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Errors in User Developed Applications

Marton Sakal
University of Novi Sad, Faculty of Economics in Subotica, Serbia
Lazar Raković
University of Novi Sad, Faculty of Economics in Subotica, Serbia
Darko Pantelić
University of Novi Sad, Faculty of Economics in Subotica, Serbia

Abstract
Volatile market and legislative conditions impose constant changes on business processes, also demanding a change in the requirements set before information systems. As a solution to a situation in which the existing information systems cannot reach an adequate level of quality to keep up with the changes set up before them, user developed applications emerge, which are often developed in spreadsheet programs. Without questioning the benefits and utility of user developed applications in spreadsheet programs, practical experience nevertheless testifies to the consequences of errors in the development. The aim of this article is to give specific examples which draw attention to the seriousness of this issue and the need to introduce a framework for building and using user developed applications in spreadsheet programs.

Keywords
End user development, spreadsheets, errors.

Introduction

Information systems i.e. transaction processing systems and ERP systems provide support to business operations. However, these systems are frequently unable to meet all the requirements of operational staff, business analysts, managers, etc. Due to constant market changes, organisations are forced to continuously change their business processes in order to survive in the market. These changes result in new information requests and modifications in system functionalities that have already been implemented. Because of the fact that it is not possible for organisations to constantly change their information systems, they often turn to creating their own applications (Baxter, 2006), both in terms of operational and in terms of analytical requirements (Pemberton & Robson, 2000; Aberdeen Group, 2009; Excel4apps & Solutions, 2010; Darr, 2010; Kulesz, 2011; Kirkup, 2011; Mint Jutras, 2011; Burnett & Scaffidi, 2013; ClusterSeven, n.d.,a). Results of a research conducted in 2011 (IFS World & Mint Jutras, 2011) indicate that end users who use their own applications as an alternative to complex or poorly designed information systems, predominantly create them by using spreadsheets (Figure 1).

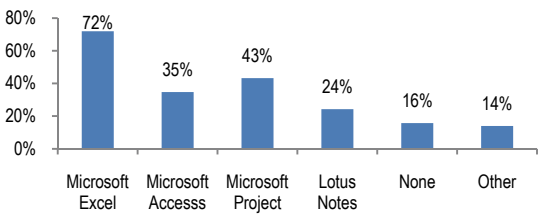

Figure 1 Alternatives to complicated or poorly designed ERP systems
Source: adapted from IFS World & Mint Jutras, 2011

1. End user development

After humble beginnings in the seventies, End User Development (EUD) sees a more significant development during the 1980s (Barker, 2007). This referes to applications that users (who are not IT professionals) develop for themselves or their colleagues in order to solve tasks which they cannot or do not know how to complete by using organisational information systems, or in order to, according to Deng, Churcher, Abell & McCallum

(2011), overbridge the gap between functionality of the implemented IS and the requirements set before it. These applications are usually developed in an uncontrolled environment without employing appropriate (or any whatsoever) development methodology and are described as „a set of methods, techniques, and tools that allow users of software systems, who are acting as non-professional software developers, at some point to create, modify or extend a software artefact" (Lieberman, Paterno, Klann & Wulf, 2006).

Reasons for End User Development arise on the one hand due to deficiencies of the existing IS and a variety of other limitations in/directly related to it, and on the other hand, due to the nature of the tools used to develop EUD applications. The first group of reasons may include the following: the lack of budget for information system implementation by ICT experts (Deng, Churcher, Abell & McCallum, 2011), insufficient number of ICT professionals, lack of domain knowledge of ICT experts, time needed to create/change the sowtare, etc. (Taylor, Moynihan, & Wood-Harper, 1998; McLennan, Churcher, & Clemes, 1998; Kreie, Cronan, Pendley, & Renwick, 2000; McGill, 2002a; McGill, Hobbs, & Klobas, 2003; McGill T., 2005; Mehandjiev, Sutcliffe, & Lee, 2006; Lieberman, Paterno, Klann, & Wulf, 2006; Dörner, Heß, & Pipek, 2007; Chen, Holt, & Sun, 2008; Fischer, 2009; Bellino, Ochab, & Rowland, 2010; Dörner, Heß, & Pipek, 2007; Burnett & Scaffidi, 2013).

On the other side, EUD tools encourage end user development through easy access, great flexibility, great functionality and speed of development that all potentially lead to increased productivity (McGill, 2002b). The most frequently used EUD tools are spreadsheets (McGill, 2005; Hole, McPhee &Lohfink, 2009).

According to Burnett & Scaffidi (2013), EUD comprises two concepts: End User Programming (EUP) and End User Software Engineering (EUSE). End user programming (Ko, et al., 2011) is only a phase in creating end user applications, whereas EUD includes the whole life cycle of end user applications, which includes, among other things, the creation, modification and extension of user-developed applications. Ko and associates (2011) include in end user software engineering the following steps: gathering of requirements, design and specifications, reuse of existing components, testing and verification, and debugging.

2. Errors in user developed applications

Even though user developed applications, among other things, provide great benefits by enabling users to directly manage the data (Deloitte, 2011), they also carry significant risks:

- risk of errors in financial statements (Deloitte, 2011),
- risk of a breach of legislation (Deloitte, 2011),
- risk of time loss due to the lack of domain knowledge (Deloitte, 2011),
- risk of redundancy and the existence of multiple versions of data (Deloitte, 2011),
- risk of the lack of recovery option (Deloitte, 2011),
- risk of counterfeiting data (Deloitte, 2011),
- risk of poor quality applications due to insufficient ICT knowledge (McGill, 2002a),
- risk of insufficient knowledge of spreadsheets due to lack of (quality) training and experience (McGill, 2002b),
- risk due to the lack of documentation (McGill, 2002a),
- risk due to inadequate design, poor testing and maintenance (McGill, Hobbs & Klobas, 2003) etc.

Since applications developed by end users often provide support to key business processes (ClusterSeven, n.d., b), it is important for organisations to recognise the need to manage these applications at all levels of management (Ko & Hurley, 1995), in order to minimise the number of errors (which are manifestation forms of the risks listed). Bearing in mind that errors are inevitable even with IT specialists who have undergone appropriate training and who use certain methodologies in software design, meaning that when developing "true" software products 80% of the time is spent on error identification and debugging and only 20% of the time is spent on actual design and delivery (Huizinga & Kolawa, 2007), claims on the existence of error pandemic are not surprising (PwC, 2011b). Research indicates that a large percentage, as large as 95%, of all user developed spreadsheet applications contain errors (Evans, 2012), resulting in not only negative financial consequences but also in those affecting organizational reputation.

One of the possible explanations for a significant number of errors in user developed applications, could be the fact that creating spreadsheets

represents a moment when "ordinary" users step out of their primary milieu of (non-ICT) professional knowledge and skills and become developers or at least become significantly involved in the development process whereas they do not possess the needed knowledge and skills to the same extent as ICT professionals do (nor this is realistic to expect). The number of spreadsheet users/developers to whom ICT is not primary business orientation but who yet carry out some form of programming when creating spreadsheets, is much greater than the number of ICT professionals who take part in spreadsheet development (Figure 2) (Scaffidi, Shaw & Mayers, 2005; Burnett & Scaffidi, 2013; Ko et al., 2011). One of the possible reasons for high percentage of errors in use/design of spreadsheets could also be the fact that the approach to their development and creation is not as systematic, careful and methodic as when it comes to the development of "true" software products (PricewaterhouseCoopers, 2004; Baker, Foster-Johnson, Lawson & Powell, 2006).

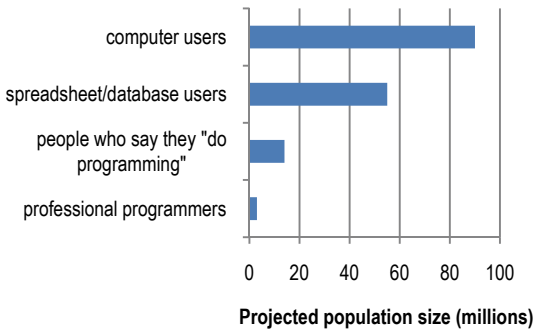

Figure 2 Projections for jobs in the US in 2012 (categories are not mutally exclusive)
Source: Burnett & Scaffidi, 2013

The number of errors and their negative impact on overall operations of numerous organisations were reason enough for a respectable number of authors to focus their research on the issue of errors in the design and use of user developed spreadsheet apllications. Some of the research results have been summarized by Panko and Port (2012) in the table below:

Table 1 Overview of results of the percentage of electronic tables with errors

Study	Year	Percentage of spreadsheets with errors	Percentage of cells with errors
Brow and Gould	1987	63%	
Hassinen	1988	55%	
Hicks	1995	100%	1.2%
Coopers and Lybrand	1997	91%	-
KPMG	1998	91%	-
Lukasik	1998	100%	2.2%, 2.5%
Butler	2000	86%	0.4%
Clermont, Hanin and Mittermeier	2000	100%	1.3%, 6.7%, 0.1%
Lawrence and Lee	2004	100%	6.9%
Powell, Baker and Lawson	2008	86%	0.9%
Powell, Baker and Lawson	2009	44%	
Panko and Aurigemma	2010	91%	
Average		**86%**	

Source: adapted from Panko & Port, 2012

Errors in user developed spreadsheet aplications are often called „horror stories" in expert literature (Evans, 2012; EuSpRIG, 2012; The Audinator, n.d.). Several examples of errors in user developed spreadsheet applications and their consequences will be given below. References to stories have been mostly found on EuSpRIG group site (The European Spreadsheet Risks Interest Group) and within discussions on Yahoo EuSpRIG group (http://tech.groups.yahoo.com/group/eusprig/). Here are some of the most significant stories listed in chronological order.

Due to an error in a spreadsheet table, projected budget revenue in the U.S. city of Lincoln for 2012/2013 was overestimated by $575,000. A simmilar situation occured in the budget for the previous fiscal year (2011/2012). This time, due to an error in the table (the same revenue projection was entered twice) the projected revenue was overestimated by $200,000. The same budget projection contained another error – the projected expenditure was underestimated by $809,000 (Sambides, 2012).

Britain's second largest pharmaceutical company sent its confidential information on the me-

dium-term financial forecast to sales anlysits. Confidental information was inadvertently incorporated into the spreadsheet template. Once the error was identified, company's shares had dropped 0.4% (Kelland & Holton, 2012).

Due to an error in entering data on government spending in the U.S. state of Kansas, an erroneous report was created on government spending in 2010 fiscal year. The error caused a difference of about $2 billion. The report indicated that spending reached $16 billion, while actual expenditures were approximately $14 billion (Hanna, 2013).

American West Baraboo underestimated the total ten-year costs due to an error made by an operator, and consequently the actual costs were $400,000 higher than planned. Subsequent table examination showed that one cell had not been included in the formula (Bridgeford, 2011).

An employee from the Commisioner's Office of U.S. municipality of Knox County made a mistake of $6,000,000 in the report sent to the audit company. The error occurred because an account had not been well connected in Excell table. The fine the municipality had to pay was $12,500 (Donila, 2011).

Tax assessors in a municipality of California overlooked, and then found, a taxable property worth $1.26 billion. The usual tax liability on a property like this is $12 million. The error occurred because an employee used a wrong table to calculate taxes (Cox, 2011).

Financial department of the U.S. city of Framingham mistakenly calculated that the city had $1.5 million more in the budget than it actually did. The consequence was that they had to withdraw $600,000 of state aid to fill in the gap caused by this error. The head of the financial department took responsibility for the error and said that the error had occurred while the employees had been managing the „monstrous tables" (Ameden, 2011).

Central Bank of Norway released a wrong table which indicated a 60% to 70% change in interest rates in the following two months (Weisenthal, 2011).

The King's Fund publicated an article containing an error in figures on health spending in Wales. Due to a spreadsheet error the report stated that the health service budget in Wales faced cuts of 10.7 % over three years while the correct figure was 8.3% (Jacobs, 2011).

Central Service Hungary sent ambiguous tabels to bidders during the course of public procurement. The tables contained two columns, out of which only the first column was supposed to be filled in while the other one was filled in automatically. Tweny-five out of twenty-eight bidders did not understand the table and filled in both columns by hand. Due to this error, the procurement had to be repeated and the Procurement Board fined the Central Service with 2,000,000 forints (Budapest Business Journal, 2010).

In its attempts to cut costs, the U.S. city of Abermale offered early retirement to employees in municipial departments. Due to a spreadsheet error, the city offered 42 retirements more than it could pay out. This error cost the municipality $66,000 (Shulleeta, 2010).

Flintshire County Council mistakenly redistributed 1 million pounds to high schools. The error occurred because the amount of money was entered into a wrong column. The error was not noticed until the money had been distributed to high schools (Goodban, 2010).

Irish C & C Group admitted that the revenue forecasts they released contained an error. Forecasted revenue was supposed to be lower than reported. The error occurred after data had been incorrectly entered into an electronic spredsheet. C & C Group share price fell by 15% (Drinks Daily, 2009).

Nevada City budget for 2006 was created using spreadsheets after tables from the previous year had been downloaded. Some of the data remained from the previous budget causing a deficit of $5,000,000 in the water and sanitation fund (Pokorny, 2006).

University of Toledo mistakenly overestimated revenue projections by $2.4 million. Just before a significant reduction in funding from the state budget, the university identified a budget error due to which it had $2.4 milloin less than assumed. The error was caused by an incorrect formula entry which led to the overestimated projections (Smith, 2004).

A simple administrative error cost a Canadian company TransAlta $24 million. The company sent a bid for participation in an auction but the company's computer spreadsheet contained mismatched bids for the contracts. According to TransAlta company, it was a cut-and-paste error in an Excel spreadsheet (French, 2003).

A school in England faced a budget deficit of 30,000 pounds. The error occurred when data taken from the accounting system were entered as text in a spredsheet table. For this reason, the SUM function ignored this cell (PwC, 2011a).

Conclusion

Starting from the 1980s, the importance of EUD is constantly growing. As EUD applications are usually developed in uncontrolled environments, without the use of proper (or any whatsoever) development methodology, the number of errors that occur in these applications raises concern. Unfortenately, the features of EUD tools themselves do not contribute enough to reductions in the number of errors. As end user developed applications often provide support to key business processes, it is important for organisations to recognise the need to manage these applications at all levels of management, with an aim to minimise the number of errors as much as possible. SM

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✉ **Correspondence**

Marton Sakal

Faculty of Economics in Subotica
Segedinski put 9-11, 24000, Subotica, Serbia

E-mail: marton@ef.uns.ac.rs