LACE Frameworks and Technique -- Identifying the Legacy Status of a Business Information System from the Perspectives of its Causes and Effects

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Abstract

This paper first presents a definition of the concept 'legacy status' with a 3-dimensional model. It then discusses LACE frameworks and techniques, which can be used to assess legacy status from the cause and effects' perspectives. A method of applying the LACE frameworks is shown and a technique with a mathematical model and metric so that the legacy status of a system can be calculated. This paper describes a novel and practical way to identify legacy status of a system, and has possibly pointed out a new direction for research in this area.

1. Introduction

One of the most difficult challenges arising from dealing with so called legacy systems is how to identify and determine the 'legacy status' of such a system, where no commonly accepted definitions existed until very recently. This paper tackles this problem. It researches into the concept of legacy status and related issues, and aims at developing a set of frameworks and an associated technique, which can be used by management to identify legacy status accurately in a current or a planned business information system. Although research on legacy information systems has been active for some years, practical solutions have been slow to emerge ([6], [8]). There is no common understanding or definition of the concept of what a legacy system is. For example, the term 'legacy system' is used, in some cases, to encompass any system that has diminished in its usefulness or usability in implementing the business task that is required of it. In other cases, it categorizes systems that suffer effects that vary from diminished user satisfaction to lack of scalability. It is also used to categorize systems by cause, such as deteriorated software quality or platform obsolescence. No matter how 'legacy system' is defined, it is always the case that given a particular information system, it is difficult to give a straightforward 'Yes' or 'No' answer to the question – is the system a 'legacy system'? Maybe an alternative question should be asked instead*: to what degree is the 'legacy status' of an information system?* The concept of 'legacy status', if clearly defined, would obviously reflect the features of an information system more accurately. However, as far as the authors are concerned, there is currently no such definition available, until very recently.

This paper consists of six sections. This section, the first, raises the question. Section 2 briefly discusses the research background and related works. Section 3 presents a definition of legacy status of an information system with a three-dimensional model. Section 4 introduces the LACE framework set together with the LACE technique for using these frameworks. Section 5 discusses the applications of LACE and mentions a mathematical model that could be applied. Finally, Section 6 sums up this paper, draws conclusion, and points out some possible future research directions.

2. Background

Definitions of legacy systems vary greatly, with many definitions focusing on some aspects of what it means to be a legacy system. Despite the fact that much research has been done in the area of legacy systems, it is only recently that analysis has focused on a broad description of what constitutes a legacy system ([4], [6]). Many authors have mentioned the effects exhibited by legacy systems or those with legacy status [8]. However, due to different objectives, the discussions provided by these authors lack depth or breadth of scope.

The means of assessing a system may influence the choice of solution, as many assessment techniques are merely provided as a component part of an intended solution. To assess a system objectively, an independent assessment technique is required. Sneed's proposal [7] for assessment measures systems in two dimensions, technical quality and business value. However, as many systems are unused or unusable due to their unsuitability to the environment in which they are intended to operate [3], any assessment should place greater emphasis on system suitability. Ransom *et al.* [6] use three headings of business value, external environment and application. These

headings imply that the assessment of the application can be separated from the external environment and the business value, a view not shared by the authors of this paper.

3. Definition of Legacy Status

In this paper, an independent assessment technique is proposed, based on a three-dimensional representation of a system in regard to its legacy status. This assessment provides greater accuracy and gives each dimension a narrower focus that can be more easily addressed. This section first introduces the 3-diminsional model and then discusses the effects and causes of legacy systems.

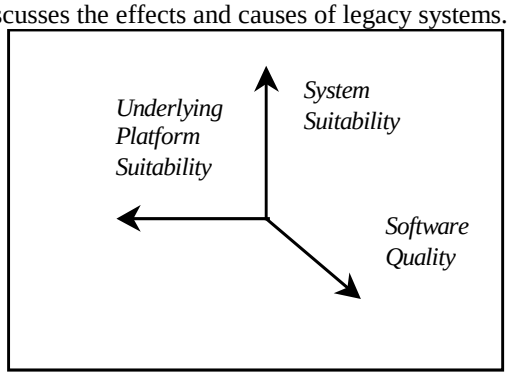

Figure 1 Dimensions of Legacy Status

3.1 Legacy Status and Causes of Legacy Systems

This paper proposes a new three-dimensional model of causal criteria for legacy status (Figure 1), where a vector represents each dimension. As the legacy status of the system increases along a vector, the co-ordinate for that vector moves away from the centre point. As the system improves, its co-ordinate will move back towards the centre. The centre point indicates a co-ordinate of (0,0,0), showing zero legacy status of a target information system.

The first dimension is *System Suitability*. This is addressed by both IT and business management and is under constant review. System suitability includes the alignment between business and IT strategy and the internal domain, which includes staff, culture and workflow. As this suitability improves, the system can be assessed as travelling along a vector towards the origin, i.e. towards a point where it has no legacy status relating to *System Suitability*. A perfectly suitable system will have zero legacy status in this dimension.

The second dimension is *Underlying Platform Quality*. It involves the technical hardware and non-application software used in the system. It excludes the suitability of this technology to the organizational environment – that factor is part of the *System Suitability* dimension. The *Underlying Platform Suitability* includes those technical aspects of the system, which are managed by the IT department but are not developed by them. Although the platform consists of several components that may or may not be legacy, the vector can be justified by assessing the impact of legacy status of each of these components on the entire platform.

The third dimension is *Software Quality*. This refers to the quality of the application software only. It incorporates the quality of software written into the components and the quality of system design and also, unlike [6], quality of change management. As an organization's software quality mechanisms improve, the system can be assessed as travelling along a vector towards the origin, and vice versa.

For the purpose of discussion here, these three dimensions are classified and sub-grouped with causal criteria are tabulated and, presented in Table 1.

Table 1 Causes of Legacy Status

Causes of Legacy Status	
System Suitability	System Suitability to business process
	Business process to organizational mission
	System technology to organizational environment
Underlying Platform Suitability	Hardware suitability
	Operating System suitability
	Network suitability
	Development environment suitability
	Data management suitability
Software Quality	Quality of change management
	Design quality
	Component Quality

3.2 Effects of Legacy Systems

This section briefly discusses the effects of legacy systems, which are of concern to this paper. All the included effects have previously been identified in the literature and/or practices of this area. They are classified into four groups: *asset value*, *ease of operation*, *ease of maintenance* and *ease of migration / evolution*. Each group contains a set of relevant effects. Due to space limitations, not all effects will be discussed and listed here. Instead, only the sub-groups of each group will be listed Table 2. See [5] for detailed discussion on the construction of this table, and full list of effects.

The *asset value* of a system is its worth to the organization in servicing a particular functional area. If this diminishes, the organization is no longer competent in this area. This group is divided into two sub-groups: 1) *mission criticality*, which refers to the level of dependence of the organization on the function the systems serves and 2) *reliability*.

Effects relating to the *ease of operation* of a system affect the users, auditors and support staff on a day-to-day basis. Even if the system provides all of the functionality that is required by the business process, the effects in this group may still be present. The *Ease of Maintenance*

group comprises effects that relate to the constant changes that need to be made to most systems, to keep them in line with current business practice.

Table 2 Effects of Legacy Status

Effects of Legacy Status	
Asset value	Mission criticality
	Reliability
Ease of operation	User satisfaction
	Ease of testing and auditing
Ease of maintenance	Cost of maintenance and resistance to it
	Availability of maintenance resources
	Program size and complexity
	Dependence on individuals
Ease of migration / evolution	Ease of use of new technology
	Scalability

The fourth group of effects *Ease of migration / evolution* relates to major or strategic changes that are required to enhance the system to meet new business needs or to move it onto new platforms or to scale it up.

3.3 Definition of Legacy Status

Having analyzed the effects and tabulated them, the definition of legacy status can be stated.

Legacy status *is a measure of the deficiency in a system in terms of its suitability to the business, its platform suitability and application software quality, with the effect that the system's asset value diminishes, as does its ease of operation, maintenance, migration or evolution.*

The critical level of legacy status that is acceptable in any of the three dimensions is dependent on the owner organization. It is incumbent upon management to determine the level of legacy status and its acceptability to the organization. This may be an existing system that is intrinsic in the organisation or a new system, for which a new strategic approach is required.

4. LACE Frameworks and Technique

This section discusses the LACE frameworks and Technique, which is used to assess the legacy status of an information system. The LACE framework set includes three frameworks: 1) Legacy Effect Determination (LED) framework; 2) Legacy causal crITeria (LIT) framework and, 3) Legacy stAtus Cause/Effect (LACE) cross-reference framework. These frameworks, together with guidelines on how to apply them, make up the LACE Technique.

LED can be used to identify the effects of legacy status on an information system; LIT to identify the causes and LACE framework serves as the cross-reference between effects and causes. If LED is used to represent the system, LACE can show where possible causes may *lie*, whereas if LIT is used, LACE can show what effects may *ensue*. These frameworks can be used either on an existing system, or on a system that is being considered as a replacement.

Furthermore, if LED is used to represent the system and is cross-referenced with LACE, a mathematical model can be applied to determine a percentage legacy status (see Section 5). The following sub-sections discuss the LED, LIT and LACE frameworks and associated application guidelines. All the characteristics and features of legacy systems in the LED, LIT and LACE frameworks are selected and determined based on a general survey of the literature, interviews with relevant people and research by the authors. For detailed justification, please refer to [5]. Before any further discussion, it is very important to point out that the LED, LIT and LACE could be tailored or revised if so necessary when applying them to a specific real-world information system. However, the principal ideas of LACE Frameworks and Technique will still apply.

4.1 Legacy Effect Determination (LED) Framework

The Legacy Effect Determination (LED) Framework is based on Table 2. A new column is added, labeled "Present, Absent or Undetermined", denoting the presence, absence or indeterminate nature of the legacy effect in the information system. Management can use this table to document the effects. With the help of staff who use or maintain this system, an effect can be assessed as being present "P", absent "A" or undetermined "U" and marked into the table. The observation of effects may be relatively subjective, but it is done by staff who are experienced in the use of the system and what needs it is trying to serve. The LED Framework can be filled out partly or in full. The framework is completed by placing a "P" in the "Present, Absent or Undetermined" column if the effect is present, an "A" if it is absent and a "U" if it is undetermined.

4.2 Legacy Causal Criteria (LIT) Framework

Based on Table 1, the purpose of the legacy causal criteria (LIT) framework is to identify where weaknesses lie in the system. It takes the legacy causal criteria and adds a column where management can mark in whether their system is enabled "E" or inhibited "I" in the causal area. In order to do this, a thorough investigation of the system must be undertaken. While a criterion is under assessment, "C" can be marked into the column, to show that it is under consideration. To sum up, 'E' in a cell means that the corresponding aspect in the row does *not* contribute to the legacy status of an information system. 'I' means it *does*. A 'C' means that further investigation is needed. Eventually, a cell should either contain 'E' or 'I'.

4.3 The Legacy Status Cause / Effect (LACE) Framework

LACE cross-references causal criteria with legacy effects exhibited as a result of those criteria being inhibited. Table 3 shows the LACE framework. There is a row for each causal criterion and a column for each legacy effect. In the row for a causal criterion, each effect that it can cause has its column marked with an "X". This allows management to see what effects could be caused by a weakness in a causal criterion. Similarly, if legacy effects are known to be present in a system, then the corresponding columns in the LACE framework will indicate possible root causes, marked "X". For justification of this framework, please refer to [5].

Table 3 LACE Framework

Causal Criteria \ Legacy Effects		Asset value		Ease of operation		Ease of maintenance				Ease of migration or evolution	
		Mission criticality	Reliability	User satisfaction	Ease of testing and auditing	Cost of, and resistance to maintenance	Availability of maintenance resources	Program size and complexity	Dependence on individuals	Ease of use of new technology	Scalability
		0	1	2	3	4	5	6	7	8	9
System Suitability	System Suitability to business process	x		x	x						
	Business Process to org. mission	x		x							
	System Technology to org. environment	x		x	x	x	x	x	x		
Underlying Platform Suitability	Hardware		x			x	x	x		x	x
	Operating System				x	x	x	x	x	x	x
	Network	x	x	x	x	x	x	x	x	x	x
	Development environment		x	x	x	x	x	x	x	x	x
	Data Management		x		x	x	x			x	x
Software Quality	Quality of Change Management		x		x	x	x	x	x	x	
	Design Quality		x		x	x		x	x		x
	Component Quality		x		x	x		x	x	x	x

5. Applying the LACE Frameworks and Technique

There are three ways to apply the LACE Frameworks and Technique against an information system. They are 1) assessing an existing system through the effects it exhibits (section 5.1), 2) assessing an existing system for legacy causal criteria (section 5.2) and, 3) assessing a solution system for fitness for purpose (section 5.3).

5.1 Assessing an Existing System through Effects

If effects are being used to check the legacy status of an existing system, then the suspicious effects must be mapped onto the Legacy Effect Determination (LED) Framework. A combined IT and business user team who are expert in the use and maintenance of the system assess the system for the listed effects. For each one, the team mark in "P" if it is present, "A" if it is absent and "U" for undetermined. For a full assessment, a result of "A" or "P" must be entered.

When all of the effects are assessed, then those that are present "P" can be cross-referenced to the *LACE framework*. The column for any effect that is present will have "X" in any row that corresponds to possible underlying causes of the effect. For example, if the system exhibits poor *Scalability*, then in LED, there will be a "P" against this effect. By cross-referencing to LACE, it can be seen that the corresponding column for *Scalability* in LACE has "X" in all rows of the 'Underlying Platform Suitability'' group and *design* and *component quality* rows. This indicates that the system is weak in one or all of those criteria.

5.2 Assessing an Existing System for Legacy Causes

This is the most definitive assessment proposed for the system. It involves the use of the *Legacy Causal Criteria (LIT) Framework* (Table 3), by using the definitions of those causal criteria and the practices available to ensure high quality in them. The criterion for the system is assessed and the corresponding row in the framework is marked with an "E" if the criterion is enabled and an "I" if it is inhibited. The values relating to some of the criteria will be known earlier than others. While a criterion has not had its value decided, the framework row is marked with a "C" for under consideration. Investigation should continue until the evaluation column contains only "I" or "E".

When the framework has been filled out, any criterion that is marked with an "I" should be looked up in the *LACE Framework* (Table 3). The row corresponding to the causal criterion will have an "X" in any column where it can cause this effect. This indicates to management what the risks are if the causal criterion's inhibiting state is left unattended.

5.3 Assessing a Solution System for Fitness for Purpose

Prospective systems should be planned based on the underlying legacy status in the current system. In some

cases, the changes undertaken may mean that criteria that show an "E" in the *Causal Criteria Framework* for the existing system may be adversely affected in the proposed solution. If a system is new, not a replacement system, then this assessment is also necessary, so that possible future problems can be anticipated and their risk weighed. When a system is proposed, management should fill out the *legacy Causal Criteria (LIT) Framework.* If a criterion has been evaluated as inhibited, then the potential effects of this, when the system is installed, can be seen from the *Legacy Status Cause / Effect (LACE) Framework*. If the criterion is enabled, this means that it does not contribute to a legacy status in the system, however the effects associated with it may be incurred by another cause.

5.4 Proposed Mathematical Model

If each causal criterion in the LACE framework is given a **weight** w ($1 \geq w \geq 0$) in regard to its contribution to legacy status, and each effect is given a **value** X_i reflecting its presence in the system, then the dimensional legacy status values d_{ss} d_{up} d_{sq} can be calculated. For example,

$$d_{ss} = w_{bp}(X_0+X_2+X_3)/3 + w_{om}(X_0+X_2)/2 + w_{oe}(X_0+X_2+X_3+X_4+X_5+X_6+X_7)/7$$

where the weights are w_{bp}, w_{om} and w_{oe} for system suitability to **b**usiness **p**rocess**,** business process to **o**rganisational **m**ission and system technology to **o**rganisational **e**nvironment respectively**.** System suitability to business process is associated with effects 0, 2 and 3. The dimensional factors are combined in the **LS Formula:**

$$LS = (d_{ss}^{\,3*(1-dss)*(1-dup)*(1-dsq)} + d_{up}^{\,3*(1-dss)*(1-dup)*(1-dsq)} + d_{sq}^{\,3*(1-dss)*(1-dup)*(1-dsq)})/3.$$

Due to space limitations, a full explanation cannot be provided here. Please contact authors for further details.

6. Conclusion

Bringing systems into the twenty-first century is an on-going struggle. Organisations are faced with a broad spectrum of solutions, making it very difficult to decide on what exactly will fulfil their needs. Before this choice can be made, the organisation needs to know where it is and what it wants to improve. This paper has first investigated the concept of legacy status and related issues and presented a 3-dimension model and a definition of legacy status. It has also presented the LACE Frameworks and technique, which can be used by management to identify legacy status in current or planned systems.

The LACE Frameworks and technique has a wide potential application area. It offers the opportunities of assessing the aspects of a current system that are causing it to be legacy and determining the legacy status accurately. This allows the organisation to take stock of their assets and liabilities, thereby leaving them more confident in what aspects they need to keep and what aspects can be replaced without loss of function.

These frameworks also allows management to compare and contrast systems that are considered legacy with their proposed replacements, thereby giving them a more robust foundation for their decision on which solutions to take. Positive results in an existing system should not be abandoned. If the current system shows high quality in a causal criterion, then it may be possible to retain this component. When a new system is being evaluated, it is necessary to ensure its fitness for purpose.

Although the LACE Frameworks and Technique has been fairly well developed, many aspects are still in need of further investigation. The Frameworks themselves could be further developed, and the mathematical model needs more research. Other very important issues include how to fill out the LIT and LED frameworks objectively. Ultimately, a well-defined practical approach could be developed to fill them out by numbers objectively. Finally, the LACE Frameworks and Technique needs to be implemented on real business information systems. Any such practice will greatly benefit further development of the LACE Frameworks and Technique.

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