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The Millenium Problem as a Form of Information Systems Failure

Paul Beynon-Davies
University of Glamorgan

Michael Lloyd-Williams
Manchester Metropolitan University

Ian Owens
University of Wales, Swansea

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Abstract - **In this paper we wish to examine the phenomenon of Y2K as an instance of information systems failure. Taking this particular stance on the issue leads we feel to a number of interesting areas that demand further investigation. We first review the current phenomenon of Y2K and discuss some of the relevant work in the area of IS failure. The topic of IS failure has tended to concentrate on issues of success or failure in relation to one specific IS project. We highlight a number of ways in which Y2K can be characterised as a particularly unique and interesting instance of IS failure. In one sense Y2K can be characterised merely as a technological failure and the responses to it merely of a technical kind. However Y2K, and the responses taken to it are of interest also on the organisational, societal, and economic level. It is therefore a phenomenon of primary concern to the IS academic. We raise a number of issues posed by our examination of Y2K that demand further investigation by IS academics. Y2K and the panic that it has generated can be seen as a clear demonstration of the degree to which IS/IT is closely embedded within modern organisations. However, there is preliminary evidence that Y2K has had an effect on the relationship between the IS/IT function and organisations. We particularly raise questions of its effect on IS strategy and planning, outsourcing and the IS development portfolio of organisations.**

I. INTRODUCTION

The millennium problem or year 2000 problem (Y2K) has been much discussed in the IS practitioner and general press. Surprisingly the IS academic community has remained largely silent over the issue [1] until recently. Kappelmann made a call for academics to contribute to the debate and analysis in this area. He makes a distinction between what he calls technology-oriented contributions such as investigations of project management practices needed to cope with Y2K, and management-oriented contributions such as the impact Y2K is having and will have on societies and economies [2].

In this paper we wish to make a small contribution in terms of Kappelman's management-oriented focus on Y2K. We particularly wish to examine the phenomenon of Y2K as an instance of information systems failure. Taking this particular stance on the issue allows us to glean a number of lessons concerning the nature of information systems failure and the uncertain link between IS academia and IS practice. It also leads we feel to a number of interesting areas which demand further investigation by the IS discipline in the early years of the next century.

The structure of the paper is as follows. First, we briefly review the current phenomenon of Y2K. Second, we discuss some of the work in the area of IS failure. Third, we highlight a number of ways in which Y2K can be characterised as a particularly unique and interesting instance of IS failure. Fourth, we raise a number of issues posed by our examination of Y2K which demand further investigation by IS academics and also consider why IS academia has been so slow to react to the call by Kappelman.

II. THE Y2K PROBLEM

The year 2000 (Y2K) problem has also been called the millennium bug, the millennium problem and the millennium time-bomb. At its essence it is that phenomenon concerned with the way in which dates have historically been stored and manipulated in computer-based systems. The concern over Y2K was originally formulated in relation to information technology systems; not only in relation to layers of software - operating systems, bespoke applications, packaged software and 'shrink-wrapped' applications - but also in relation to hardware, particularly the BIOS chips of personal computers. The last area of concern was raised over the prevalence of date problems in so-called embedded systems - microprocessor-based controllers in applications ranging from washing machines to CAT scanners. Therefore it is not surprising that the problem has been described as an 'onion' in that when you peel off one layer of the onion more layers are revealed below.

The scale of the problem is a matter of some debate. Capers Jones estimated that the Y2K problem will cost the US $70 billion to fix, while he estimates the world-wide cost of fixing the problem will be $530 billion [3]. This includes only an estimate of the costs of software fixes and excludes costs associated with: litigation surrounding the issue, potential failures of information systems as a result of the problem and the cost of business failures that might ensue. Kappelman [4] puts the figure for software fixes in the US as being $136 billion while the global impact as being somewhere in the range of $323-$486 billion.

It is difficult to state precisely when the phenomenon began to become prominent in the IS/IT practitioner literature. The conventional response of many organisations to Y2K has been to set up year 2000 projects which engage in phases such as impact analysis, planning and scheduling, conversion, testing and implementation [5]. Most large-scale companies in the UK have had a year 2000 project running

for three to four years and will have completed testing of their system by April/May 1999. Many sectors have not been so organised in their response: health [6], government [7], and SMEs are notable examples. There are also some reports that companies on the European continent may be slower in responding than their UK counterparts [8].

The Y2K problem has also been framed in relation to a number of interesting contemporary phenomena affecting the IS/IT industry:

A The IS/IT Skills Crisis

Y2K has been cited as a significant contributor to the skill crisis in IS/IT. A current estimate solely for the UK is that there is a supply gap of some 30,000 IS/IT people. Much play has also been made of the difficulties of keeping skilled IS/IT staff and the pressure Y2K has placed on pay rates in the industry.

B The Compliance Industry

It has spawned what some have called the compliance industry. Many companies have issued so-called compliance questionnaires to their major suppliers. Many other companies have publicly announced that they will cease to trade with companies that cannot publicly state they are Y2K compliant. Therefore it is not surprising that claims have been made that the legal profession is likely to be that group which will benefit most from Y2K.

C IS/IT Investment

It is claimed that the significant investment that companies have had to make in addressing the Y2K problem has critically affected the IS development portfolio of most companies. A study conducted by Dataquest predicted that organisational spending on Y2K work would stifle organisational spending on important IT initiatives (Pettitt 1998) in the period to 2000. An example of this is the way in which action on a recently published IS/IT strategy for the UK National Health Service was deferred for two years to give the organisation sufficient time to tackle Y2K.

D Opportunity

Robertson [9] argues that Y2K provides an opportunity as well as a threat for companies. For instance, the necessary process of conducting an impact analysis and the consequent construction of an organisational systems inventory can provide real benefit for future IS planning in organisations.

E Embeddedness

The business guru John Harvey-Jones cites the Y2K problem as important because of the way in which it has demonstrated very clearly to business the necessary embeddedness of IS/IT within modern organisations. He argues that managers must learn the lesson that organisations in the West are significantly reliant on IS/IT for effective performance.

III. Y2K AND FAILURE

IS failure has been a significant topic of investigation for IS academics for a number of years. However, the topic of IS failure has tended to concentrate on issues of success of failure in relation to one specific organisational IS and/or project. Notable case studies such as LASCAD [10], Mandata [11] and Confirm [12], for instance, have been built on this basis. Y2K is particularly interesting as a phenomenon that has an impact on an industrial and even world-wide level.

In one sense Y2K can be characterised merely as a technological failure and the responses to it merely of a technical kind. We might posit that this is perhaps part of the reason why IS academics have not devoted a vast amount of attention to it. This is supported by the way in which the majority of the literature published on Y2K over the last five years is made up of 'How to solve it' discussions relating to Y2K projects and associated software/hardware fixes. But Y2K, and the responses taken to it are of interest also on the organisational, societal, and economic level. As a phenomenon it is therefore of primary concern to the IS academic.

At a broad level, Y2K is unique as an example of IS failure because:

1. It crosses internal information system boundaries within any one organisation. For instance, the whole idea of conducting an IS/IT inventory, an essential part of most Y2K projects, works under this supposition.
2. Y2K is a cross-organisational experience. Many inter-organisational information systems [13] will be equally subject to Y2K. For instance, companies in the banking sector have been taking a close look at the Y2K compliance of their Automatic Teller Machine (ATM) networks as part of their Y2K projects.
3. The scale of the problem is enormous even in comparison to a costly information systems failure such as the Stock Exchange's Taurus project [14] which is estimated to have cost between £75M and £300M. This is true both in terms of the amount of effort needed to be devoted to it and the diverse sectors it impacts upon. Y2K is a global example of IS failure that has been discussed on a whole range of levels: governments and international organisations alike. Recently estimates of the cost to the UK have ranged between £5bn to £50bn.
4. Y2K is unique due to the degree it has been reported both in the IS/IT industry but also more widely in the national and international media. It is particularly interesting for the way in which it constitutes a sociological phenomenon associated with issues such as millenarianism, disaster and technophobia. As examples of 'disaster planning' in this area, the British government recently issued a leaflet to all UK households in an attempt to allay fears and the Japanese government recently advised its citizens to stock up on essential food items over the new year period.

A IS Failure

Lyytinen and Hirschheim [15] in conducting a survey of the literature on IS failure identify four major theoretical

categories of such phenomena:

1. Correspondence Failure. This is the most common form of IS failure discussed in the literature and typically reflects a management perspective on failure. It is based on the idea that design objectives are first specified in detail. An evaluation is conducted of the information system in terms of these objectives. If there is a lack of correspondence between objectives and evaluation the IS is regarded as a failure.
2. Process Failure. This type of failure is characterised by unsatisfactory development performance. It usually refers to one of two types of failure. First, when the IS development process cannot produce a workable system. Second, the development process produces an IS but the project runs over budget in terms of cost, time etc.
3. Interaction Failure. Here, the emphasis shifts from a mismatch of requirements and system or poor development performance to a consideration of usage of a system. The argument is that if a system is heavily used it constitutes a success; if it is hardly ever used, or there are major problems involved in using a system then it constitutes a failure. Lucas (1975) clearly adheres to this idea of failure.
4. Expectation Failure. Lyytinen and Hirschheim describe this as a superset of the three other types of failure. They also describe their idea of expectation failure to be a more encompassing, politically and pluralistically informed view of IS failure than the other forms. This is because they characterise correspondence, process and interaction failure as having one major theme in common: the three notions of failure portray a highly rational image of IS development; each views an IS as mainly a neutral technical artefact. In contrast, they define expectation failure as the inability of an IS to meet a specific stakeholder group's expectations. IS failures signify a gap between some existing situation and a desired situation for members of a particular stakeholder group. Stakeholders are any group of people who share a pool of values that define what the desirable features of an IS are, and how they should be obtained.

Y2K can be seen as an instance of each of these types of failure. It is a correspondence failure in that as a result of it information systems unless corrected will not deliver expected business value. It is a process failure in that it can be portrayed as a problem associated with the design and implementation of information systems, particularly legacy systems. It could even be classed as an interaction failure, at least after year 2000, if many of the proposed systems do not perform as expected because of this inherent 'design feature'.

If we are to analyse the Y2K issue in terms of expectation failure, we need to ask the necessary question, Who are the stakeholders in Y2K?. The easy answer is of course to state that at least in Western societies, everybody is a stakeholder, since everybody is purported to have a notional stake in the modern information society. In the next section we perform a more discriminatory analysis of this situation by considering Y2K as a global 'project'.

IV. Stakeholder Analysis

The expectation failure concept emphasises the importance of identifying stakeholders and analysing the profile of each stakeholder type in terms of an IS project. In this section we first describe a simple framework for conducting stakeholder analysis [16]. We then apply this framework to the Y2K problem, treating it as a global 'IS' project.

A Framework

In terms of a typical IS project we may identify five major categories of stakeholder types: producers. clients, users, customers, and regulators:

1. Producers are the people actually producing the IS. This group is what Sauer [11] calls the project organisation. This may constitute an internal IS service or an external IS supplier.
2. Clients are Sauer's supporters of IS in that they sponsor and provide resources for the continuation of an IS project. Clients normally equate to managerial groups within organisations.
3. In terms of users, managers are rarely the end-users of information systems. Most IS are produced for use by other levels within the organisation.
4. Information systems normally impact upon the customers or clientele of organisations. A major set of modern IS are devoted to improving the value delivered to customers.
5. Regulators are agencies that set environmental constraints for an IS and its development. For instance, within the UK the Inland Revenue set clear guidelines on the calculation of income tax that must be adhered to by financial systems. Likewise, the UK data protection registrar sets clear parameters for the storage of personal information within information systems.

We may analyse the relationship of each group of stakeholders to an IS project in terms of:

1. Degree of Impact. The degree of impact that the IS is likely to have on the stakeholder group might be expressed in terms of high impact, medium impact and low impact.
2. Stakeholder Expectations. The key expectations that the stakeholder group has in relation to the IS may be expressed in terms of how the group 'frames' the IS [17]. In very general terms, each stakeholder may 'frame' a technology in a negative or positive way in relation to their interests.
3. Impact on Stakeholder Group. The likely impact of the stakeholder group on the development and post-implementation trajectory of the project. Pouloudi and Whitley [18] define stakeholders as any group whose actions can influence the development of an information system whether directly or indirectly. They distinguish stakeholders from participants. Participants are interested parties to an IS project, but who have little or no influence over the trajectory of an IS project.
4. The Degree and Type of Support. The degree and type of support needed on the part of the project organisation from the stakeholder group. In general, physical resources

such as budgets are needed from clients, personnel resources are needed from users, and information resources are needed from regulators.

TABLE 1
STAKEHOLDER ANALYSIS OF THE Y2K PROBLEM

Stakeholder Type	**Producers**	**Clients**	**Users**	**Customers**	**Regulators**
Representative Groups	IS/IT industry, Internal IS services, External IS services IS Academia	Public and Private Sector Organisations	IS users	Organisational customers and suppliers	Governments, trade organisations, professional bodies, Standards organisations
Degree of Impact on Stakeholder	Low Impact	Medium-High Impact	Low Impact	Low Impact	Low Impact
Stakeholder 'Frame'	Positive	Negative to Ambivalent	Negative	Ambivalent	Positive
Stakeholder Impact - Development Trajectory	High Impact	Low Impact	Low Impact	Low Impact	Low Impact
Stakeholder Impact - Use Trajectory	High Impact	Low Impact	High Impact	High Impact	Low Impact
Degree of Support	High	Medium to High	Low	Low	Low
Type of Support	Effort	Personnel	None	None	None

B Analysis

In table 1 we have attempted an analysis of the Y2K issue in terms of the framework described above. In a sense we are conducting an instance of what Ewusi-Mensah [19] has called a Post-Mortem analysis. This variant of summative IS evaluation is normally used in developing an understanding of the reasons for full or partial abandonment of information systems projects.

This attempt at a post-mortem analysis for the Y2K problem indicates a number of interesting features.

Producers.

The IS industry in general and internal and external IS services of relevance to a particular organisation have an inherent stake in the Y2K problem and its solution. This stakeholder group is directly involved in scoping and developing Y2K solutions for organisations. Interestingly however besides providing an impetus to recruitment in the industry the Y2K problem has contributed little to changing the current shape of the industry. In the longer term a range of predictions have been provided ranging from an IS/IT backlash to a continuing rise in the impact of the industry on general business.

One could argue that IS academics also have an inherent stake in understanding the ramifications of the Y2K problem for organisations. To date, however IS academia appears to have contributed little to the informed debate in this area.

Clients.

At the time of writing, the Y2K problem has not provided significant problems for organisations except insofar as many organisations have invested significantly in the solution of this problem. For example, the Hong-Kong and Shanghai Bank is reported as having spent £43M on its Y2K project. Significant problems are likely to impact within a short time-frame if the predicted level of business failures and litigation ensue. Kappelman [5] has portrayed the conventional business response to learning of the Y2K problem as being: awareness, denial, anger then response. A large question is whether residual anger may be left over within the business community. We might hypothesise that Y2K and the responses to it may contribute to the continuing rise in the outsourcing of both IS software and personnel.

Users.

At the time of writing, users of information systems have currently only been impacted by forward date problems. Again, the expected impact on the use of IS is an unknown quantity. If some of the predictions prove correct then Y2K could paralyse information-based economies.

Customers.

Both customers and suppliers generally wait to be directly impacted by the Y2K problem. It could be argued that many suppliers to organisations have already been impacted to some degree in the way they have participated in compliance questioning and subsequent agreements.

Regulators.

Surprisingly perhaps, regulators like governments and professional bodies have had little impact on the trajectory of development work in this area. Governments such as that in the UK have attempted to participate in awareness raising exercises but have contributed relatively little in the way of resources to the issue. The UK Prime Minister came under much criticism for his initiative to develop a £30 million national training scheme of 'bug busters' and a recent letter in the *Computer Bulletin* {the professional bulletin of the

British Computer Society (BCS)} criticised the lack of BCS action in this area.

V. ISSUES ARISING FROM Y2K

In this section we wish to discuss some of the issues arising from Y2K that are of concern to Information Systems as a discipline. We first address the affect that Y2K is likely to have on IS practice, particularly the IS/IT strategy of organisations. Second, we discuss some of the interesting consequences of Y2K as far as IS academia is concerned.

A Y2K and IS/IT within Organisations

Y2K and the responses to it are likely to have a profound impact on the shape of IS/IT within organisations not only in the UK but internationally. It is important to recognise that the effects of Y2K will not disappear after the year 2000. It is likely that perturbation established by the Y2K problem will take at least five years to filter out of the system. Hence there is justification for continuing research on this topic for some years after the millennium.

This leads us to propose that studies are needed to analyse the relationship between Y2K and IS/IT infrastructure in greater depth. In this section we detail a preliminary framework for investigating elements of this linkage which we are considering in current research.

We propose that Y2K has currently had and is likely to have an impact on three dimensions of the IS/IT infrastructure of organisations:

1. Levels and the shape of investment in IS/IT. Currently most UK organisations seem to invest somewhere between 2 – 7% of their capital expenditure on IS/IT. This raises a number of questions: How much of this expenditure has been diverted to solving the Y2K problem? How has the need to tackle Y2K affected future investment plans for IS/IT?
2. The structure of the internal IS service of organisations. Y2K can be seen as a problem that confirms the low opinion of the IS/IT profession on the part of general business management. UK organisations have experienced a significant degree of outsourcing in relation to the IS service. Outsourcing has been of two major forms: outsourcing of personnel, outsourcing of software. The latter form of outsourcing is evident in the increasing rate of adoption of enterprise resource planning (ERP) systems such as SAP. This raises the question: to what extent has this been fuelled by an organisation's experience of the Y2K problem?
3. The state of IS/IT strategy within organisations. Strategy as applied to IS/IT has been much discussed by the IS academy over the last decade. Are companies now ditching strategy in the face of Y2K? How precisely has Y2K affected strategy? Have any companies explicitly addressed Y2K in their strategy? There are some suggestions that Y2K is causing organisations to defer strategic IS/IT decisions in the short term. This beggars the question as to what effect Y2K will have on the future of IS/IT strategy?

We are currently collecting data on Y2K projects being undertaken in five UK organisations, three in the public sector and two in the private sector. Preliminary results suggest that IS/IT investment appears to have increased and that the investment has critically affected other planned IS/IT initiatives. In the organisations the use of packaged solutions for replacing legacy applications seems to be a popular form of outsourcing strategy. Most of the organisations appear to have planned their Y2K project as a reaction to external pressures rather than as a proactive measure.

Commentators seem to suggest that the ramifications of Y2K will continue well into the next century. Longitudinal studies are therefore needed to assess the affect of Y2K on each of the elements described above.

For instance, in terms of IS/IT investment, the Dataquest study reported in Pettit [20] described five possible scenarios concerning the impact that Y2K is likely to have on organisational IS/IT spending:

1. Spending on IS/IT enjoys a significant increase between 1998 and 2001. Spending then reverts to pre- 2000 levels.
2. Spending increases up until 2000 then falls as user organisations fail to reach operational sustainability
3. Organisations realise they cannot make all their systems Y2K compliant, practise triage and abandon 30% of systems that are judged to be non-critical. Y2K generates a significant loss of confidence in IS/IT at the business level and long-term spending is reduced. The IS/IT industry shrinks by 30% as a result.
4. As above, in that organisations reduce their overall IS/IT spend by 30% up to 2000. However, overall confidence in IS/IT is maintained and underlying growth trends for the industry continues.
5. Organisations increase spending on IS/IT to cope with Y2K, it does not affect other planned initiatives and growth in IS/IT spend continues in the longer term.

It is clearly important to determine which of these scenarios turns into reality as far as UK and European organisations are concerned. Recent articles published in the computing press in the UK suggest that there is some evidence of option 1 happening earlier than expected. This conclusion, based on a National Computing Centre (NCC) survey, could indicate that organisations are slashing back on their investment patterns post-Y2K.

In conclusion, Y2K as a phenomenon is affecting most, if not all, organisations internationally. A close, longitudinal study of the impact of this phenomenon therefore offers a unique opportunity for identifying the relationship between environmental effects and the pragmatics of IS planning/management/development strategies within organisations.

B Y2K and IS Academia

IS Academia has been extremely slow to react to what has been seen as a significant problem for organisations. To illustrate the paucity of material in the academic arena we conducted a small survey of past issues of seven journals

which we would have expected to have some contributions on the Y2K problem: Information Systems Journal, International Journal of Information Management, Information and Software Technology, Accounting, Management and Information Technology and MIS Quarterly. In each case there was not a single paper published on this topic since 1994, a period when literally thousands of practitioner articles and books have been published on the topic. Some recent papers have appeared in the more general computing journals (such as Communications of ACM :[9]) particularly re-emphasising the line taken in the vast volume of practitioner literature [21], [4], but no paper has raised the focus to IS rather than purely technological concerns.

This lack of IS academic material on the issue of Y2K is particularly interesting in light of the degree to which journals in other professional areas have latched on to the issue. Over the last five years there has been a rush of papers in architectural, finance, electrical engineering and other disciplines. So how do we account for this lack of coverage by the IS academic fraternity of a topic which is considered of such interest by IS practitioners and most other professional groups and disciplines? A number of tentative hypotheses are expressed below:

1. One reason for the lack of academic material may be that, on the one hand Y2K is not seen as a suitably difficult computing problem; and on the other hand it is not seen as a significant business problem. This would perhaps explain the lack of interest in the phenomenon on the part of computer scientists and business and management academics. It does not explain the lack of interest by IS academics in such an important topic which contributes to the shape of the IS/IT interface.
2. Another argument may be that academic research turns around so slowly, that people have done research in this area but have not reported on it yet in academic journals. There is some evidence of this in that a number of papers have indeed considered Y2K within academic IS conferences over the last two years. However, most such papers have focused on the problem itself rather than on its effects.
3. Yet another argument may be made that the lack of IS material on Y2K is yet another instance of the gulf between IS academia and practice. [22] has argued that much of IS academic research is seen as untimely and mostly irrelevant on the part of IS practitioners. This surely raises questions about the validity of our IS research agendas as we move into the new millennium.

VI. A RETROSPECTIVE CONCLUSION

This paper has examined the phenomenon of Y2K as an instance of information systems failure. We have argued that Y2K cannot be characterised merely as a technological failure but that it is of interest also on the organisational, societal, and economic level.

The aftermath of Y2K is interesting for similar reasons. The predicted level of failure expected from Y2K has apparently not materialised in the first month of 2000. This has led to claims of a significant overspend on Y2K projects amongst companies in nations like the UK. In global terms this overspend is estimated to be in the region of $70 billion.

There have been a range of reactions to this apparent overspend:

1. It is claimed that this is merely another example of IS/IT projects going into overspend and therefore to be expected.
2. Spending on Y2K was a necessary expenditure that served to ‘insure’ or ‘vaccinate’ businesses from inevitable IT failure. It was therefore money well spent.
3. The small range of reported problems that have occurred are only the tip of the ice-berg. More and more date problems will come to light throughout 2000 demonstrating the importance of Y2K preparedness.

What is perhaps important from the perspective of the IS discipline is that Y2K has done something to demonstrate to organisations the centrality of IS/IT to their business. It therefore remains important to plot the effect that Y2K will have on issues like the IS strategy of organisations in the near future.

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