

Analyzing Requirement Prioritization Techniques Based on the Used Aspects

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Abstract: Requirement prioritization is a critical activity in the system development life cycle, since it aims at assuring the satisfaction level of the project's stakeholders by identifying the most significant requirement. Prioritization process can be performed using different techniques based on various aspects such as value, time, complexity and importance. Aspects of requirement prioritization play a key role in the success of the prioritization, since it declares the aim of prioritizing the requirements in the techniques. In addition to that, it impacts the quality of the prioritization result. However, majority of existing requirement prioritization techniques do not support these aspects comprehensively. Thus, the purpose of this study is to review the aspects that are considered in the requirement prioritization as well as critically utilizing the existing techniques of requirement prioritization based on the used aspects in the prioritization process in order to support the experts and software industry thus improving the quality of the prioritization process in the techniques. The expected result of this study is to display categorization of requirement prioritization aspects and the implemented aspects with existing requirement prioritization techniques will be presented based on the analysis result. Not only that but it will also highlight factors that impact the implementation of these aspects in the requirement prioritization process. Moreover, this study identifies limitations of the existing techniques with aspects of requirements prioritization and provides future enhancements to overcome the identified limitations.

Key words: Requirement prioritization, stakeholders, requirement prioritization aspects, requirement prioritization techniques, factors

INTRODUCTION

In fact it is not easy to develop a complete and successful system for any organization, since all phases of system development have to be performed correctly to produce a good system and obtain the stakeholders' expectations. One of these phases is collecting and prioritizing requirements in order to identify the most critical requirements among other requirements (Somerville, 1995). This phase is considered to be a critical stage; since it produces an order list of core requirements for development team based on the stakeholders' expectations which will help to produce a good system (Somerville, 1995; Berander and Andrews, 2005). The prime factor of determining the success of a developed system is to achieve and satisfy the expectations of the stakeholders. Therefore, there is a major challenge to specify high risk and the most significant requirements from other requirements to users of the project. Moreover, according to statistics based on recent studies, only 32% of all submitted projects or systems were eligible to be

delivered according to project constrains. The remaining percentage is divided between 44% of projects being presented as challenges due to not being delivered in time and/or not meeting stakeholders' expectations while a percentage of 24% are failed and not delivered (Berander and Jonsson, 2006; Sher *et al.*, 2014). Meeting the stakeholders' expectations and time constrain are major challenges in producing a successful system. The impact of these two challenges can be reduced or eliminated by executing the requirements prioritization process. This is because, the requirement prioritization process will highlight the most important requirements to the stakeholders from other requirements and this will let the project's teams to concentrate on implementing and delivering, not all the requirements but only the most critical ones which have been identified by the prioritization process. The existing techniques of requirement prioritization prioritize requirements based on different aspects or factors such as penalty, importance, cost, customer satisfaction (Babar *et al.*, 2015; Achimugu *et al.*, 2014). The selection of the involved

aspects in prioritization is relied on the type of the stakeholders as well as the aim of the project. For example, the customers are some of the most participated types of the stakeholders in the prioritization to prioritize the importance of the requirements while the requirement engineer, product manager, developers and experts are participated in different techniques to prioritize the requirements based on cost, time and penalty aspects (Berander and Andrews, 2005; Karlsoon *et al.*, 2006). It is necessary to determine the aspects that will be used to prioritize the requirements (Berander and Andrews, 2005; Khari and Kumar, 2013). This is because; the used aspects in the prioritization process will specify the objectives of the techniques which will affect the quality of the produced result. However, various prioritization techniques have been implemented but none of them have been approved to achieve the experts' expectation and the need of the industry (Sher *et al.*, 2014; Babar *et al.*, 2015). Furthermore, most of existing requirement prioritization techniques do not support these aspects comprehensively (Berander and Andrews, 2005; Sher *et al.*, 2014; Babar *et al.*, 2015; Achimugu *et al.*, 2014). Thus, there is a need to focus on aspects of the requirement prioritization in order to improve the quality of software and to specify future research trends. As a result, the main objective of this paper is to study these aspects of the requirement prioritization. As well as to review, utilize and evaluate the existing prioritization techniques based on the currently used aspects in the prioritization process to highlight the limitation of the existing prioritization techniques based on the currently implemented aspects.

Aspects of requiremet prioritization: System requirements can be prioritized using different attributes or properties of system. These attributes or properties are defined as aspects of requirement prioritization (Berander and Johnsons, 2005). There are various aspects that are used to prioritize the requirements. As shown in Fig. 1, the aspects of requirement prioritization can be categorized into two different categories: commercial aspects and technical aspects (Berander and Johnsons, 2005; Berander and Andrews, 2005; Sher *et al.*, 2014a, b; Lehtola *et al.*, 2004; Babar *et al.*, 2011; Karlsson *et al.*, 2006; Babar *et al.*, 2011; Achimugu *et al.*, 2014; Vestola, 2010; Khan, 2006; Khari and Kumar, 2013; Berander and Jonsson, 2006; Karlsson *et al.*, 1998; Karlsson, 1996; Soni, 2014; Ahl, 2005; Voola and Babu, 2012a, b; Xu *et al.*, 2006; Hatton, 2008; Aasem *et al.*, 2010; Karlsson and Ryan, 1997; Duan *et al.*, 2009; Karlsson *et al.*, 2007; Ramzan *et al.*, 2011, 2009; Iqbal *et al.*, 2010).

These two categories include all stakeholders' perspectives in software development. The technical aspects focus on technical side of the requirements which

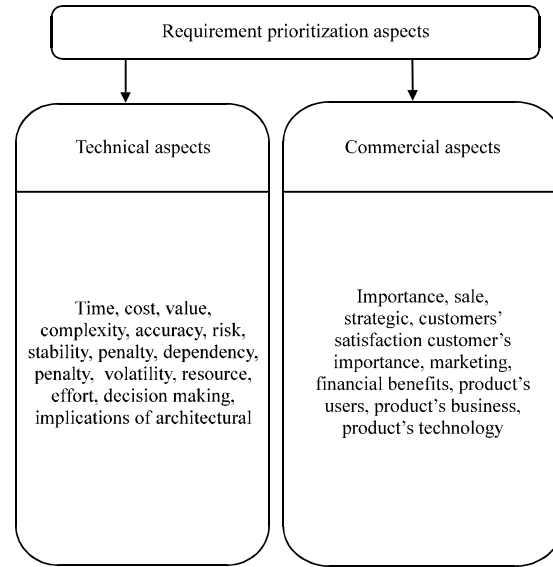


Fig. 1: Requirement prioritization aspect

is quite significant to the project development team. For example, prioritizing the requirement base on the complexity aspects will provide a clear view of the complexity range of each requirement in order to be implemented. Not only that but also the commercial aspects category cares more about the business and clients sides by allowing other stakeholders like customer to specify the most important requirements among others. This will also assist the development team to achieve the customers' satisfaction which leads to produce a successful project.

Technical aspects: The aspects of this category concern about technical factors of each requirement in the prioritization process. Used aspects of requirement prioritization that can be under this category are time, cost, value, complexity, accuracy, risk, stability, dependency, penalty, volatility, resource, effort, decision making, implications of architectural making (Berander and Jonsson, 2006).

Commercial aspects: Commercial aspects of requirement prioritization can be called as clients or business aspects as well. The main concern of commercial aspects is to prioritize the requirements based on the aspects or factors that affect the value of business and/or clients. The aspects that can be included in this category are Importance, sale, strategic, customers' satisfaction, customer's importance, marketing, financial benefits, product's users, product's business, product's technology (Berander and Jonsson, 2006). There is description of the common aspects from literature.

Importance: The importance can be presented as importance of requirement in term of the implementation, importance of requirement to the stakeholders, importance of requirement for quality of the produce and importance strategy of the organization. Therefore, specifying the meaning of the importance will minimize the conflicts that might arise during the prioritization (Berander and Jonsson, 2006; Sher *et al.*, 2014; Ahl, 2005).

Time: It considers the time that is needed to develop successful system based on the success implementation. The difficulties of implementation requirement and the staff training are the main factors the impact the time, since the complexity of requirement is high, the developers team will spend more time to implement it.

Complexity: The complexity aspects indicate the complexity of the requirement where the requirements will be prioritized based on their complexity of the implementation (Berander and Jonsson, 2006; Sher *et al.*, 2014).

Cost: Actually the cost is estimated by the organization which is entitled to developing the system. The major cost in system development is the number of hours (effort) which will be spent by organization staff in order to complete implementation of the system requirements. It includes the complexity of requirements and the extra resources that will be needed to implement the system.

Risk: Risk can be presented as the degree of likelihood that a project will fail to achieve its goals. When stakeholders do the prioritization process based on the risk aspect, each requirement will be prioritized based on its risk level which can be estimated in order to gain the risk level (Berander and Jonsson, 2006; Sher *et al.*, 2014; Achimugu *et al.*, 2014).

Penalty: It represents the cost of money which should be paid if requirement is not fulfilled. Thus, the organization should evaluate and estimate the penalty, since it is considered as grantee cost of not implementing the requirement (Berander and Jonsson, 2006; Sher *et al.*, 2014a, b).

Other aspects can be used to prioritize the requirement such as financial benefits, customer satisfaction and many others illustrated in Fig. 1.

Research questions: The aim of this study is to review, analyze, evaluate and summarize requirement prioritization aspects in the prioritization process of existing requirement prioritization techniques in order to provide

a clear view that supports the experts and software industry to enhance the quality of the software and techniques of requirement prioritization. To obtain this aim, the research questions of this study were formulated as following:

- RQ1: what are the aspects of requirement prioritization?
- RQ2: what are the aspects that are implemented by existing requirement prioritization techniques?

The RQ1 is designed to report, review and summarize all the aspects of requirement prioritization in order to differentiate and categorize them. Using RQ2 existing prioritization techniques are utilized based on the used aspects in order to find out the implemented aspects that will help to identify limitations of the requirement aspects based on the used aspects and providing future enhancements to improve the quality of software and existing requirement prioritization techniques.

MATERIALS AND METHODS

In order to address the above questions list, the researchers have used the methodology that is shown in Fig. 2.

The used methodology is comprised of six activities. Starting with the research questions which specify the area and the boundaries of this study. Then, searching for resource was conducted on the previous related search studies in various electronic databases resources such as Springer, SinceDirect, IEEE Xplore digital library, Google scholar and Web of science. While collecting and extracting data are performed from the published

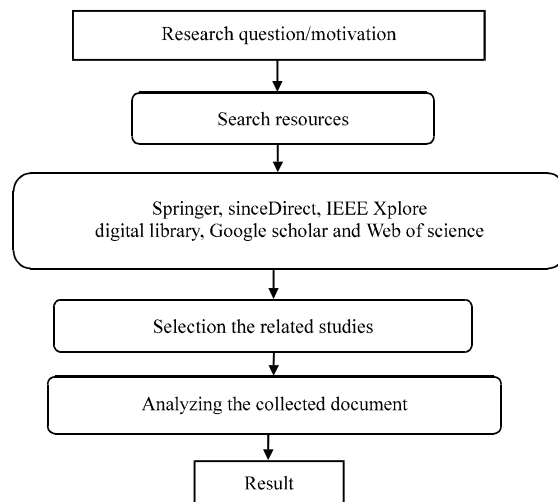


Fig. 2: Research methodology

conference, journal paper, books chapters. In the initial phase, 270 papers were retrieved and then 160 papers have declined after studying their titles and abstracts and removing the duplicate studies. The selection of the related studies is also conducted by considering only relevant studies based on the research questions and by considering the relevant search studies that were published before sixteen years. In order to produce the result, the studying of selected relevant studies is done by the researcher via analyzing and evaluating the existing requirement prioritization techniques based on the used aspects in the prioritization process.

RESULTS AND DISCUSSION

After studying and analyzing the collected data which include 110 primary studies, the outcome result of this study is presented in Table 1. It illustrates the most

existing requirement prioritization techniques with the used aspects in the prioritization process. Based on that critical analyze and evaluation of Table 1, the importance and cost aspects are the most significant and used aspects in the existing techniques. This is because, the prime aim of most existing prioritization techniques is to identify the importance of each requirement to the system’s users in order to estimate the expected users’ satisfaction (Berander and Andrews, 2005). This can be obtained by prioritize the requirements based on the importance aspect. Whereas it is essential for the project’s team to prioritize the requirement based on the cost aspect, since it will enable the project’s team to identify the order of the requirement based on the required cost value for each requirement to be implemented. Furthermore, most of the current existing requirement prioritization techniques focus more on the technical aspects like cost, time, risk than business

Table 1: Analysis of requirement prioritization techniques based on the aspects

Technique name	Citations	Used aspects in requirement prioritization process						
		Importance	Cost	Time	Risk	Penalty	Complexity	Other aspects
Numerical assignment	(Berander and Andrews, 2005; Babar <i>et al.</i> , 2015; Khan, 2006; Achimugu <i>et al.</i> , 2014; Vestola, 2010; Karlsson, 1996; Hatton, 2008)	*		*	*		*	
Ranking	(Berander and Andrews, 2005; Babar <i>et al.</i> , 2015; Achimugu <i>et al.</i> , 2014; Hatton, 2008)	*	*					
Top ten	(Berander and Andrews, 2005; Babar <i>et al.</i> , 2015; Achimugu <i>et al.</i> , 2014; Duan <i>et al.</i> , 2009)	*						
100 dollars or cumulative voting	(Berander and Andrews, 2005; Achimugu <i>et al.</i> , 2014; Vestola, 2010; Khari and Kumar, 2013; Voola and Babu, 2012)	*						Customer’s satisfaction, strategic
Priority groups AHP	(Achimugu <i>et al.</i> , 2014; Karlsson <i>et al.</i> , 1998) (Berander and Andrews, 2005; Vestola, 2010; Khari and Kumar, 2013; Babar <i>et al.</i> , 2015; Achimugu <i>et al.</i> , 2014; Karlsson <i>et al.</i> , 1998 Karlsson and Ryan, 1997; Karlsoon, 2007)	*	*		*		Decision	making
Cost-value approach	(Babar <i>et al.</i> , 2015; Aasem <i>et al.</i> , 2010; Karlsson and Ryan, 1997)	*	*					Marketing, sales, strategic
Hierarchy AHP	(Achimugu <i>et al.</i> , 2014; Vestola, 2010; Karlsson <i>et al.</i> , 1998)	*				*		Decision making
Minimal spanning tree	(Achimugu <i>et al.</i> , 2014; Khan, 2006; Karlsson <i>et al.</i> , 1998)	*						Decision making
Planning game	(Babar <i>et al.</i> , 2015; Ahl, 2005; Aasem <i>et al.</i> , 2010; Ramzan <i>et al.</i> , 2009)	*	*	*				
Binary search tree	(Khari and Kumar, 2013; Karlsson <i>et al.</i> , 1998; Soni, 2014; Ahl, 2005; Duan <i>et al.</i> , 2009)	*						Decision making
PHandler	(Babar <i>et al.</i> , 2015; Ramzan <i>et al.</i> , 2011; Ramzan <i>et al.</i> , 2009)	*						Decision making
Benefit and cost prediction	(Sher <i>et al.</i> , 2014; Lehtola <i>et al.</i> , 2004; Babar <i>et al.</i> , 2015; Achimugu <i>et al.</i> , 2014)	*	*			*		Customers’ satisfaction and decision making
Requirement uncertainty Prioritization approach	(Achimugu <i>et al.</i> , 2014; Voola and Babu, 2012a, b; Somerville, 1995; Berander and Andrews, 2005)	*	*					
Case based ranking	(Ramzan <i>et al.</i> , 2009; Berander and Lehtola, 2006)	*				*		
SERUM		*						
Evolve	(Achimugu <i>et al.</i> , 2014)	*						
Pair-wise comparison	(Karlsson and Ryan, 1997;	*	*					
Cost-Benefit Analysis Method (CBAM)	Achimugu <i>et al.</i> , 2014)							Benefit, schedule implications of architectural decisions

aspect. While, it is quite important to have a technique that can prioritize requirements based on technical and commercial aspect in order to balance the output list of ranked requirements for the development team and business/client side as well. Moreover, implementing some aspect in the prioritization process of any techniques can also be affected by the stakeholders' availability. For example, implementing the aspects like client sale, marketing, financial benefits, strategic and decision making create a significant need of participation of the highly professional analysts and experts in performing the prioritization of the technique based on their decision so the used of these aspects is not common in the current techniques. In addition, based on the finding on Table 1, the researchers observed that dependency constrains aspect has not been implemented with most of existing prioritization techniques, since majority of the existing techniques ignore the dependencies among the requirements even though the dependencies between the requirements have an important influence on requirement prioritization and software engineering activity. However, it is not easy to prioritize the requirement based on various aspects since one aspect can affect and impact another one. As result, it is extremely significant to figure out the conflicts among the used aspects during the prioritization.

CONCLUSION

Requirement prioritization is an extremely significant activity in the system development phases. Since, it plays the role key in identifying a stable set of requirement from other. Selecting the core requirements can be done via software prioritization techniques. These techniques performing the prioritization depend on various aspects of requirement prioritization. These aspects are studied and explained in this paper. Based on the findings of this study, importance aspect is considered as first of the most implemented aspect in prioritization process of the existing techniques. Followed by the cost aspect that is implemented by the most existing techniques. However, some of the existing requirement prioritization techniques prioritize requirements based on decision making, customers' satisfaction, time and complexity as aspects. These aspects require the supports of highly professional human like an expert during the prioritization process. Therefore, there is a need to eliminate the role of highly professional human by introducing the automated expert system to perform their roles. Moreover, Based on the given critical analysis and evaluation in Table 1 that

shows the majority of existing requirement prioritization techniques focusing more on the technical aspects such as cost, risk and time only in addition to lack of support for the commercial aspects. While, it is really essential that requirement prioritization techniques must balance between the commercial and technical aspects by including aspects from both categories in prioritization. Also, the researchers observed from the findings that most of the existing techniques do not handle dependencies among the requirements before prioritization. As a result of that, there is a need to cater requirement interdependencies, eliminate the involvement of experts in implementing the aspects and prioritize the requirements based on technical and commercial aspects to produce ranked list of requirements for development team, business and clients' side as well.

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REFERENCES

- Aasem, M., M. Ramzan and A. Jaffar, 2010. Analysis and optimization of software requirements prioritization techniques. Proceedings of the International IEEE Conference on Information and Emerging Technologies, June 14-16, 2010, Karachi, Pakistan, pp: 1-6.
- Achimugu, P., A. Selamat, R. Ibrahim and M.N.R. Mahrin, 2014. A systematic literature review of software requirements prioritization research. *Inf. Software Technol.*, 56: 568-585.
- Ahl, V., 2005. An experimental comparison of five prioritization methods: Investigating accuracy, easy to use and scalability. Master's Thesis, Blekinge Institute of Technology, Sweden.
- Babar, M.I., M. Ghazali, D.N. Jawawi, S.M. Shamsuddin and N. Ibrahim, 2015. Phandler: An expert system for a scalable software requirements prioritization process. *Knowl. Based Syst.*, 84: 179-202.
- Babar, M.I., M. Ramzan and S.A.K. Ghayyur, 2011. Challenges and future trends in software requirements prioritization. Proceedings of the International Conference on Computer Networks and Information Technology, July 11-13, 2011, Abbottabad, Pakistan, pp: 319-324.

- Berander, K.A. and L. Lehtola, 2006. Towards a research framework on requirement prioritization. *SERPS*, 6: 18-19.
- Berander, P. and A. Andrews, 2005. Requirements Prioritization. In: *Engineering and Managing Software Requirements*, Aurum, A. and C. Wohlin (Eds.). Springer, Berlin, Heidelberg, pp: 69-94.
- Berander, P. and P. Jonsson, 2006. Hierarchical cumulative voting prioritization of requirements in hierarchies. *Intl. J. Software Eng. Knowl. Eng.*, 16: 819-849.
- Duan, C., P. Laurent, J.C. Huang and C. Kwiatkowski, 2009. Towards automated requirements prioritization and triage. *Require. Eng.*, 14: 73-89.
- Hatton, S., 2008. Choosing the right prioritisation method. *Proceedings of the 19th Australian IEEE Conference on Software Engineering*, March 26-28, 2008, IEEE, Perth, Australia, ISBN: 978-0-7695-3100-7, pp: 517-552.
- Iqbal, M.A., A.M. Zaidi and S. Murtaza, 2010. A new requirement prioritization model for market driven products using analytical hierarchical process. *Proceedings of the International IEEE Conference on Data Storage and Data Engineering*, February 9-10, 2010, IEEE, Bangalore, India, pp: 142-149.
- Karlsson, J. and K. Ryan, 1997. A cost-value approach for prioritizing requirements. *IEEE Software*, 14: 67-74.
- Karlsson, J., 1996. Software Requirements Prioritizing. *Proceedings of the 2nd International IEEE Conference on Requirements Engineering*, April 15-18, 1996, IEEE, Colorado Springs, Colorado, ISBN: 0-8186-7252-8, pp: 110-116.
- Karlsson, J., C. Wohlin and B. Regnell, 1998. An evaluation of methods for prioritizing software requirements. *Inf. Software Technol.*, 39: 939-947.
- Karlsson, L., M. Host and B. Regnell, 2006. Evaluating the practical use of different measurement scales in requirements prioritisation. *Proceedings of the ACM/IEEE International Symposium on Empirical Software Engineering*, September 21-22, 2006, ACM, New York, USA., ISBN:1-59593-218-6, pp: 326-335.
- Karlsson, L., T. Thelin, B. Regnell, P. Berander and C. Wohlin, 2007. Pair-wise comparisons versus planning game partitioning experiments on requirements prioritisation techniques. *Empirical Software Eng.*, 12: 3-33.
- Khan, K.A., 2006. A systematic literature review of software requirement prioritization. Master's Thesis, Blekinge Institute of Technology, Sweden.
- Khari, M. and N. Kumar, 2013. Comparison of six prioritization techniques for software requirements. *J. Global Res. Comput. Sci.*, 4: 38-43.
- Lehtola, L., M. Karuppinen and S. Kujala, 2004. Requirements Prioritization Challenges in Practice. In: *Product Focused Software Process Improvement*. Bomarius, F. and H. Iidapp (Eds.). Springer Berlin, Heidelberg, Germany, ISBN: 978-3-540-21421-2, pp: 497-508.
- Ramzan, M., M.A. Jaffar and A.A. Shahid, 2011. Value based intelligent requirement prioritization: Expert driven fuzzy logic based prioritization technique. *Intl. J. Innovative Comput. Inf. Control*, 7: 1017-1038.
- Ramzan, M., M.A. Jaffar, M.A. Iqbal, S. Anwar and A.A. Shahid, 2009. Value based fuzzy requirement prioritization and its evaluation framework. *Proceedings of the 4th International IEEE Conference on Innovative Computing, Information and Control*, December 7-9, 2009, IEEE, Kaohsiung, Taiwan, pp: 1464-1468.
- Sher, F., D.N. Jawawi, R. Mohamad and M.I. Babar, 2014. Multi-aspects based requirements prioritization technique for value-based software developments. *Proceeding of the International IEEE Conference on Emerging Technologies*, December 8-9, 2014, IEEE, Islamabad, Pakistan, ISBN: 978-1-4799-6088-0, pp: 1-6.
- Sher, F., D.N. Jawawi, R. Mohamad and M.I. Babar, 2014. Requirements prioritization techniques and different aspects for prioritization a systematic literature review protocol. *Proceedings of the 8th Malaysian IEEE Conference on Software Engineering*, September 23-24, 2014, IEEE, Langkawi, Malaysia, pp: 31-36.
- Somerville, I., 1995. *Software Engineering*. 5th Edn., Addison Wesley, Boston, Massachusetts.
- Soni, A., 2014. An evaluation of requirements prioritisation methods. *Intl. J. Innovative Resour. Adv. Eng.*, 1: 402-411.
- Vestola, M., 2010. *A Comparison of Nine Basic Techniques for Requirements Prioritization*. Helsinki University of Technology, Espoo, Finland.
- Voola, P. and A.V. Babu, 2012. Interval Evidential Reasoning Algorithm for Requirements Prioritization. In: *Information Systems Design and Intelligent Applications*. Chandra S.S., P.S. Avadhani and A. Abraham (Eds.). Springer Berlin Heidelberg, Visakhapatnam, India, ISBN: 978-3-642-27442-8, pp: 915-922.
- Voola, P. and A.V. Babu, 2012. Requirements uncertainty prioritization approach: a novel approach for requirements prioritization. *Software Eng. Int. J.*, 2: 37-49.
- Xu, D.L., J.B. Yang and Y.M. Wang, 2006. The evidential reasoning approach for multi-attribute decision analysis under interval uncertainty. *Eur. J. Oper. Res.*, 174: 1914-1943.