Managing Information Technology Investments - The Application of a Dynamic Systems Approach.

Phillip Wing & Mark Maloney
Ernst & Young
GPO Box 2646
Sydney NSW 2001, Australia
Tel: 61 2 248 4380

Abstract

Understanding, quantifying and realising the net benefits derived from Information Technology investments is becoming a complex and difficult management process.

A theoretical framework for managing Information Technology investments has been developed by the authors and applied to a process innovation initiative in the health sector in Australia. As part of this study, a dynamic systems approach was used as the underlying conceptual and analytical approach to support this framework.

This paper details the background to the process innovation project, how a dynamic system approach was applied and the results of the case study.

The preliminary results confirm the conceptual robustness of the IT investment management framework and validates the practical use and application of a dynamic system approach within this framework.

Managing Information Technology Investments - The Application of a Dynamic Systems Approach.

As investments in IT continue to consume increasing levels of resources, an effective approach to ensuring business benefits are derived from IT investment is now crucial. An imperative to develop a framework for more effective IT investment management in the Health Industry has emerged as a result of the major economic and organisational changes occurring in this sector.

A proposition has been developed (Wing 1994) that no coherent process for IT investment management is available to management. Traditional approaches based on financial cost benefit analysis were never particularly appropriate for technology investments and are now providing limited utility in the face of:

- a diminishing portfolio of labour replacement IT investments,
- process views of business activities,
- new and evolving organisation structures, and
- complex inter-enterprise relationships.

A theoretical framework for managing IT investments has been developed and a systems thinking and dynamic systems approach selected as the conceptual underpinning for this framework. The framework and systems thinking approach was applied to a process innovation initiative in the Australian Health sector. This paper explores;

- why a dynamic system approach was adopted,
- how it was applied, and
- the lessons learnt from the case study.

The nature of the process innovation initiative, Asthma Management, required a conceptualisation of the issues from a holistic, cross functional and cross organisation perspective. In addition, the relationships between processes within these enterprises needed to be understood in order to determine the leverage points for process innovation.

With the overall framework developed, a mechanism for making it operational was required.
After examining a number of alternative approaches it was proposed that a dynamic systems approach satisfied the attributes and characteristics required for the initiative. In summary it was proposed that a dynamics systems approach would;

- facilitate a process view of an organisation,
- support the entire IT investment management process from need identification, process re-design and implementation,
- deal effectively with complexity and second order (or feedback) impacts,
- embody a set of techniques and tools which provide effective communication to executive management,
- identify leverage points to focus investment and implementation in order to realise the benefits, and
- quantify the net benefits of both infrastructure and application based IT investments.

The remainder of this paper presents the findings of the case study and discusses the appropriateness and effectiveness of a dynamics systems approach to support the management of IT investments.

Asthma Management Case Study

Background

The asthma care process was targeted for process innovation as a pilot project within the Australian Health Communication Network (HCN) initiative. Information technology was used to enable quantum improvements in the process.

The HCN represents an investment in communication and information infrastructure to achieve significant benefits within the Australian Health System at several levels. These levels include improvement in information exchange and access, reduction of waste by breaking down barriers between health segments, and the provision of more effective health service delivery and outcomes. (HCN, 1993)

The process innovation required the development of a conceptual solution and the deployment of that solution into a live patient care environment within a selected geographic region in south west Sydney (New South Wales - Australia).

Problem Definition

Asthma, and childhood asthma in particular, is a major health problem in Australia. Approximately, 1 in 5 children and 1 in 10 adults in Australia exhibit asthma symptoms.

The cost of asthma in Australia is approximately $1 billion per year or 3% of the national health budget.

Asthma is a chronic condition that requires treatment from a number of health care providers. A long-term, severe asthmatic can expect to receive care from:

- primary carers or general practitioners (GPs);
- specialists physicians;
- hospital accident & emergency staff; and
- in severe cases, hospital in-patient staff.

The health sector in Australia is characterised by organisations with diverse structures who are often driven by different incentives. As a result, the current asthma care process is characterised by:

- disparate approaches to care delivery, resulting in patients receiving inconsistent messages about their condition;
- poor access to patient information, which is fragmented across care providers;
- uncoordinated care management; and
- reliance on treating sickness rather than managing wellness.

In general, the system does not support sustainable improvements in the quality of life for asthma patients.

Objectives

The objectives of re-engineering the asthma management system were to simultaneously achieve;

- reduced morbidity,
- reduced hospital resources in testing acute asthma episodes,
- proportionately more primary and preventative care and,
- effective knowledge management and patient satisfaction through information exchange.

A major investment in IT was required to enable the achievement of these objectives. The IT investment management framework developed by the authors was applied in this initiative.

Analytical Approach

The investment management framework required a supporting analytical approach and set of techniques which could;

- conceptualise and describe the re-engineered asthma management process,
- provide a quantified investment justification business case,
- accommodate cross sector delivery of care,
- manage the complexity and breadth of health care processes without disregarding the human element,
- identify leverage points in the process, and
- make the links between IT infrastructure investment and the benefits of improved health outcomes explicit.

A systems thinking approach was adopted in order to understand the "whole" of the asthma management process, and to identify the subtle actions and changes in structure that can lead to significant, sustainable improvements (Forrester 1975). An important part of the change management process was to bring to the surface the underlying assumptions of people involved in Asthma Management. Dynamic modelling techniques proved to be a successful vehicle for this process.

Since very little historical data was available, an approach and a tool was also needed to construct a continuous (or cybernetic) evaluation framework that could map the existing and the re-engineered processes, and produce a set of process metrics. As new information became available through implementation, the actual results could be continuously compared to the expected results. The use of dynamic simulation models provided the solution to this need.

Technologies & Tools

It was found that the re-engineered process needed to be viewed and understood from at least three perspectives.

(a) A **Logical Model** of data and processes to ensure effective system integration, where the right information is delivered to the right people at the right time.

(b) A **Physical "Discrete Event" Activity Model** to understand activity dependencies and how the process could be implemented. This model describes what happens to an individual patient.

(c) A **Dynamic Model** to develop a continuous view of the process and to understand the impacts on the patient population over time. This included second-order effects and emerging behaviour that results from the process being performed continuously according to a defined process structure.

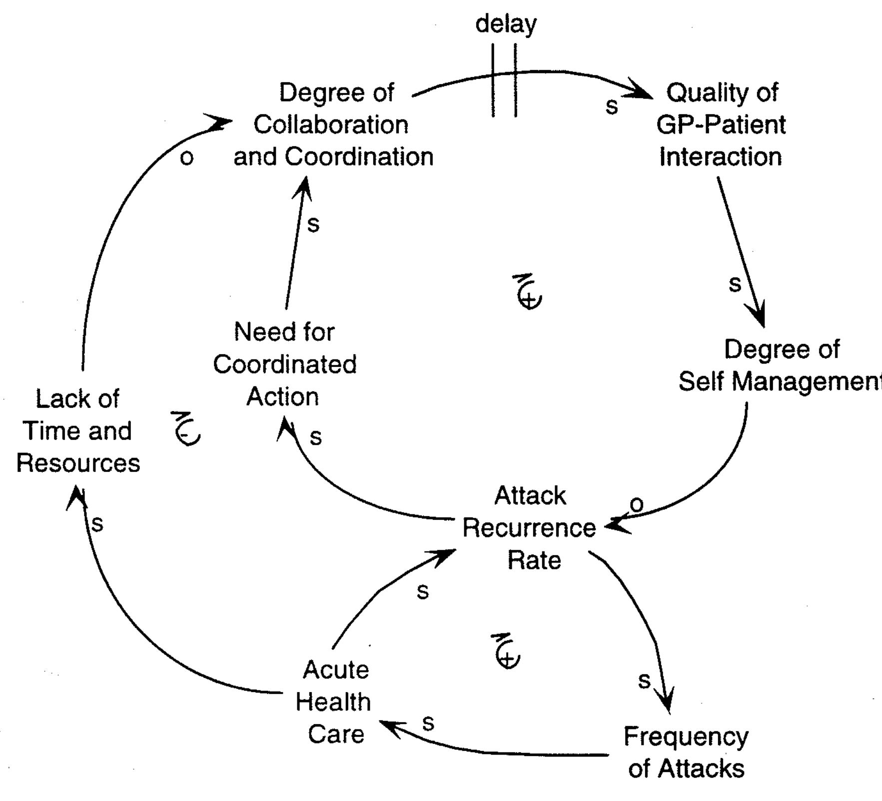
Visual presentation of the process was an important communication consideration and a weakness of most tools surveyed.

After a series of evaluations it was concluded that the three perspectives of the process could not be represented by one tool.

A Computer Assisted System Engineering (CASE) tool following Information Engineering principles was used to develop the logical model. "I think" from High Performance Systems was used to develop the system dynamics model and DEC Model, developed by Digital Equipment Corporation, was used to produce a process model at the discrete event level.

Model Description

A dynamics model of the asthma care process was developed as a learning and continuous evaluation tool. The main feedback loops portrayed by the model are shown below.



"Shifting the Burden" Feedback Structure in Asthma Management

The diagram above shows the main feedback loops involved in the asthma system dynamics model. Arrows indicate cause-effect relationships. The sign of the arrow ("s" for same or "o" for opposite) indicates whether the cause-effect relationship is directly or inversely proportional. The small curved arrow surrounding a plus or minus sign indicates whether a feedback loop is balancing/negative (-) or reinforcing/positive (+). The arrow represents the direction of feedback. Finally, two small vertical lines indicate a significant delay in a relationship; where the effect is lagged.

The structure of the asthma model, in its generic form, has been identified as a "Shifting the Burden" System Archetype. System archetypes are a relatively small number of generic structures that are common to a very large variety of management situations (Senge 1992).

The recurring nature of asthma, and the tendency for attacks to occur at night, creates a pattern where a class of asthma patients continually cycle through the hospital system.

As the recurrence rate of asthma attacks rises, so to does the frequency of attacks. The symptomatic "solution" is to improve acute health care services to cope with the increasing number of attacks.

The intuitive solution is to reduce treatment cycle time within hospitals. This approach will initially result in patients spending less time waiting for treatment in hospital. However, in the long-term, since asthma is a chronic condition, patients will cycle through hospitals more quickly and in increased numbers, thereby increasing costs, and placing pressure on the hospitals such that waiting times will mount again.

In addition, a focus on acute health care will divert time and resources away from preventative initiatives and hence reinforce the recurrence rate of asthma attacks. With the loop closed, a "viscous cycle" persists, which, in the long-term, results in the falling quality of life of asthma patients and escalating costs of care. This counter intuitive result was disclosed by the dynamic model.

The fundamental solution, as disclosed by the dynamic model, is to raise the proportion of the asthmatic population that self-manages by establishing a co-ordinated and co-operative environment in which the quality of the relationship and information exchange between the GP and patient can be significantly improved.

One of the key enablers for a strengthened GP-patient relationship is a documented self management plan which allows patients to regularly monitor their condition and adjust preventative medication usage. It will also provide patients with the information and support to make lifestyle changes that will minimise the risk of attack. Overall, this dynamic should lower attack severity, and strengthen the role of primary care. The key dynamic, is that as the level of self-management rises, the attack recurrence rate will be lowered.

Simulated Outcomes

The asthmatic population was classified into three types: Mild, Moderate, and Severe. (A patient in an asymptomatic state is classified as Mild.)

A Markov process was used to represent this spread, with individual patients continually moving between classifications as they experience an attack, but with the population within each classification remaining in a steady state. The intensity of attacks experienced by an individual patient will change over their life, and will be impacted by the patient's age, location and climates, changes in air pollution levels, viral epidemics, etc.

A sustainable improvement in the process structure would activate a shift in the state for the overall population.

The flow down the chain (from Severe to Moderate to Mild) is impacted by the precision and timing of appropriate treatment. This can be enhanced by improving the quality of interaction between the patient and their GP.

The leakage flow back up the chain, Mild through to Severe, can be minimised through promoting and supporting effective patient self-management, that is, ensuring that the attack does not recur once treated.

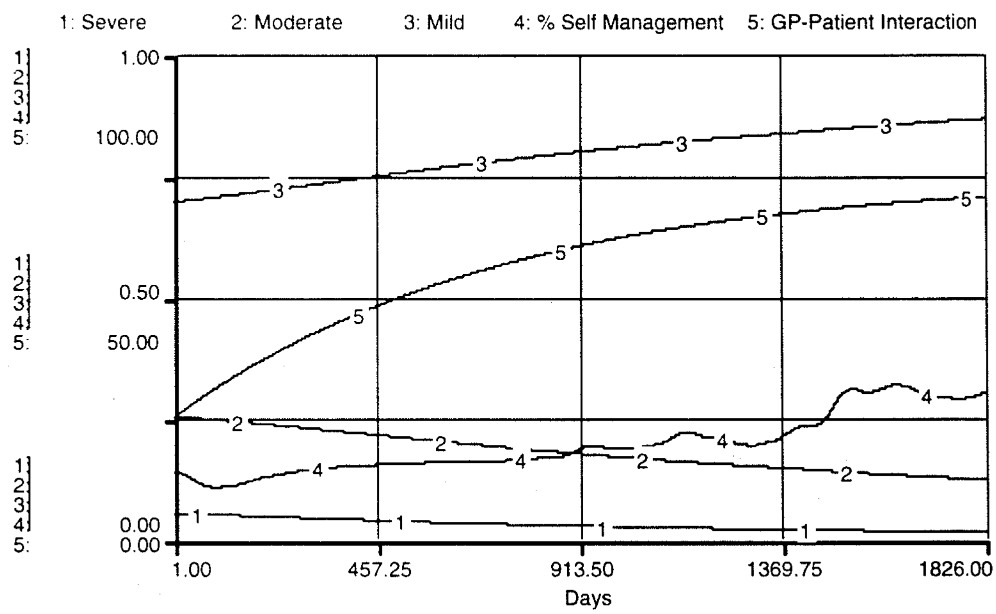
The disease expression profile initially displays steady-state behaviour with 5% of the asthmatic population experiencing severe symptoms, 25% moderate symptoms, and 70% with mild symptoms.

Using sensitivity analysis, it was identified that the variable that achieved the most impact was the percentage of patients using self management techniques, that is, halting the leakage flow through preventative treatment and individual patient management plans.

By improving the mean quality of GP-patient interaction, and increasing the proportion of patients that self-manage, a new profile is attained with less severe cases. These dynamic relationships are shown in Figure 1.

Figure 1: Summary of Dynamics Relationships

Percentage of asthmatic population in each state of disease expression over time

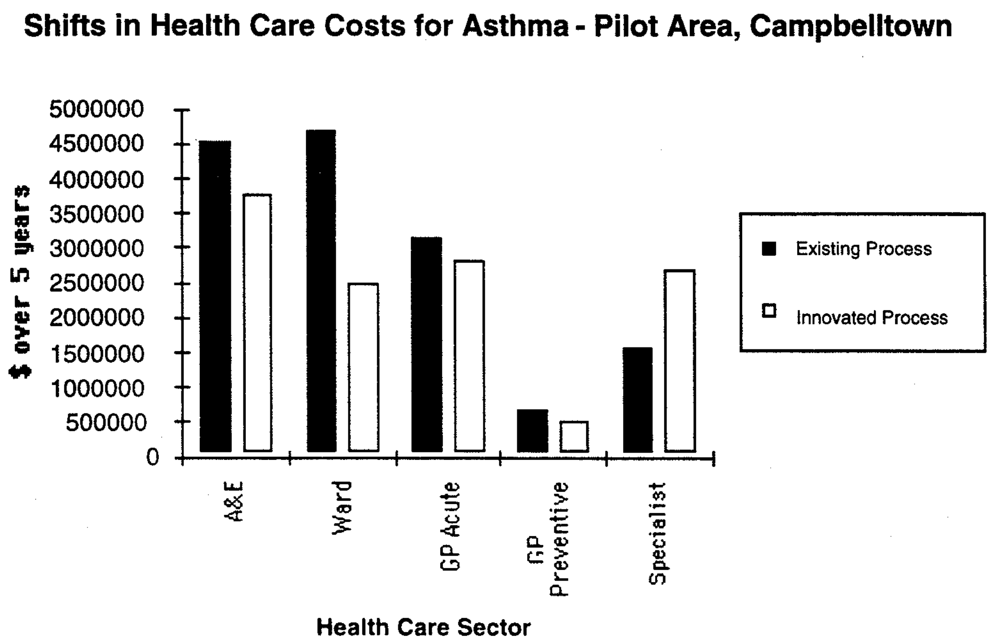


In addition to the positive impact on the health status and outcomes, the simulated re-engineered process resulted in a change in resource consumption through less hospital usage and greater emphasis on primary care. Since hospital treatment is inherently more costly from primary care, a reduction in hospital usage, even though primary care costs rise, will result in an overall reduction in the cost structures for managing asthma.

The simulated financial impact is summarised in figure 2.

Figure 2: ***Summary of Financial Inspect of Process Redesign***

Health care costs for asthma by health care sector over 5 years, before and after the Asthma Management System implemented by the HCN



Initial Evaluation Results

The evaluation of the process innovation project and the investment management approach has been in progress for six months. There was a shift in the disease expression profile to a less severe state as predicted by the dynamic simulation model. However, there was not the anticipated shift in cost structures resulting from less hospital usage and greater primary care.

An early hypothesis for this is that there is a mismatch between a consumerist demand for health services and clinical relevance. In other words, there is a "fix me quick" mentality which education and awareness programmes can help address.

There are also a number of "perverse incentives" in operation which were not captured in the dynamic models. For example, some relief medication such as bronchodilators are available without prescription, whereas preventative medication is more expensive and must be obtained with medication.

Another factor was that the system was implemented in a lower socioeconomic area relative to the rest of the city (Sydney). This can impact the amount of support to the child from the home and the ability to fund the more expensive medication.

Investigation of these factors has forced the scope of the model to be even further extended. However, we now have better information about where to look and how to actively and purposefully redirect the process re-engineering effort.

Another major insight from the initial evaluation is the importance of change management and understanding the factors that shape the perceptions of people involved in the process. This aspect was initially understated or ignored because it was perceived to be too complex or unable to be quantified.

The enhanced system dynamics model now being developed is attempting to unearth and communicate these human elements to identify their impact on the ultimate behaviour of the system.

Conclusion

Based on project analysis, a survey questionnaire and detailed interviews, the need for a cohesive, process oriented investment management framework has been established. The use of a dynamic system approach and its related techniques and tools have allowed the following shifts in the thinking and analytical process to be achieved.

	Traditional Approach	**Dynamic Systems Approach**
Mind Set	Modify current paradigm	Develop new paradigm
Perspective	Optimising	Modify dynamics
Process Focus	Discrete activities	Interdependent relationships
Resources	Profile resource consumption	Identify drivers of resource consumption
Benefits	Once-off	Sustainable
	Broad based impact	Focus on leverage points

The result of the research provides sufficient evidence to encourage investigation into a broader application of systems thinking and dynamic system modelling as the underlying philosophy and analytical approach to support the management of investments in information technology.

References

Forrester, J. W: 1975 Collected Papers of J. W. Forrester

Health Communication Network: 1993 Business Case presented to Australian Health Minister - 3 August, 1993.

Senge, P. M: 1990 The Fifth Discipline- The Art & Practice of the Learning Organisation. Double Day

Wing, P. J: 1994 Unpublished draft Doctor of Philosophy Dissertation.