of sociological thought.

The order or 'integrationist' view emphases a social world characterised by order, stability, integration, consensus and function co-ordination. At the other extreme the 'conflict' or 'coercion' view stresses change, conflict, disintegration, and coercion.

Information Systems Development Paradigms (Hirschheim, Klein & Lyytinen 1995 p48 based on Burrell and Morgan 1979)



Each quadrant in the grid is given a name (paradigm) to represent the sociological viewpoint adopted. These are shown on the diagram opposite.

This all may seem a long way from the process of developing Information Systems (IS), however the philosophical view adapted by the analyst dictates which method and techniques are used and therefore what system will be produced. See Boland 1979, Jayaratna 1986, Howard 1987, and Hirschheim, Klein & Lyytinen, 1995 p57-67.

The table below provides a view of the modeller using each of the above viewpoints. They range from her / him being seen as an EXPERT to that of a CATALYST.

Sociological Paradigms and Implications for Information Systems Development (Hirschheim, Klein & Lyytinen, 1995 p52)

Paradigm	Role of Modeller	Nature of Information System (IS) Application	Objectives for In formation System Design (ISD) and Use of Information Systems
Functionalism	The EXPERT: similar to an engineer, who masters the means for achieving given ends	IS is built around deterministic laws of human behaviour and technology to gain optimum control of socio-economic environment.	ISD is concerned with fitting technology, to pre-defined organisational objectives. IS use is aimed at overcoming computation limitations of man and improving productivity.
Social Relativism	A CATALYST who smoothes the transition between evolutionary stages for the social system for which he is a part.	IS is concerned with the creation and sharing of meaning to legitimate social action whatever it may be: overcoming tension due to transition from one set of conditions to another.	To elicit the design objectives and modes of use which are consistent with the prevailing conditions; to help others to understand and accept them. To develop systems which implement 'the prevailing Zeitgeist' (spirit of the times).
Radical Structuralism	A WARRIOR on the side of the forces of social progress	IS can contribute to the evolution of society by overcoming the inherent social contradictions; use of IS should be to achieve emancipation of working class. This involves aggressive application of the natural sciences which is a force of progress.	ISD must be a process of better understanding the requirements set by the current evolutionary stage of society and the place of the organisation within it. IS designer must be on guard not to work in to the hand of vested interests, in particular the use of IS must further the class interest and not the exploitation of the common man.
Neohumanism	An EMANCIPATOR from social and psychological barriers	Understanding of the options of social action and free choice; IS is to create a better understanding of these by removing bias and distortions.	IS development must be concerned with removing bias and distortion due to seemingly natural constraints; external (power) and internal (psychopathological) barriers to rational discourse must be removed.

The above framework is very useful and certain commentators recommend that modellers (IS developers / designers in the above table) keep this aspect firmly in mind whenever modelling as failure to do so results in inappropriate Information Systems Development (ISD) (Jayaratna 1986).

Exercise 4: (60 mins)

Forgetting modelling for a minute! Taking the four above sociological paradigms produce a set of brief notes suggesting how adopting each of the above paradigms might influence your daily job?

The following table compares the four paradigms in terms of their implications for six fairly standard aspects of systems development.

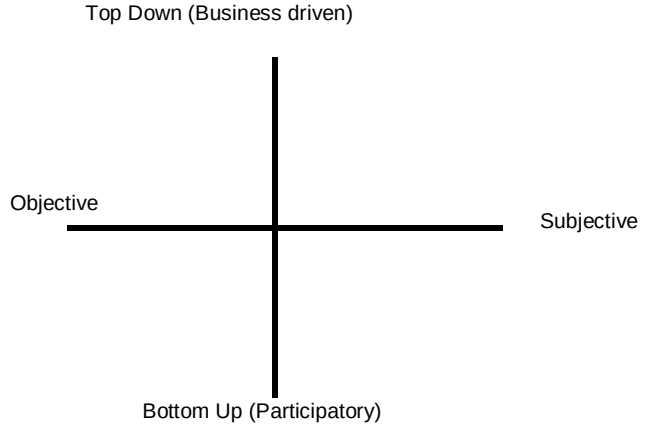
Implications of Sociological Paradigms on functions within Information Systems Development (Hirschheim, Klein & Lyytinen, 1995 p53)

Activities in ISD	Functionalism	Social Relativism	Radical Structuralism	Neohumanism
Defining Information	Information is a product; it is produced, traded and make available at will, like a commodity	Information is a journey with a partner; information emerges from reflection, interaction and experience	Information as a means of manipulation and a weapon in ideological struggle	Information as means of control, sense-making and augumentation
Framing ISD	ISD is like engineering with the systems developer being the expert of methods and tools	ISD is like a journey to an uncertain destination with the systems developer acting as the facilitator	ISD is like a form of rationalisation directed against worker interests; or a counter-strategy by the workers to deflect exploitation	ISD is like an opportunity to improve the control over nature and to overcome unwarranted barriers to communication
Problem finding and formulation	Improved prediction and control of the various entities in the business functions through maintaining and analysing data; identify misfits between organisation mission and IS;align structure of IS with business strategy; seek opportunities for competitive advantage	Improved conditions for learning and co-operation; identify means to support the improvement of mutual understanding and the creation of new meanings; facilitate interaction and exchange of information	Improved productivity of the workers; or improve the position and enhance the craftsmanship and skills of the workers	Improve institutional tools and organisational arrangements for prediction and control, mutual understanding and discourse, and emancipation of all stakeholders
Analysis	Determine how the key processes of the organisation contribute to the intended performance outcomes and which data they eed for their effective functioning. For a good review of possible requirements determination strategies see Davis (1982)	Understand and investigate the existing basis of interaction and communication such as differing horizons of meanings of various stakeholders	Identify how IS can increase competitiveness and productivity by increasing work intensity, division of labour and control; or identify alternative forms of IS that improve the wags and general conditions of work	Identify existing technical, social and linquistic barriers for optimal prediction and control, mutual understanding, and emancipation from unwarranted constraints
Logical design	Model the portion of organizational reality which is relevant for the system using tools such as process modelling, object modelling and demonstrate functionality through prototyping	Reconstruct user language to support interaction to more effectively capture meanings as conveyed in ordinary speech (Boland & Day 1982)	Construct systems models that enhance productivity and competiveness; or, use prototypes to experiment with technology that will retain and enhance the skills and tradition of the craft	Reconstruct the technical, liguistic and organisational basis for improving prediction and control, mutual understanding and discourse, learning and emancipation
Physical Design and Technical Implementation	Find cost-effective hardware and software solution to implement the logical design	Not discussed in the literature	Find cost-effective hardware and software; or, find alternative hardware and software solutions that will improve the works' quality of work life	Realise changes in technology, language and organisation to improve control, mutual understanding, discourse and emancipation
Organisational Implementation	Develop strategies to seek compliance by the users to avoid resistance and implementation games (Keen 1981) [Also Eason K 1988 p32]	No implementation strategy needed since ISD supports the on-going evolutionary change	Develop strategies to seek compliance by the workers to avoid resistance so as to maximise productivity. Or, consider structural changes of control in work organisation to enhance position of the workers	Anticipate potential impacts of changes in organisation, language and technology on each other: develop strategies to mitigate unwanted side effects
Maintenance	Monitor environmental changes and continued functionality of IS	No difference between maintenance and continuing evolution of IS	Monitor the realisation of the system objectives regarding productivity and competitiveness; or, monitor the continued use of IS to support the interests of the workers	Monitor the actual performance of IS with regard to control and prediction, mutual understanding, and emancipation and make adjustments, accordingly in the domains of technology, language or organisation

The above four sociological paradigms, although useful, are less than user friendly for the person not familiar with Sociological concepts. With this in mind I suggest that the 'conflict'/order dimension be thought of as a method of Information System Development (ISD) itself. The 'ordered' world view envisages a top down approach to ISD while the 'conflict' world view can be interpreted as the bottom up approach.

Main Approaches to Information Systems Development (my classification)

My approach is not completely accurate as the two dimensions are not orthogonal (i.e. independent of each other) because subjective approaches usually imply a bottom up approach. However I feel they provide a pragmatic framework for modellers.

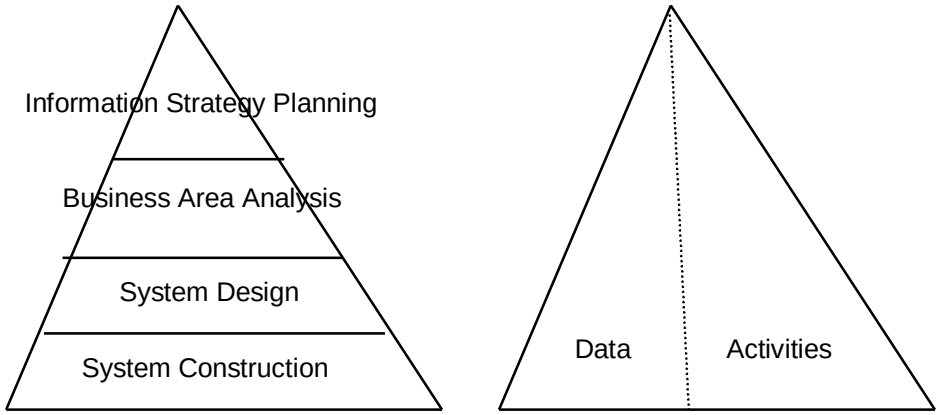


The following sections will look at a modelling method from each of the four quadrants.

5.1. Top Down - Objective Approach

The top down objective approach to Information Systems Development has been up until now the most popular but not necessarily the best approach. Most Methodologies implicitly or even explicitly assume this paradigm by possessing names which including the word 'business' in there title.

James Martin in the 1980s developed the prescriptive popular method of 'System Engineering'. (**IE**) The methodology consisted of four phases each exploring both data and activity issues.

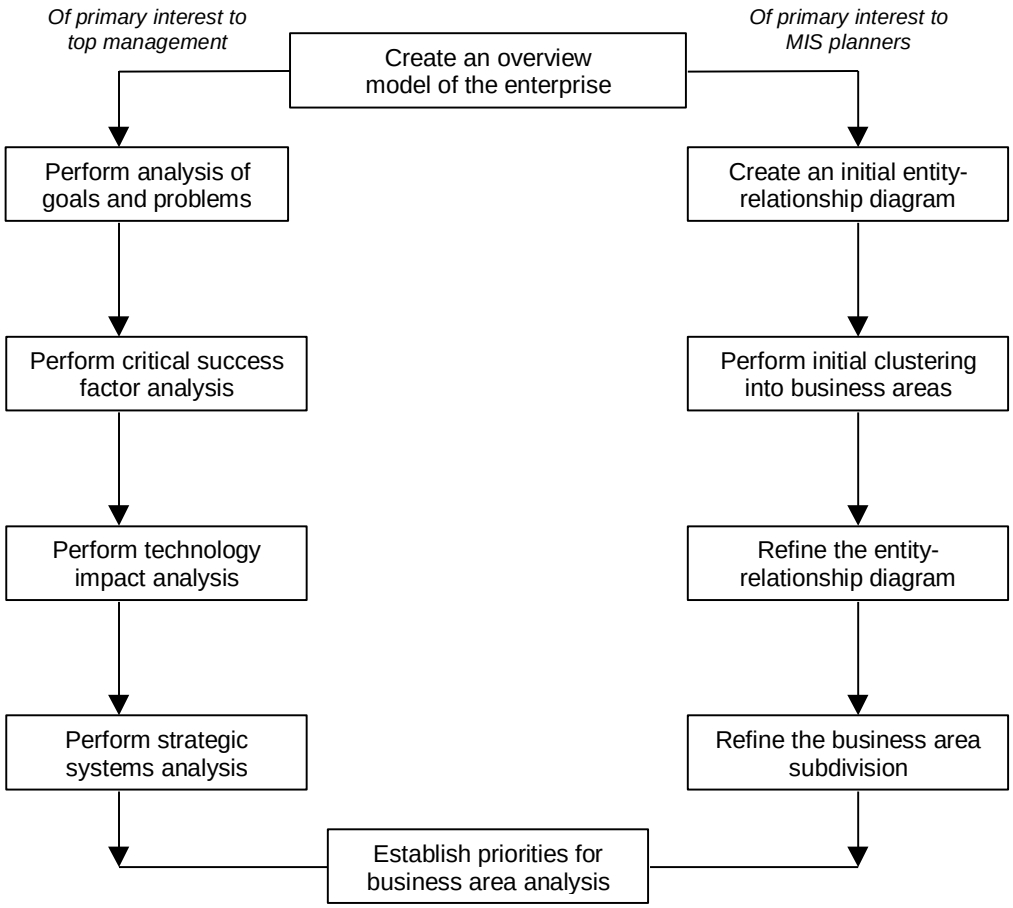


The Bottom two levels make extensive use of various tools (i.e. diagrams) such as Data flow diagrams, Entity models, Process models, Data dictionaries and a whole variety of Matrixes.

Martin presents the IE method in great detail with regard to the actions to take, frequently several pages of small print list each action along with the required deliverables.

Each of the above four phases are initially broken down into a set of steps, the diagram below shows that for Information Strategy Planning:

Phase one: Information Strategy Planning (James Martin 1990 - vol. 2)



Key tasks in James Martins Information Strategy Planning (Vol 2 p24 - 32)

Understand the benefits of ISP (listed on vol 2 page 31 - 32)
Determine the Scope of task
Ensure that the prerequisites exist:
- Champion
- Appropriately skilled individuals
- Scope identified
- Charter
- Strategic Business plan exists
- Data administration function exists

Select senior management participants
Obtain top management commitment
- Seniority appropriate to task
- Distribute reading article
- Obtain agreement

Determine which locations are involved
Determine which organisations locations are involved
Prepare Information Strategy Planning Team
If an outside consultant is to be used then . . . .
Ensure in-house project leader is trained in:
- Communication skills
- Negotiation
- Information Engineering
- Diagramming techniques
- Automated tools used

[further team preparation details]
Collect and evaluate existing strategic plans
Define a plan for successful completing this ISP project
- Modify this action diagram as required

Determine the target date for completing the study
Hold kickoff meeting
- All senior management participants should attend
- Have the chief executive of the enterprise make the opening speech
- Review with participants the purpose and objectives
- Review the business assumptions that are to be made
- Review the agenda
- Give the participants the preparatory material for them to study

Create overview model of enterprise
- Organisational chart
- Identify Business functions and decompose them

Matrix creation
- Executives against business functions
  - R: Direct management Responsibility
  - A: Executive or policy-making Authority
  - I: Involved in the function
  - E: Technical EXPERTISE
  - W: Actual execution of the WORK
- Business functions against organisational units
- Business functions against executives

Review data collected print out relevant diagrams
Conduct Goal-Problem Analysis (see chapter for details)
Conduct Critical Success Factor Analysis (see chapter for details)
Conduct Technology Impact Analysis (see chapter for details)
Conduct Strategic Information Systems Study
Create a top-level analysis of corporate data
- Identify the data subjects
- Decompose into entity types
- Create an initial entity relationship diagram
- Create a matrix mapping functions against entity types
- Create a matrix mapping organisational units against entity types
- Print relevant versions for participants to review

Refine the enterprise model and entity-relationship diagram
Conduct meetings with end users and management to critique the enterprise model
Make any improvements to the enterprise model as a result of above
- Refine the entity relationship diagram
- Refine the matrix mapping business functions against entity types
- Refine the matrix mapping organisational units against entity types

Group enterprise model into natural clusters
- Cluster the functions / entity matrix to show natural systems.
  - Use the clustering algorithm of the strategic planning tool.
  - Cluster on the basis of what functions CREATE what entity types
  - Assign all remaining functions and entity types to clusters.
  - Refine the groupings manually to identify natural systems.
  - Identify what data must flow from one system to another.
  - Refine the clusterings to minimise the interaction among systems.

Cluster the function/entity matrix to show natural business areas.
- Adjust the clustered function/entity matrix to form BAA boundaries.
  - [details]

Make top-management presentation
- Obtain agreement to follow-on actions.
- Assign all functions to a business area.
- Determine the locations of that business area.
- Build a matrix of business areas and locations
- Build a matrix of business areas and departments
- Refine the business areas as necessary.

Refine BAA project boundaries by considering:
- Time to implement BAA.
- Effort required to implement BAA.
- How the proposed BAA fits with the current organisation.
- Risk Assessment:
  - User acceptance / participation
  - User sophistication/ readiness
  - Technical complexity

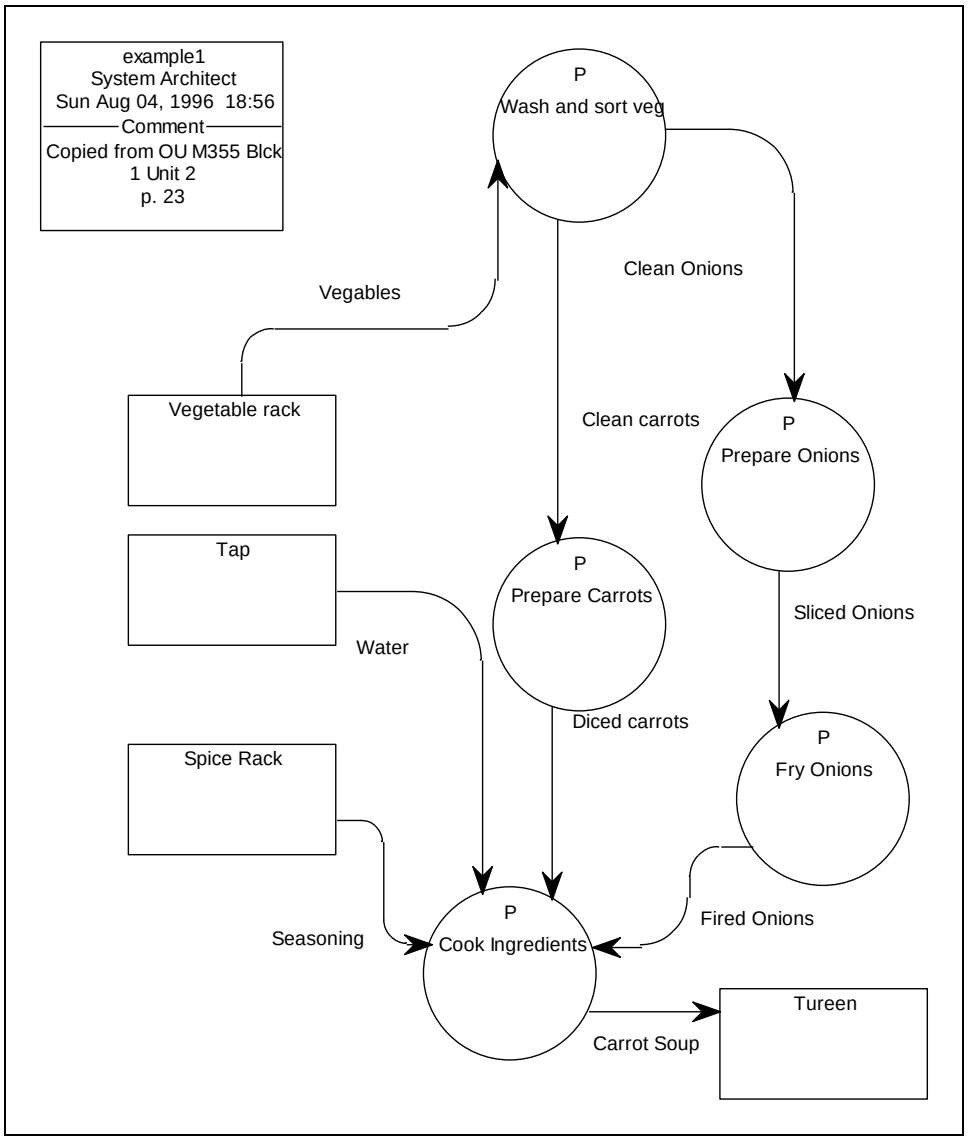
Analyse current systems to determine what changes are needed:
- Build a matrix mapping I.S systems against organisational units.
- Build a matrix mapping I.S systems against executives.
- Build a matrix mapping I.S systems against business functions.
- Build a matrix mapping I.S systems against entity types.
- Cluster the above matrices into business areas.
- Identify which systems are in need of replacement or redesign.
- Identify which systems are expensive in maintenance costs.

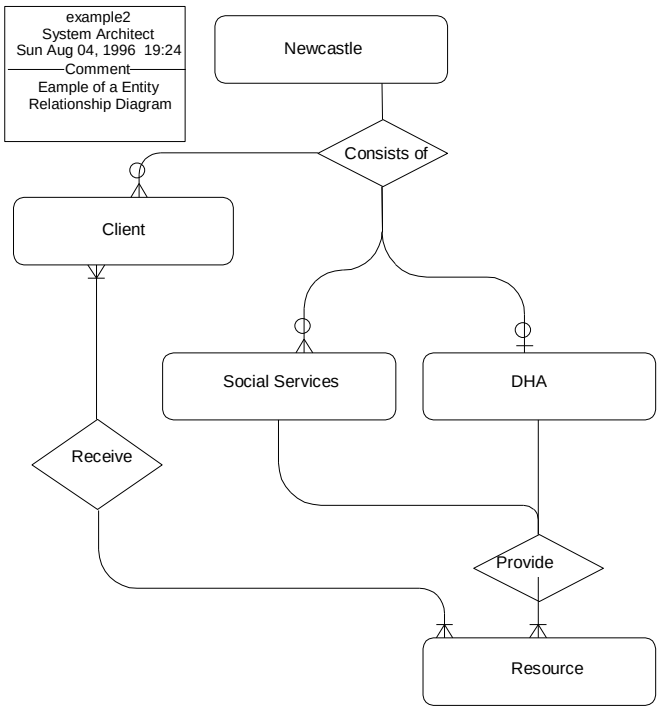
Prepare follow-on from Strategic Information Planning
When the ISP results are presented to top management a detailed action plan should accompany them saying what happens next. It is desirable that the ISP study is immediately followed by vigorous action which leads to implementing better systems.
- Prioritise the business areas for Business Area Analysis
- There are multiple factors that affect the prioritisation of which business area to work first.
- Rank the factors below on a scale of 1 to 7
- Potential Benefits (this may be difficult to calculate and need value judgements)
  - Return on investment
    - Tangibles
    - Intangibles
  - Achievement of critical success factors
  - Achievement of goals
  - Solution to serious problems
- Demand:
  - Pressure of demand from senior end users for new or improved system
  - Assessed need
  - Political overtones
- Organisational impact
  - Number of organisations and people affected
  - Whether the organisations are geographically dispersed.
  - Qualitative effect.
- Existing systems
  - Adequacy or value of existing systems
  - Relationship with existing systems
  - Estimated future cost of maintenance. (systems which are fragile or have high maintenance costs should be replaced)
- Likely success
  - Complexity. (Relatively simple areas shouls be the first to be tackled until experience is gained.)
  - Degree of business acceptance
  - Length of project
  - Prerequisites
  - Risks
- Resources required
  - Whether existing data or process models exist
  - Whether a suitable tool kit is installed
  - Quality of available analysts
  - Funds required
- Concurrent implementation
  - Whether multiple Business Area Analysis project can proceed concurrently.
  - Whether one project will quickly train people to move to other projects.
  - Whether an existing data administration function has already done good data modelling.
- Initiate Business Area Analysis
- [further details]

Determine what systems should be built immediately. The ISP generates certain urgent needs for systems for senior management. These should be satisfied as quickly as possible with relatively simple techniques such as spreadsheet tools, decision support software, or executive information system (EIS) software.

Initiate actions to keep the ISP up-to-date

Example of a Data Flow Diagram





Example of an Entity Relationship Diagram

James Martins developed a computer tool to assist with the process by keeping a repository of at the information collected (called the 'encyclopaedia'). The tool also allowed diagram construction and keeping all the information synchronised. Most system development methods of the Top down Objective approach now possess such tools (called generically CASE or I-CASE).

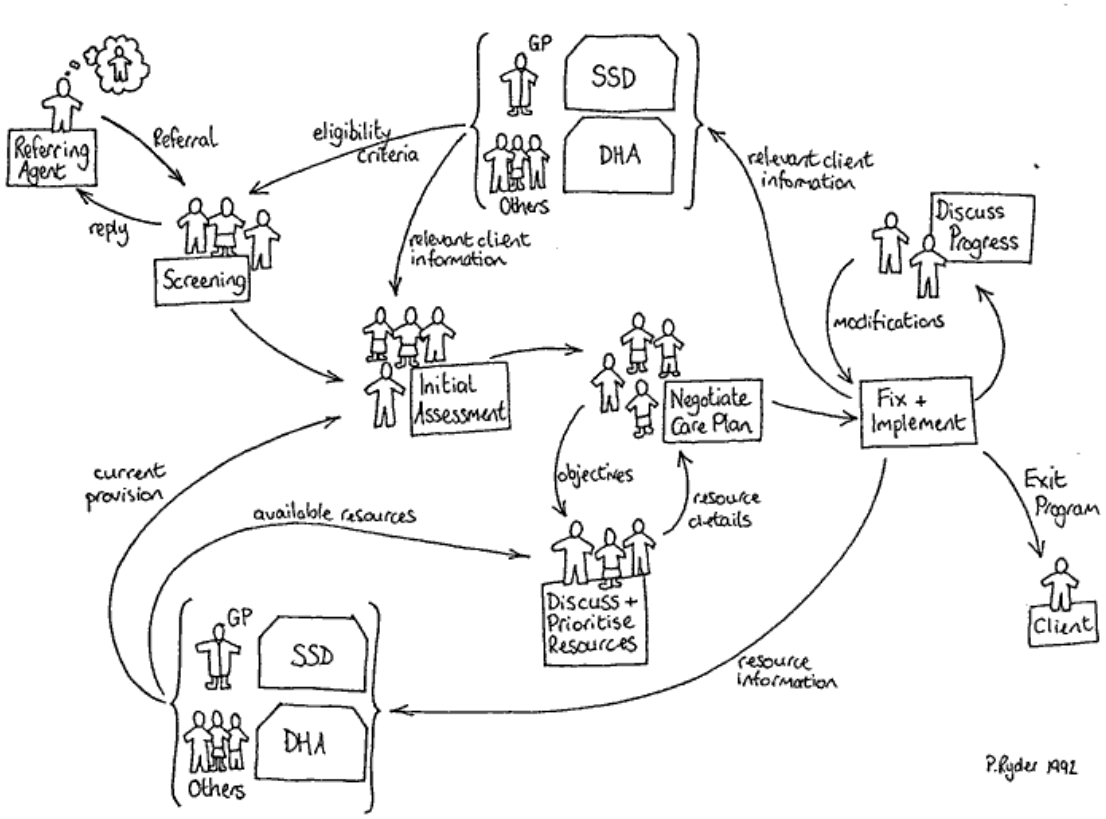
There are now examples of Documents which have been developed using a similar approach to that of James Martins on the Web. One such example is that produced by the State or Oregon http://spr.das.state.or.us/pandg.htm written by Scott Smith (scott.smith@state.or.us)

5.2. Top down - Subjective Approach - SSM

In contrast to the prescriptive approach of James Martin Checklands Soft Systems Method (SSM) is far more flexible. Checkand developed his method in the 1980s at Lancaster University where he still works part time (http://www.lums.lancs.ac.uk/mansci/Staff/CHECK.HTM) The method is primarily to help people investigate their own organisations. As with James Martins approach Checklands has a number of stages, 6 in all, however Checkland recommends that modellers (he tends to call them 'problem solvers') use what they want of the method. A key feature of the method is the production of **Rich Pictures**. These are drawings of the situation from the users perspective using symbols they decide upon rather than standard Systems development symbols as in the James Martin diagrams.

The example below is taken from a project in the UK (North Tyneside Information Sharing Project, Paul Ryder, 1992 e-mail: Paul@bconline.co.uk) that worked with service users to help clarify various issues concerning information management. SSD = Social Services department. DHA=District Health Authority

Rich Picture Representation of Simplified Community Care System



Developing a Rich picture "expresses the problem situation attempting to avoid structuring the problem situation that would close down original thinking and hence learning. Conceiving the problem situation as a system in the [traditional mechanistic] manner would, in Checkland's view, put in structure to thought before learning had had a chance to unfold in a creative fashion . Rich pictures are advocated as one suitable means of expression. They are cartoon type representations that allow people to express their experiences and, as is the case with cartoons, accentuate points that stand out in their minds (abstracted from http://www.think-systems.ch/uni/hoax/62_system.htm by Peter Meier http://www.think-systems.ch/cv-pm.htm)

Checklands method does not focus on the possible develop of an information system but rather on the 'problem' and aims to allow those who take part in the process to come to a greater understanding of it at the end. The lack of an appropriate product (i.e. one that can be used as the basis for a IS development) at the end of the process is a frequent complaint when the outcome is the desire to build an Information System. Because of this much of the information collecting process needs to be gone through again to organise it in the appropriate way for systems developers.

The key stages of Checklands soft systems method are listed below, remember that the user has the choise to pick and choose:

1. Drawing a Rich Picture

Concerned with:

- Structure (entities)
- Process (transformations)
- Climate = cultural analysis
  - Role analysis (problem owners / solvers)
  - Social analysis (roles / norms / values)
  - Political analysis (power/ commodities production and usage)
  - Desirability / feasibility change analysis (technically feasible / socially acceptable)

2. CATWOE analysis to obtain Root definitions of transformations (**t** = transformations)

- Customers the victims or beneficiaries of **t**
- Actors those who would do **t**
- Transformation process is the conversion of input to output
- Weltanschauung the world-view which makes this **t** meaningful in context
- Ownership those who could stop **t**
- Environmental constraints / elements outside the system which makes it as given

Also need to consider:

- Effectiveness - is **t** meeting the long term aim
- Efficiency - output / resources
- Efficacy - does it work

3 Conceptual Models (CM's) produced from above to give:
Greater understanding
'No matter how the models are used for comparison with the real world the aim is not to 'improve the models' - it is to find an accommodation between different interests in the situation, an accommodation which can be argued to constitute an improvement of the initial problem situation'
(Checkland 1990 pp. 44)

4. Comparison of CM's with the rich picture to obtain Agenda of possible change
5. Changes judged with actors in the situation to be desirable and culturally feasible
6. Take Action

In the UK the NHS has also produced a booklet of NHS examples of Soft systems case studies also Checkland & Scholes 1990 contains a number of NHS case studies.

Exercise: Go to one or more of the following sites:

http://www.infc.ulst.ac.uk/informatics/events/smbpi.html Details of a workshop given in 1999 about SMBPI: Systems Modelling for Business Process Improvement

http://members.tripod.com/SSM_Delphi/ssm4.html porvides a list of links to softsytems sites.

http://ironbark.bendigo.latrobe.edu.au/courses/subjects/c301/Checkland.html - an example

http://www.dsto.defence.gov.au/corporate/reports/DSTO-TN-0183.pdf - an example in the miltary

http://iris.informatik.gu.se/sjis/vol5/vidgen.shtml I disucssion of using SSM to improve quality.

Unfortunately much of Checklands material which was previosly on the web seems to have disappeared.

Bottom Up - Subjective Approach

I have chosen Enid Mumfords Socio-technical Approach as an example of the bottom up subjective approach. Unfortunately this is not strictly true as although it takes into account subjective elements (i.e. Job satisfaction) these elements are treated in a quantitative fashion (i.e. scores are applied to them). You can find more information about the Socio-technical approach by looking at Section 12.3 Getting Clinicians / Users Involved in developing Information Systems from the main contents web site http://www.robin-beaumont.co.uk/virtualclassroom/contents.htm. The details below provide a very short summary.

Aim: Allow workers, by consensus, to reorganise work (for computerisation)

Participation of workers important:

Representative participation - all grades

Consensus participation - staff elections to groups

Unit operations defined i.e. set of related tasks carry out by a work group

Work group:

- allocates work structures for workers within group
- ensures all staff within group are able to carry out all tasks
- Identify and investigate variances

Method develops:

Best work organisation balancing between what is technologically possible and organisationally desirable and also achieving optimal job 'enrichment'.

5.3. Bottom Up - Objective Approach

Within James Martins IE method he describes two techniques, Joint Requirements Planning (JRP) and Joint Application Design (JAD) these methods aim to allow stakeholders to be able to develop systems using 'modern structured analysis techniques'. (one presumes any objective technique would be suitable e.g. Object Oriented approach). As would be expected of Martin he provides very prescription details of how to carry it out. Martin lists the following individuals who should be involved in a JAD session; Executive sponsor, Stakeholders (including end users who what a system to automate or streamline), JAD leader, IS professionals, Scribe, Project manager and a CASE Tool specialist.

We will now consider the question as to how objective those methods that purport to be actually are.

6. Are the Objective Approaches to Modelling Really Objective?

Several commentators have criticised the standard entity modelling approach to data modelling (frequently a part of the process of systems modelling). and in this section I will introduce a few of these criticisms based upon the work of Klein & Hirschheim 1987 and Hirschheim, Klein & Lyytinen, 1995. I have never studied philosophy and find this aspect very difficult, so please bare with me if you also find my explanations muddled! If you are interested I suggest you go back to the excellent source articles.

Klein & Hirschheim 1987 provide three reasons why the so called objective entity modelling approach is not as objective as it first appears:

6.1. Frege's Sense and Reference

This is when the same object has a different term assigned to it due to a particular context. For example the planet Venus (the reference) has two senses ('meanings'); 'morning star' and also the 'night star' depending upon the time of day it is. Frege (1848 - 1925) was professor of Mathematics at the University of Jena, and developed the concept of Sinn (sense) and Bedeutung (reference) to allow him to express these denotational examples.

What the above demonstrates is that to define meaning in terms of reference is inadequate (Klein & Hirschheim 1987 p12) For further details see Flew 1979 p88 - denotation; p324 sense and reference.

One last example:

You see Jane in night club = someone to desire

You see Jane in an Intensive Care Unit = someone to provide care

6.2. Wittgenstein's Rules of correspondence

The following section is taken from Klein & Hirschheim 1987.

In the realist theory of meaning (necessary for data modelling) a sentence (or data record) is said to be correct if it corresponds to an actual state of affairs. There are two problems with this.

- First, it must be assumed that the world - defined as the sum of all actual states of affairs can be decomposed uniquely into a set of actual states of affairs.
- Secondly, each elementary state of affairs can be described by a corresponding sentence (statement of fact).

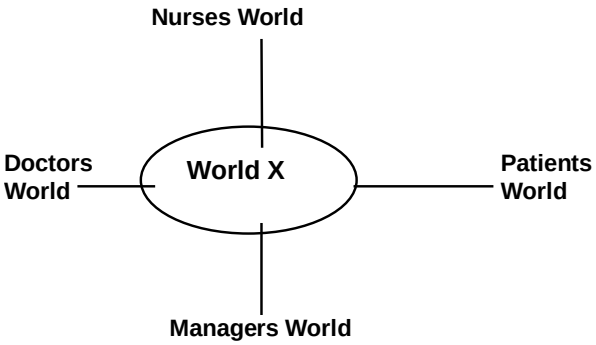
Both of these assumptions had to be abandoned.

The second assumption was tackled by the philosopher Wittgenstein (1889 - 1951) who fund that he could not find any connections (correspondences) between marks on paper (descriptions of sentences) and states of affairs in the real world. If such a relationship can not be established there is no objective correspondence between symbolic descriptions of data and real events of states. Rather it was discovered that any such correspondence would have to be established through the social uses of words and symbols. For instance, the meaning of the word 'sales' is different for the sales person, the accountant and the lawyer, because they listen to different social conventions which determine the use of the word.

The meaning of the word changes with social use. (Klein & Hirschheim 1987)

A historical aside: Wittgenstein, already a famous philosopher worked as a pharmacy porter at Guys London, from 1941 until 1943 where he told patients not to take the medications! (Monk R 1990 p432). He then moved to the RVI, Newcastle upon Tyne (UK) to work, initially as a probationary, Laboratory Assistant to a Dr Grant who was investigating trauma 'shock'.

In medicine, as in all professions, the meaning certain words take on is often very different from that generally ascribed to them. The situation is even worse in the Health care Arena where different professionals often have different meaning for the same term and different terms which have the same meaning. In other words homonyms and synonyms abound.



Homonym = Words having Same sound or form but different meaning. e.g. Pole (flag) Pole (magnetic), bear (grizzly) bear (children)

Synonym = Different word same concept

6.3. Austin's Performance Meanings

The third criticism Klein & Hirschheim 1987make concerning entity modelling is based on the findings of Austin 1962. Austin discovered that the same sentence can mean rather different things depending on the social context in which it is used. Additionally there is no way to determine which meaning applies, rather it depends on the context in which the speaker 'performs''. Roughly, the performance meaning of a sentence depends on socially accepted consequences which its uttering can be expected to produce. This can include authority relationships, personal psychological profiles etc.

By looking for an objective relationship between a sentence and reality, the realist position is incapable of accounting for the differences in the social uses of data which determine its performance meaning (Klein & Hirschheim 1987).

6.4. Summary

Criticism	Description
Frege's Sense and Reference	Multiple meanings for one reference
Wittgenstein's Rules of Correspondence	Descriptions and reality not linked
Austin's Performance meaning	Context ('performance') defines meaning

Hirschheim, Klein & Lyytinen, 1995 restructure the above argument somewhat and take it much further. They also present various subjective data modelling examples. I do not intend to take the analysis any further. I will end this section quoting once again at length from them concerning the effect the objectivist approach has upon information systems development.

7. The objectivist approach and it's effect

"One of the limitations of objectivist data modelling is that it has a very one sided view of the role of a database in the organisation: consistency and correspondence with the facts. This obscures the insight that much data in the organisation are used to misrepresent facts in negotiations, which serves to advance stakeholders' bargaining positions 'opportunistically'. Under these circumstances the purpose of a database cannot be to display facts consistently. From a opportunistic transaction cost perspective, a database could serve the role of cutting the costs related to social transactions, e.g. search costs, contracting costs, control and regulation costs. As information Technology will have an effect on social transaction costs, it can be expected to influence the choice of organisational control mechanisms, i.e. the choice between bureaucracies, markets and clans. This in turn has implications for the nature of user participation as well as the formulation of privacy and integrity constraints [the rules which govern the way the data is organised] in database development." (Klein & Hirschheim 1987).

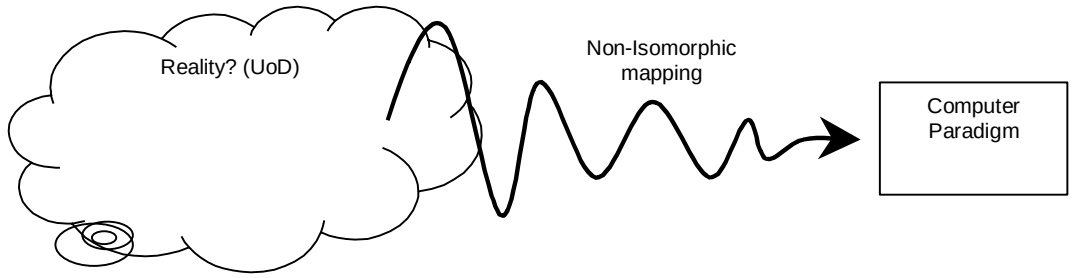
8. Other Problems

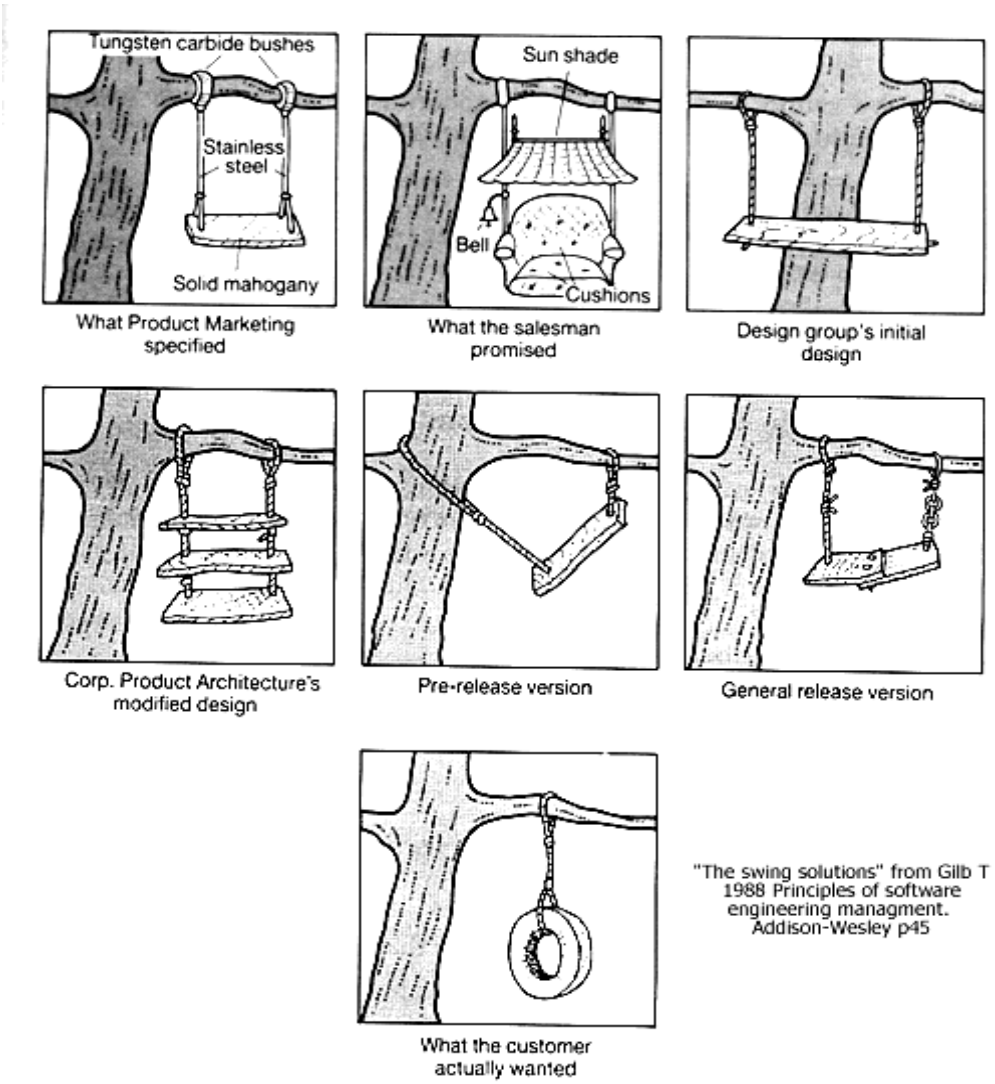
In addition to, and as a consequence of, those problems described above there are two other problems concerned with mapping a model onto a computer system.

8.1. Non Isomorphic Mapping between world and Computer implementation

The above has demonstrated that it is impossible to modal reality (whatever that is) onto a computer consisting of zeros and ones? However if a computer is chosen as the target system it is necessary to do this at some point during the modelling process. The question is when will this transfer from the real to the computer paradigm be most appropriate during the process, i.e. be most efficient.

A well known consequence of this problem is the disparately between the customers expectations and what is finally delivered, as Tom Gilb so aptly illustrates in his book (see below).





"The swing solutions" from Gilb T 1988 Principles of software engineering managment. Addison-Wesley p45

8.2. Gödel's proof (1931)

Nagel & Newman 1986 provide a non-mathematicians explanation of the proof which is that it is:

"Impossible to establish the internal logical consistency of a very large class of deductive systems {e.g. computer systems} unless one adopts principles of reasoning so complex that their internal consistency is as open to doubt as that of the systems themselves." (Nagel & Newman p.6)

Flew 1979 (p133) states that this does not *prove* that man is superior to a machine. He explains this, for those of you who are interested:

Gödel's first Incompleteness theorem: That in any formal system ***S*** of arithmetic, there will be a sentence ***P*** of the language of ***S*** such that if ***S*** is consistent, neither ***P*** nor its negation can be proved in ***S***.

The theorem only allows one to conclude that *if* ***S*** is consistent, neither ***P*** nor its negation is provable in ***S***. One can not go on to conclude that ***P*** is not provable in ***S***, and hence must be true, without having proved the consistency of ***S***.

Indeed, because Gödel's proof is formalizable in ***S***, it could be said that one machine ***T*** *could* prove of another machine ***T'*** that if ***T'*** is consistent, there is a proposition that ***T'*** cannot prove. But ***T'*** could prove exactly the same thing about ***T***.

9. Summary

This handout started by introducing the GST movement at the start of the 20th century, with its aspirations of developing generic models. It then discussed the various pragmatic approaches that have been taken to such theoretical ideals. Examples were given of both subjective and so called objective approaches ending with a discussion of their assumed objectivity.

A framework was introduced which used four different sociological paradigms to categorise the particular approach along with a more pragmatic framework derived from it.

This introduction has presented a large amount of difficult information which, to even begin to understand, requires you to have used the various techniques in a number of situations and have reflected upon them. Hopefully this handout may have encouraged you to try an approach you may not have thought of before?

10. Multiple Choice Questions

1. Which of the following provides the most appropriate definition of holism?
    a. It is the appearance of a characteristic at some level in a hierarchy that is not exhibited by any of the individual parts.
    b. It means that wholes, or some wholes, are more than the sum of the parts.
    c. It is the possession of a vital force within a system.
    d. It is the possibility that a system possesses a metaphysical aspect.
    e. It is the situation whereby a particular system is incapable of being analysed by studying the individual components of it.
2. Which of the following provides the most appropriate definition of emergence?
    a. It is the appearance of a characteristic at some level in a hierarchy that is not exhibited by any of the individual parts.
    b. It means that wholes, or some wholes, are more than the sum of the parts.
    c. It is the possession of a vital force within a system.
    d. It is the possibility that a system possesses a metaphysical aspect.
    e. It is the situation whereby a particular system is incapable of being analysed by studying the individual components of it.
3. What could be said to be the overall aim of General Systems Theory (GST)?
    a. To develop computer software to automate tasks
    b. To develop computer software to assist with modelling (eg CASE tools etc)
    c. To discover structural similarities between systems frequently using mathematical models
    d. To redesign systems more efficiently using mathematical models
    e. To develop techniques to advise management on how to develop optimal systems
4. The NHS data model is an example of which of the following:
    a. Holistic analysis
    b. Oganicism
    c. Process modelling
    d. Pattern
    e. Patient centred analysis
5. A particular computer simulation of ants moving is an example of the following:
    a. Finality
    b. Self organising system
    c. Teleology
    d. Soft system
    e. Homeostatic system
6. Various sociological theories can be placed on a grid. What do the two lines represent?
    a. Degree of complexity and conflict
    b. Degree of subjectivity and conflict
    c. Degree of subjectivity and objectivity
    d. Degree of subjectivity and theoretical validity
    e. Degree of subjectivity and inclusiveness

7. Which of the following best describes radical structuralism:

a. Inherently social order exists which can be encouraged by the aggressive application of science. Repression also exists and must be fought against.

b. Inherently social contradictions exist which can be corrected by communication between all parties. Ultimately repression does not exist.

c. Inherently social order exists which can be encouraged by the aggressive application of science. Ultimately repression does not exist.

d. Inherently social contradictions exist which can be corrected by the aggressive application of science. Repression exists and must be accepted.

e. Inherently social contradictions exist which can be corrected by the aggressive application of science. Repression exists and must be fought against.

8. Traditionally the modeller (systems analyst) is considered to be an expert who is brought into an organisation for a specific purpose. They attempt to take most people's opinions on board within organisational constraints to develop a consensus. This scenario presents which sociological paradigm most closely:

a. Social relativism

b. Functionalism

c. Radical structuralism

d. Neohumanism

e. Marxism

9. I suggest that a pragmatic interpretation of the modelling approaches grid results in the following two axes:

a. Structured/unstructured and objective/subjective

b. Top down/bottom up and standardised/customised

c. Participatory/non-participatory and objective/subjective

d. Top down/bottom up and objective/subjective

e. Top down/bottom up and large scale/small scale

10. James Martin's Information Strategy Planning is an example of what approach?

a. Bottom up/subjective

b. Bottom up/customised

c. Top down/objective

d. Top down/large scale

e. Structured/objective

11. A data flow diagram is usually a particular technique used in what type of approach:

a. Bottom up/subjective

b. Bottom up/customised

c. Top down/objective

d. Top down/large scale

e. Structured/objective

12. Rich pictures are:

    a. Cartoon type diagrams that allow people to express their experiences and accentuate points that stand out in their minds

    b. Cartoon type diagrams that are produced using a standard set of symbols that allow people to express their experiences and accentuate points that stand out in their minds

    c. Cartoon type diagrams that are produced using software to support the SSM method

    d. Diagrams that allow people to express their experiences and accentuate points that stand out in their minds using a specialised description language

    e. Diagrams that use standard symbols and semantics to facilitate detailed design (modelling) with technical people

13. It has been said that the context has as much effect upon the meaning of something as the actual thing (eg utterance or action) itself. In which of the following concepts is this idea most clearly embodied:

    a. Wittgenstein's rules of correspondence

    b. Metaphor

    c. Frege's sense and reference

    d. Austin's performance meanings

    e. Homonym

14. Tom Gilb is:

    a. The person in charge of the NHS data model

    b. A philosopher

    c. A software management writer

    d. A systems modeller

    e. The person who developed the Soft Systems Method (SSM)

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