The Neglected Challenge for Practitioners to Practice Requirement Prioritization Methods

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ABSTRACT

Background: Though the academic has been studying the requirement prioritization methodology, the industry still encounters challenges of the requirement prioritization in real world. Most academic models only study requirement prioritization under some limited contexts. Unexpected factors induce the challenges when practicing a requirement prioritization method.

Objectives: The objective of this study is to find what challenges to practice requirement prioritization methodologies commonly need to be improved or have been neglected.

Methods: We used systematic mapping study and interview-based survey. The systematic mapping study conducts the overview and generalization on the present requirement prioritization techniques in the academic. The survey does the interview on the actual status of practicing requirement prioritization in real world. The data of both methods is qualitatively analyzed by thematic analysis.

Results: Through the systematic mapping study on 17 articles, we found some characters common in the design of the academic requirement prioritization models, about the usual workflow step, advantage and limitation. Then through the survey with 14 interviewees, we studied what method the practitioner is most using and what challenge exists to practice the requirement prioritization in real world, mainly related to the workflow and limitation of these practical methods. Finally, based on the contrast of results above, we find what challenge for practitioners between the academic and practical methods worth to be improved or studied further. Besides, according to the acquired empirical insights, we proposed some potential future trends.

Conclusions: This study elicited the challenges and insights to practice requirement prioritization methods, which brings the value to inspire the industry for designing and applying more productive requirement prioritization method. Besides, based on the empirical result, we proposed 2 new definition (Practicable Requirement Prioritization Engineering and Modularized Requirement Prioritization Model) and 1 potential situation (Requirement Prioritization of Compounded-Business Software) worth to be studied for the future trend.

Keywords: requirement prioritization method, practitioner, practice, challenge, future

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CONTENTS

1 INTRODUCTION

Problem Domain &Others' Work

Many challenges are still available when applying prioritization method, according to the practitioner's feedback we have contacted ahead or the proposed articles we have studied. And also research articles that we have reviewed in related work do not adequately research challenges of "practice prioritization methods" as an independent topic, though they have studied the limitation of various requirement prioritization methods. Therefore, the actual condition when practicing a prioritization method in IT company needs to be studied as an independent topic from the view of the execution procedure of methods. By this way, the usability of a prioritization method can be studied further.

Firstly, though current researches have many contributions, there are still many shortages in the proposed methods. As the below deduction, it can be found that many unexpected challenges come out from some steps in the process of practicing requirement [35]. Many existing prioritization methods still suffer from some limitations including lack of scalability, rank updates during requirements evolution, requirements dependency issues, etc [1]. Many aspects may cause this, such as the applicability of current techniques in the complex and real setting has not been reported yet, or be evaluated very narrowly [1][2].

More specifically, for instance, methods acquiring the priority input by human intuitive estimation in meeting is also a challenge [40], like MERTS model [8], REPEAT model [9] and QUPER model [10]. However, holding meeting may cause many unexpected issues: firstly, if the design of meeting is not good, quality of meeting will not be good and affect the meeting output [3]; secondly, worldwide team distribution may also become a barrier on communication and affect the meeting holding [14]. As for the trend, it was identified in 2011 that current prioritization techniques do not provide sufficient automation for large-scale projects [11]. It can be found that the prioritization still encounters many defects, including but much beyond the discussed above, even though some articles proposed some likely advanced methods with utilizing the algorithm to save efforts, like machine learning [12].

Secondly, research articles we have studied focus on proposing a model and evaluating it in one specifically designed case, but such particular studies may acquire one-sided feedback. Because it is the trained researcher who conducts the study, they do not encounter unexpected challenges, just what have been planned for the specific case. Or they later find some unexpected challenges but they have to study these new challenges in the future. However, the practitioner cannot wait for new study and may be encountering these challenges from not-studied cases. For a representative instance, many tools for requirement prioritization and specification, like the object-oriented analysis and UML which has been discussed for decades, are accepted by the academics, but both are less commonly utilized, even if their reports emphasize its effect and easy-using [4]. Thus, research should be conducted separately under real industrial cases to find the gap between the practical usage and academic proposition.

Study Aim, Strategy & Approach

As above of both problems in this domain, this research article aims to deeply study the challenge for practitioners to practice requirement prioritization methodologies, by comparing the academic proposition and practiced methods. As well, the view of practitioner towards the academic proposition is the emphasis of this study.

However, the comparison among models is complex and it needs an effective analysis point for various methods. If we directly investigate the challenge, it will be too shallow to find some neglected challenges inside various models, because the design of models differs much. As well, practitioners we surveyed do not understand much their used methods.

The workflow step, in other words, "execution procedures", may reasonably be regarded as the main analysis point. The analysis point is based on a reasonable assumption that the practitioner when practicing the prioritization may more concern the usability of a method workflow stage instead of other aspects.

But to study the challenge from "procedure", the relevant advantage and limitation of the method also needs studying. Therefore, we study and refine the limitation and advantage and the procedure that these methods commonly have. The advantage, limitation and procedure that these methods commonly have and are refined into a developed theme are called "common characteristic". By this way of analysis, we split various methods into pieces of "common characteristic" as data extraction.

Then we can compare various models and analyze their characteristic to discover more potential challenges. To study the proposed academic methods, we use the systematic mapping study. To study the practitioner's method, we use the survey. As well, to better explore more insights from the literature and transcript, this research uses a relatively more formal qualitative analysis (thematic analysis) with "common character", based on the reference of the medicine and sociology, where the qualitative analysis is more stringently used for years.

Results

By studying the academic research and practitioner's method, the research contributes insights of neglected challenge to improve prioritization method practice and validate the study trend towards a beneficial direction. Then with these findings, we propose new definitions of concepts to assess the practicability of prioritization methods and inspire the future study. By above contributions, we hope this research could make the requirement prioritization play well the role it should have played well.

Overall in this study, firstly we discovered the "common character of proposed models", like common workflow stage and its relative common limitation of models by systematic mapping study. Secondly, we researched the "actual situation" in IT company by interview-based survey to identify what strategy, principle or process the practitioner actually is using. Finally, by comparing the result from above 2 steps, we found the insight and proposed new concepts to improve the prioritization practice.

2 BACKGROUND AND RELATED WORK

2.1 Background

2.1.1 The Basis of Software Engineering for Requirement Prioritization

To discover valuable findings, we need to study the requirement prioritization under a profound context and identify what factor is of most impact in the software requirement prioritization. Therefore, this study needs to review the basis of topic history, or the study may be lost in the countless contemporary cases. And this deduction shows why the requirement prioritization is worth to be studied further in software engineering.

The definition of software engineering can be "the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software [19]". In other words, the software engineering needs to utilize the computer technology and management experiences to cater the customer's real requirement. The software engineering is proposed by computer scientist and programmer to help solve the crisis of software. Therefore, we think this academic topic is very vital for the industry, or even for the society [21]. With following deduction, we find the requirement prioritization is an important section in the software engineering.

The classic research article of F Brooks[23] claimed there is no "silver bullet" to kill the challenge in software engineering: we can only mitigate the challenge in some extent. If the "amount of effective code line" is regarded as the most important productivity measurement, the productivity of software engineering cannot grow by more than one order of magnitude, because the "essence task" for human thinking cannot be reduced, even though the evolvement of tool much helps reduce "accident task" for coding [23]. In other words, the productivity of SE increases from eliminating the man-made barrier in "accident task", like more easy-using coding language, but thinking and design in "essence task" relies on human brain and cannot be improved much forever. Besides, though the "code quality" is also regarded as a vital factor in software engineering, human factor is still the key point if we try to discover something new.

Thus, the essence of software engineering can be considered as the "handicraft in workshop", much more relying on human resource, instead of the "industry in factory", much relying on mechanized manufacture facility. Therefore, some human-factors related to developer and customer in requirement prioritization have more impact than its existence in other industries and require more particular emphasis. Actually there have been some related subjects in this way of thinking, such as GM Weinberg's programming psychology[24] and BW Boehm's software engineering economics[25]. But they didn't much concern the requirement prioritization directly with this perspective.

Hence, it can be seen that "human factor" is the core of this area, and "requirement", the concept tightly related to human factor, must play a vital role worth to be studied in the whole software engineering.

2.1.2 Requirement Engineering and its Speciality in Software

The definition of requirement engineering can be a systematic and disciplined approach to the specification and management of requirements with goals: knowing the relevant requirement, achieving the consensus among stakeholders, understanding stakeholders and meeting the real needs[20]. But "requirement" actually has been much concerned more and longer under other more complicated contexts by other majors, like business analysis (BA) and user experience design (UX).

Firstly, now the software must more orient the UX to cater the market, which is under a very complex and hybrid context, but the latest study also finds the combination of UX design model and software requirement model both not integrated well [28]. Secondly, we also find the "Business Analysis" has been much more studying "applying requirement analysis on real world", and many knowledge and models in software engineering actually comes from MBA, the original major of "Business Analysis" [29]. Actually, we found that many companies let the product manager do the job of UX design. As well the requirement prioritization can be conducted by various stakeholders, especially business analyst, customer and manager. That means the job related to requirement including prioritization must be participated by various stakeholders and various scopes.

However, besides multiple scopes beyond software, the requirement prioritization also needs to consider the software engineering, like testing, engineering management, engineering process, maintenance and etc [21]. This proves the particularity of requirement prioritization in software engineering that the requirement requires to be prioritized with the consideration to development as a vital factor.

2.1.3 Software Requirement Prioritization and Its Importance

Generally, the requirement prioritization of software engineering selects the requirement more important into a release for minimizing risks or achieving goals during development. In IEEE SWEBOK [21], the requirement prioritization is classified under the phase of "analysis". The "classification" in requirement prioritization analysis concerns the "priority value and category" of a requirement and the "negotiation" concerns "resolving conflicts". Both "classification" and "negotiation" in requirement analysis support the "prioritization". Fundamentally, the requirement prioritization more resolves the trade-off on conflicts among many aspects: relative requirements, stakeholders, market organizational goal, environmental resource and etc.

The prioritization can be a vital step highly involved with other steps: elicitation, specification and validation during the software requirement engineering, because it applies the accumulated results from other steps. For instance, many models of requirement engineering require to prioritize the elicited or specified requirements to utilize limited resource. Thus, the challenge of requirement prioritization cannot be mitigated as an independent issue.

It has been mentioned above that the "human factor" has big impact in every phase of software engineering, especially the requirement engineering. Also, the challenge of requirement prioritization actually is much related to "human factor", like stakeholder cooperation. For instance, some requirement can be prioritized to be postponed and get into an obsolete state during the development, which is no longer required for the current or future release [30]. The obsolete requirement induces the requirement dependency complex. The inconsistent and ambiguous requirement can become obsolete. Under some cases, requirements proposed by expert are less likely to become obsolete than requirements originating from customers or (internal) developers [30]. For another instance, over-scoping prioritizes too many requirements that cannot be implemented. At the early project phases, low involvement from the development-near roles in combination with weak awareness of overall goals may result in an unrealistically large project scope [31]. Both challenges in requirement prioritization are typical instances strongly relevant to "human factor".

Besides, the context of requirement engineering now is market-driven and large-scale according to the reviewed thesis. The requirement engineering also has to last continuously during development because the change of requirement costs more and always happens. Under this situation, the

requirement prioritization in the academic or practice must concern more aspects. How vital the requirement prioritization is and what challenges the requirement prioritization encounters are specifically discussed in the following related work.

2.1.4 Contemporary Challenges in requirement Prioritization

Here, we conclude the contemporary condition of requirement prioritization based on the related work. More details of evidence, please see the 2.2 related work.

The first challenge originates from the method difference. People find the fine-grained pieces of information do not match the description in literature, which might be related to the project environment characteristics [22]. In addition, the implementation functions in methods are diverse and company don't know which one is the best. Since different system has different characteristics, include external validity (different characteristics) and construct validity (such as different position distance or time performance) [26].

The second challenge is thinking about risk of stakeholder. People find that stakeholders or developers have insufficient understanding of needs and domain knowledge could leads to failures [16]. Sometimes, too tight time will cause the communication deficiency between stakeholders and developers. On the other hand, the customer don't know the technology opportunity exist, so that they can't achieve the accurate data and use their subjective awareness to judge [18]. To solve this, the article [11] thinks the future trend of the technology in software prioritization will be the method automation, because now conducting a complex priority calculation relies on the expert, but needs various stakeholders, including the group not understanding this prioritization method.

As well there are many challenges concluded from the literature review, which can help study a lager range of challenges. The article [40] reflects that many assumptions of prioritization approaches in agile development do not hold all the time: the role of client has balanced interest with developer, or the client will not be helpful to prioritization; subjectively estimating the value input of requirement priority is questionable; the practice of prioritization varies cross projects with the various project characteristic, like size of client organization. These challenges are depicted by article [41] in another way: prioritization is an ambiguous concept, informal, dependent on human, concerning too many factors, not understanding clients and involving many phases.

The article [42] thinks most of the studies focused on techniques and methods, while "higher views" on the prioritization processes are less covered. Prioritization approach practice needs to be evaluated more to give recommendation on future study. This article [42] finds that the research needs to provide: more details of the context, and broader discussion on method attributes, including not only just accuracy. Its findings about prioritization evaluation is valuable, so this kind of topic is worth to be studied further.

But these literature reviews do not concern the "execution procedure" for the approach usability, or do not provide empirical research to compare the practitioner's applied methods. This may induce to neglect challenges that affect the practitioner to adopt a prioritization approach.

2.2 Related Work
2.2.1 Current Technology
There are so many techniques now. In article [27], the authors compared with three RPT(requirement prioritization technology): ENA(Extensive Numerical Assignment), NA(Numerical Assignment) and

AHP(Analytic Hierarchy Process), through a control experiment for determining the champion RPT according to several objective and subjective measures, such as number of decisions required, time consumption, scalability and prioritization, Etc.

According to the experiment in article [27], the result shows that ENA is superior to NA and AHP. ENA is an effective, informative and trustworthy method. It helps to make a decision under uncertainty and incompleteness. It can be suitable in small as well as large projects. In small projects, it can warrant the relevance as different users carry different interpretations of different requirements, which seem to increase the confidence among the users. It also be adaptable of the large projects for modeling uncertain predictions.

Of course, there are some other models, like MERTS model [8], REPEAT model [9] and QUPER model [10] that we have mentioned. They utilize a statistical decision algorithm or a concept workflow of analysis to help give priority on requirement, even though some of them only support the analysis on priority factors. The design of them cannot be illustrated definitely with a few words but need a wider and deeper range of study.

2.2.2 More Challenges and Methods

In article [18], the authors use data collection practice to help identify the practice challenge in 5 software development companies, and they introduced a model to help company use system approach to collect customer data. In practicing usage process, although companies all have well-established techniques for collecting qualitative customer feedback in the early age, they find the customer don't know the technology opportunity exist when they communicate with customers. In addition, the company also lacks the skills of validation of qualitative feedback. As company cannot achieve the accurate customer data, they will choose their optimism idea to make decision (open loop problem). Since lack of validation for the usage of feature, it will lead company convinced that numerous of requirement which are never used and no need to be proved to the customer. On the other hand, the implement way of feature is variable, they don't know which alternative is the best one to implement.

In the article [17], This approach still has drawbacks in practice, rating priorities may not accurately reflect the expected ranking order of requirements. Because mathematical normalization can lead to mathematically correct but intuitively incorrect priorities.

The article [16] studies what situation cause the requirement practice not working well in China and has good implication to the global. It finds that the shortage of stakeholders' or developers' understanding to the requirement and domain knowledge causes the failure. Also, the design reuse in wrong context, users' understanding change leading to requirement change, and too tight schedule leading to insufficient communication between users and developers, all are problems. The improvement can be related to developing requirement tool, making the customer feel ownership, combining more thinking into process management, like communication, documentation and change control. Thus, it can be found that the situation of the practice of requirement engineering in different countries could be diverse.

The article [17] propose a two-step prioritization approach based on a decision theory model, it helps reducing the communication overhead through decouples MMF (Minimal Marketable Features) prioritization form individual requirements; when the individual requirement changed, it will helps people to gauge the MMF prioritization for decrease the overhead. More importantly, it provides a critical preclude which could be used as input for lean/agile and Kanban development processes, this

could highly reduce the coordination and transaction costs so that the team could mainly focus on the negotiation. This method is analyzed by changing the target weights and assessing the impact of priority requirements. This allows the team to determine which projects have high business value or high risk. It helps us understand the target weights and has a clear understanding of how to use weights to sort.

The article [11] specifies the challenge and trend of the prioritization technique. In terms of challenge, most techniques are not scalable and their evaluation is under small scale project. About the future trend, the current model is insufficient automatic.

In article [22], the author uses GT to acquire a conceptual model that explicates the requirement prioritization in agile projects. This model helps to determine and classify the best practice and investigate the fitness of different requirement prioritization approach. The author finds the practice challenge that their fine-grained pieces of information is not often agree with description in literature, and they find the important concepts of requirement prioritization are different, it seems related to the characteristic of project environment.

The article [26] proposes an interactive approach. It helps to finding an order relation among requirement through interactive knowledge acquisition. The main threat to the validity of their case study is external validity, the author finds their findings are not very appropriate to the other cases, because different cases have different characteristics. The other threat concerns the construct validity, for instance, different of the position distance or time performance.

3 METHODOLOGY

3.1 Aim and Objective

The overall aim of this study is to find what challenges to practice requirement prioritization methodologies commonly need to be improved or have been neglected with the contrast of the academic proposition and practice research on the practitioner's method applied in IT company.

As our discussion in introduction about the overall aim towards challenges in "practice", the study emphasis has to incline more to the "execution procedure" to narrow down the study point.

But to study the challenge from "procedure", the relevant advantage and limitation of the method context also needs studying. The advantage, limitation and procedure that these methods commonly have and are refined into a developed theme are called "common characteristic". By this way of analysis, we split various methods into pieces of "common characteristic" as data extraction. Then we can compare various models and analyze their characteristic to discover more potential challenges.

Besides, though the practitioner may not use any proposed method in research article, this does not matter because the contrast of academic and practiced methods analyzes the usability of workflow of various methods.

Thus, sub-objectives are as following:

> a. Refine the common characteristic of proposed prioritization methodologies from the view of how to practice, such as their execution procedure.
>
> b. Research actual condition when practicing methods of requirement prioritization in IT company, like what barrier comes out when using a prioritization method.
>
> c. Discover the potential challenge to practice a prioritization method in IT company by comparing academic proposition and practiced prioritization method, from the view of "execution procedure".

3.2 Research Question

Description of Questions

For our study, we try to discuss the "execution procedure" to find the challenge of practicing requirement prioritization model. Firstly, we need to understand the common character of each model about its execution procedure. Secondly, we need to figure out the real status in practicing requirement prioritization. Lastly, we need to find the challenges cross various models. To be noticed, the sub-aspects under one research question are detailed points to be studied, which can give the origin view of thinking, instead of question to be answered.

Question Motivation

Both following points indicate that this question design more suits the overall aim to discover neglected challenges of prioritization practice.

Firstly, we study the "execution procedures", because when practitioners practice a requirement prioritization method, inherently they will more care about the usability of the workflow stage of a model, instead of the method context or others. So here we from the view of execution procedure study the "common characteristic".

Secondly, here, the "common characteristic" is defined as the workflow stage, advantage and limitation for practice usage that various methods commonly have. It is derived by the thematic coding. It helps understand massive details of various methods.

At the beginning of study, we cannot identify which procedure or limitation are the cause of challenge. Besides procedure, many other aspects need study. Therefore, by studying the "common character", we can split the detailed design of prioritization method into the "common characteristic". This makes it clearer and more effective to extract the key information and compare various methods for more neglected challenges. Specifically, if we don't use the "common character", the data cannot be extracted effectively by research question 1&2, and therefore the contrast between the academic and practice in research question 3 will have no effective evidence support from research question 1&2.

Questions Design
- **RQ1.** What are the "common characteristic" of the proposed requirement prioritization model or methodology from the view of execution procedure?

By discovering common characteristic among available articles from the view of "execution procedure", we can identify what current articles can reach, so further to discover what issue of it worth attention. Though there have been many articles to review requirement prioritization approaches, the execution procedure and relevant challenge are not detailed enough to help this research. Thus, we will study this question from following aspects:

    1.1 The execution procedure of proposed requirement prioritization models and methodologies.
    1.2 Refine and summarize the academic evaluation to proposed models, like their advantages, disadvantages and etc., also about execution procedure.
    1.3 The common characteristic in these proposed methods and models (like design, execution step or shortage), which will be refined and classified.

- **RQ2.** What is the actual status in the real world when practicing requirement prioritization?

Many practitioners we contacted do not use any method fully from research articles. Therefore, we need to investigate the real condition of the practicing requirement prioritization in IT company, such as what method they are using practically, which proposed model has been used or referred to more often, and how the reference is adapted or tailored for practice. And this can prepare for the further contrast and analysis to reveal more. Thus, we will study this question from following aspects:

    2.1 The currently applied methods in IT company to practice requirement prioritization.
    2.2 Models that practical methods are based on if they have references, and if so how these practical methods tailor the model basis for better execution.
    2.3 Refine and classify the common characteristic of the practical requirement prioritization methods in IT company, from the view of execution procedure.
    2.4 Refine and classify the feedback towards these practical prioritization methods in IT company, related to their advantages and disadvantages in execution procedure.

- **RQ3.** What challenges are the models or methodologies of requirement prioritization suffering from when to practice them in IT company?

With comparing the neglected gap between the academic and practical method, we can find more neglected challenges, like disadvantages, advantages and workflow design in proposed methods, to acquire a valuable discussion for better practical execution. Though some methods applied by

practitioner may not follow the academic proposition, this does not matter because the contrast among academic and practiced methods analyzes the design detail of various methods from the workflow procedure and usability evaluation.

Because this question is important to achieve the aim 3, it needs to be analyzed and discussed mainly from the view of "execution procedure": we will compare the similar procedure between the academic and practitioner methods, and then find the relevant practice challenge of this execution procedure worth to be studied further.

Thus, we will study this question from following aspects:

3.1 The gap of prioritization method between the academic proposition and real practice, such as what different emphasis between the academic methods and workshop practice.

3.2 The potential challenge worth to be studied further to discover more unknown, such as one bad design in prioritization method may cause bad impact.

3.3 Expected Outcome

1. The grid refining and classifying the proposed requirement prioritization methods in academics based on their execution procedure. (RQ1)

2. The research and its analysis on how in IT company to practice requirement prioritization methods and models. (RQ2)

3. The current and potential challenges in the execution procedure of practicing a requirement prioritization method in workshop by comparing the gap of execution procedure design between the academics and practical methods. (RQ3)

3.4 Method Design

We plan to use systematic mapping study and interview-based survey. The systematic mapping study can structure a research area, because its aim is through classification and counting contribution to overview the study area for scope generalization [5]. The survey collects information from people to describe, compare or explain their knowledge for industrial practice research [6], which is suitable for our research objects. As for analysis plan, we use qualitative analysis to generalize the scope and find the point to study.

Specifically, we design the questions in the survey based on the understanding from mapping study. But the data output of survey cannot be predicted and some unexpected findings may come out. Especially, the practitioner may not use any method from academic proposition and this may induce it tough to compare the academic and practiced method. Therefore, we study the detail of interview and academic mapping study mainly from the workflow design. Through this way to narrow down the detail, we can find more potential challenges to practice requirement prioritization method.

Figure1. Method Design
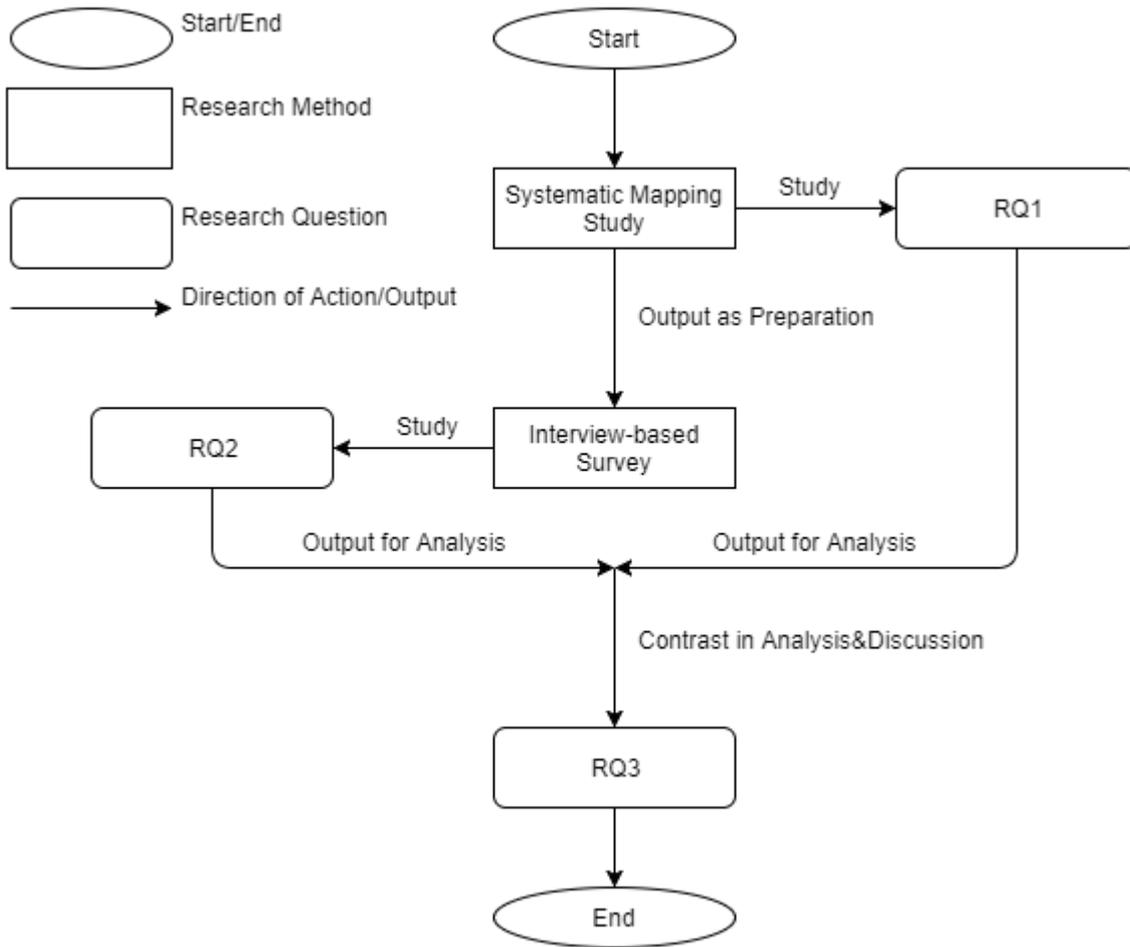
3.5 Systematic Mapping Study
3.5.1 Motivation and Comparison
Motivation of Usage
To study the research question 1, the scope of proposed methods needs overview and synthesis from primary studies. So we choose systematic mapping study because its main goal gives an overview of a state-of-art or state-of-practice of an area [6]. By the area overview of mapping study, we can identify what current researches have studied and then further discover what detailed issues are worth attention.

As the research question 1 needs a more detailed study on prioritization method, we need to do our own systematic mapping study by using the "common character" as the analysis point. Specifically, to discover potential challenges of prioritization practice, we need to compare various methods among the academic and practice to generalize the common character. But per individual method differs much from others, so the comparison is complex without an effective analysis point. Therefore, we need to split the design of model into very detailed pieces as the data extraction and then study the extracted data. As a practitioner may more care about the usability of method workflow than other aspects when practicing a method, we set the "execution procedures" as the main point to start the analysis and data extraction.

Why It's of SMS
The literature review is of SMS not SLR though it is conducted mainly by extracting data rather than classifying articles, because its necessary qualitative analysis is in a shallow extent and SLR needs more stringent analysis. Specifically, because of the above study tactic, some qualitative analysis

methods are required to classify the method procedure and limitation into "common character". But here the qualitative analysis methods are still used in a shallow extent, just fitting the area overview from the view of "execution procedure". Therefore, the systematic mapping study is more reasonable than the systematic literature review that needs more stringent analysis on the data extraction from primary studies [6].

Particularity of This SMS

Obviously, this SMS does not intend to study per model thoroughly by literature review like what others did. By the "common character" analysis, this SMS can conduct the qualitative analysis on large range of models and their design detail, because the "common character" actually, generalizes data into higher abstract-theme level to reduce the data amount, like a phrase naming similar procedures. This makes it possible to effectively compare the academic and practitioner's methods. Otherwise, our work is repeating others.

Comparison of Other Studies

There is no article that can perfectly answer the research question 1. This way of study needs more close understanding to the design of some representative models, but many literature reviews on our topic, like research article [1], [15] and [42] only provide the general synthesis with no detail of method design, which is not helpful enough for us. Some empirical articles in the related work, like [40] and [41], study the scope of prioritization method practice, but the challenge of practice is not studied in enough depth to find the reasonable correlation. This can be studied from the view of "execution procedure" by our article.

As well, these existing articles are good. We use them as seed reading in the related work to understand the topic and find more relative articles. This way can augment the findings of these articles with our particular perspective, "execution procedure".

Comparison of SLR

We choose mapping for the 1st research question, instead of systematic literature review, because here the 1st research question needs overview and classification on the topic from the particular perspective, "execution procedure", and mapping study more fits this situation. Specifically, the systematic literature review is more appropriate to prove more specific questions by rigorously extracting data from primary studies, such as "whether method A is better than method B" [13], instead of "area overview and classification from a particular perspective".

3.5.2 Description of Conduct and Analysis

Based on the guidelines in article [5][6], our steps of systematic mapping steps are as the following. Please see the figure 4.
1. Specify the search string related to the topic and search them to database.
This actually design the searching strategy for research article collection, such as what key word can get most full searching to this topic, what database possesses academic authority, like IEEE, ACM and Scopus. This constructs the prerequisite to conduct the studying.

2. Set the selection criteria of inclusion and exclusion to select primary studies.
We read title and abstract and use the "inclusion & exclusion criteria" to filter the selected article. Among the searched research article, based on what to collect or eliminate research article, like the publish year, study type, context not meeting our question, etc. This ensures the data away from bias

but also broad enough to answer research question. If it is needed to understand the context, we may conduct backward snowballing briefly in one iteration to add articles [33].

3. Assess the quality of the primary studies.

We read the content of articles and use the quality criteria to assess and extract the article content. The quality criteria are the guide to extract relevant data from selected primary studies, which can also help understand the limitation of each article. As well, if the study quality is part of the selection criteria, the quality assessment may lead to some primary studies removed [6]. The most practically useful mean for assessing good research article is checklists [5][6], which contains of more detailed criteria, like data validity, case context. But the guideline [45] identified that "quality assessment should not pose high requirements on the primary studies as the goal of mapping is to give a broad overview of the topic area". So, 2 researchers will set assessment question for peer review to avoid biased and poor research article, instead of using rigorous mark criteria.

4. Extract the data into the form appropriate to analyze the question from selected research article.

Specifically, we will collect the data about: the customer evaluation/feedback to method in research article, step process, equation of weight calculation, time cost of usage, human cost of usage and etc into grid and list. These data can help answer RQ1 because the data can depict the situation about the aspects of RQ1. And we both will assess whether the form of extracted data can answer the 1st question.

5. Conduct the synthesis and analysis on collected data to acquire beneficial discussion.

Based on the outcome of both the mapping and survey and with our increased understanding, we will use multiple techniques of qualitative methods, by a formal thematic analysis with some reference. More details are further illustrated in section 3.7 and 4.1.

3.6 Interview-based Survey
3.6.1 Motivation, Data Collection and Comparison
Motivation

Survey is more fits the aim of research question 2 to discover practical challenges under a wide range of practitioner's project experiences. This is because Surveys are conducted when the use of a technique or tool already has taken place or before it is introduced [43]. Survey can be identified as "a system for collecting information from or about people to describe, compare or explain their knowledge, attitudes and behavior" [37]. Specifically, the survey is aimed to analyze the result to acquire descriptive and explanatory conclusions, which is generalized to the population from which the sample was taken [7]. For instance, by interviewing 25 developers, the population of 100 developers can get assessed [6].

There are 3 objectives of conducting a survey: descriptive, explanatory and explorative [6]. In this study, this survey is explorative, because this survey does not answer the basic question, but provides new possibilities worth to be studied further, by creating a loosely structured questionnaire and letting a sample from the population answer it [6].

Interview vs Questionnaire

Based on guidelines [7], our survey is a small-scale interview-based survey for 2nd research question instead of the solely questionnaire-based survey, because the interview-based survey can get deeply understanding, more appropriate to the 2nd research question of deeply researching the workshop for qualitative analysis, while the questionnaire is to depict the trend by quantitative analysis and requires

a large amount of samples. In this way, the actual situation can be studied deeply enough and therefore it answers question 2.

Semi-structure vs Unstructured vs Fully-Structured
The survey can be conducted in semi-structured interview to get detailed answer under any interview condition, because this way ensures the trade-off on changing question checklist dynamically for deviation, such as appending questions based on different answers to discover more [7]. By contrast, fully-structured interview more fits the questionnaire of large scale sampling [7]. Then we conducted it via social-network and face-to-face. In terms of the question design inside this, we can refer to the outcome of systematic mapping study to design the question.

Comparison of Case Study
With the contrast of case study, the survey can be found more appropriate to our study overall goal regarding the challenge of practicing requirement prioritization method, because the study goal of survey is purer to study the explanation of data for a conclusion.

Firstly, the case study should be contemporary with studied project at same moment, while survey study the projects before or after the project execution [6]. This is because in the essence, the case study is similar to the experiment, but the other factor of context is out of control [6]. It is observational and of less control than experiment. Its context depends on the actual project. Projects that the research question 2 needs to study are not contemporary with our study. Thus, survey suits more.

Secondly, the objective of research question 2 needs to discover challenges under a wide range of cases. Survey can systematically collect information from population, but the case study is limited in one specific context of case. In case study, the data is collected for a specific goal to track specific attributes to then build their relation, like building a model to predict the number of faults in testing [7][38]. The guidebook [7] identifies the case study as "an empirical method aimed at investigating contemporary phenomena in their context, especially when the boundary between phenomenon and context cannot be clearly specified" [36].

Specifically, in our study, various academic models and interviewees gets evaluation under various contexts, so it is one-sided to study various models under a specific context. Also, the phenomenon and its context in the evaluation of a proposed requirement prioritization model most are divided definitely, like a prioritization method for various sizes of companies or various business. Actually, besides the diversity of our studied academic models, our interviewees come from worldwide and various business. If the analysis point, "challenge to practice requirement prioritization method", can be regarded as the case, we will need to involve various contexts for the study conduct, which aggravates the internal validity about the data analysis isolated from context, which is described in section 3.8.

Thus, it is better by survey to purely study the practical usage of requirement prioritization method without concerning the method context.

3.6.2 Sampling and Question
The sample strategy is based on the non-probability sampling: quota sampling and the convenience sampling, because the probability of sampling selection is unknown in this study [6]. Quota sampling

is used to get subjects from various elements of a population, and convenience sampling normally get the nearest person as subjects for each element [6].

We pick the sample from the background appropriate to the study. Specifically, the interviewee can be the product manager and programmer from software company, which is regarded as both population elements of the quota-sampling. The product manager most understands the product in multiple views, like business and customer requirement [32]. Programmers work on the frontline and have the professional knowledge, so they can deeply understand the design and development of software from the expert view. As for the convenience sampling, under the selection of product manager and developer, we select the nearest and most convenient person, so as to avoid the probability of subjects limiting the range of interview selection, because our study goal inherently cannot be restricted by irrelevant contexts [6].

We hope the question could collect the data from them about: what strategy, principle and process the practitioner uses to cater the requirement priority under uncontrollable real situation, because some programmers told us they don't know what model they refer to for requirement prioritization. Most time they just apply some principle and strategy because a model cannot be executed efficiently in real case. Thus, the interview transcript can include the data about "how the practitioner deals with requirement prioritization", "how they tailor the model to apply", "if not knowing what method is called, describe the method" or "how do they feel about these methods". We will analyze the data mainly by thematic analysis (see details in section 3.7 and 4).

3.6.3 Description of Conduct and Analysis
Steps are as following:
1. Select the targeted population according to the research question
On step 1, we need to select suitable population class as the interviewee, such as experienced programmer or project manager under different company cases. Otherwise, interviewing the practitioner with limited working experiences will acquire the biased information.

2. Select the sampling strategy to choose the interviewee
Selection of sample subjects is closely connected to the generalization of the results [6]. Here to ensure the research on industry deep enough and away from risk of trivial interview, we choose the convenience sampling, because it is a non-probability sampling, which can more enjoy a small survey, like saving our efforts from contacting interviewee to focusing on studying question [7].

3. Formulate the initial question draft
On step 3, the interview question should be designed close and friendly to the subject's case, so that we can gather deep and real information for corresponding research questions. The question can be designed both extremely general and detailed in this phase to reveal our thinking conflicts, such as "what method your company is using practically?", "which proposed model has been used or referred to more often?", and "how the proposed model is adapted or tailored for practice?", "how the customer assesses the output of your method?", "what barrier exists when using your methods?", or "what is the cost of human, time and money on your method".

4. Test the question draft in a few interviewees and revise the question
On step 4, through asking the initial question to some interviewees, we can polish the questionnaire based on the acquired data, such as eliminating ambiguous and too general question, altering the range of interview content too limited and shallow.

5. Carry out survey and collect data

On step 5, we conduct the interview-based survey on the samples, but during execution we may still update the question for better structured interview according to our collected data. And this can last in a relatively longer duration for outcome quality, parallel with other activities.

6. Code data and analyze

On step 6, the data will be extracted and coded for thematic analysis or quasi-statistical[7] approach as the initial data synthesis, so that later with comparison in qualitative and quantitative analysis, we could conclude the common characteristics and discover potential findings about practicing the requirements prioritization method in workshop. And this will also help analyze research question 3 with combining the data from research question 1. More details are further illustrated in section 3.7 and 4.1.

3.7 Analysis Method

To prove the rationality of researched outcome, the rigor of analysis method should be illustrated as the following.

3.7.1 Usage Motivation

Reason to Choose Thematic Analysis

The choice of method depends on the aim of the study [48]. The thematic analysis is our main analysis method, because the "common character" in research question 1 and 2 needs to analyze data of various models. The thematic analysis can generalize data into higher abstract-theme level to reduce the data amount and support large scale qualitative analysis, which the research question 1 and 2 needs. The generalized data can be the abstraction of phenomenon. Besides, to effective analyze the "common character" and the view of "execution procedure", we need to use a more formal qualitative analysis on literature or transcript in software study.

Thematic analysis is a method for identifying, analyzing, and reporting patterns (themes) by data [46]. It aims to minimally organize and describe the data set in rich detail and frequently interprets various aspects of the research topic [47], which is just what this study requires. In this study, thematic analysis method is to group the key information into a label as a theme, which directs the thinking into one study goal [7].

Reason to Use Qualitative Analysis

Firstly, the qualitative analysis is much more appropriate for our study than the quantitative analysis. The guide book [6] and [7] give the following understanding. The qualitative analysis suits this situation: if the study concerns the real-world phenomenon and try to extract this phenomenon into the form for the purely academic thinking, we have to deal with the data collected from the real world and identify a study goal from the context view. However, the quantitative analysis is more appropriate to study the subject under a purely assumed context, such as proposing an algorithm theory and analyzing the massive data of its experiment on computer virtual environment. If we used quantitative analysis in our study, we would collect much more data, but the data extraction could not eliminate extra useless factor from real world in the data.

Specifically, the thematic analysis can extract the valuable data into classification theme, which is useful to analyze both interview transcript and the result of mapping study. Firstly, the mapping study just makes the overview of the area by synthesis and generalization, whose data form is complicated and not massive. Therefore, we need to code the data, but the data amount is not high enough to

support the quantitative analysis. Secondly, the information of interview requires to be extracted from human-speaking transcript into a more researchable and structured form of scientific language. Therefore, the thematic analysis can code the key words into the theme appropriate to think and analysis the study goal.

Overall, the data extracted from research article synthesis and interview transcript is not in the structured form. Therefore, only the qualitative analysis can suit this condition.

3.7.2 Choice Comparison
Comparison to Grounded Theory
The aim of grounded theory is to develop a new theme classification on extracted and coded data as a new theory [7] [49], which does not fit the research aim. But in this study the research aim only needs to minimally organize, describe and interpret the data set by thematic analysis, rather than develop a new theory of data category by grounded theory. The grounded theory, regarded as a version of thematic coding, codes the information, such as the interpreted term in texts, based on the interaction across these data so to conclude a new classification of similar concepts [7].

In terms of conduct, the grounded theory needs 3 level coding to develop a new category theory: opening coding, axial coding and selective coding [49]. This is not what the research aim needs. The research only needs to organize the extracted and coded data into the specific priori-theme (theme determined in advance of coding [50]) to analysis the research question

Comparison to Content Analysis
Content analysis is of quasi-statistical approach [7]. It aims to build a model to describe the phenomenon in a conceptual form [48]. It does not fit the research design. But the research question only needs to categorize the extracted data into "common character". The Quasi-statistical approach uses word or phrase occurrence and inter-correlations to determine the relative importance of terms and concepts [7].

In terms of conduct, the content analysis needs the abstraction phase to formulate a general description of the research topic through generating categories [48], which does not fit the research aim. This research question about "common character" only needs the minimal data classification to support the question analysis and illustrate the studied phenomenon. The abstraction phase constructs a model to describe the phenomenon to generate 3 layers: sub-category, generic category and main category [48], which is similar to grounded theory.

Comparison to Other Studies
The trial of using a more formal qualitative analysis on literature or transcript in software study can be a kind of contribution, because all articles in the related work does not use the qualitative analysis method in a very stringent and definite way to study the software engineering scope. In fact, the reference of qualitative analysis method that we have read more comes from the medicine and sociology.

3.7.3 Operation Strategy
Conduct Description
General Description
The thematic analysis is conducted mainly according to the guideline [46]: formalize data, code data, categorize the coded data into themes, name themes and report the discussion. Meanwhile, because

there are "common character" defined in the research question, the priori-theme (themes determined in advance of coding [50]) is set as the table-column definition of data extraction table, so to instruct the theme classification of coded data. It works like the "categorization matrix" in the deductive content analysis to group the correlative data in the category the research requires [48].

The analysis workflow is illustrated in the following workflow figure. The more detailed practice of analysis and extraction on data is described in the Appendix, section 4 and 5. The first 3 procedures of workflow is mainly conducted in section 4, and the "report discussion" is in section 5.

Figure 2: Analysis Workflow Figure
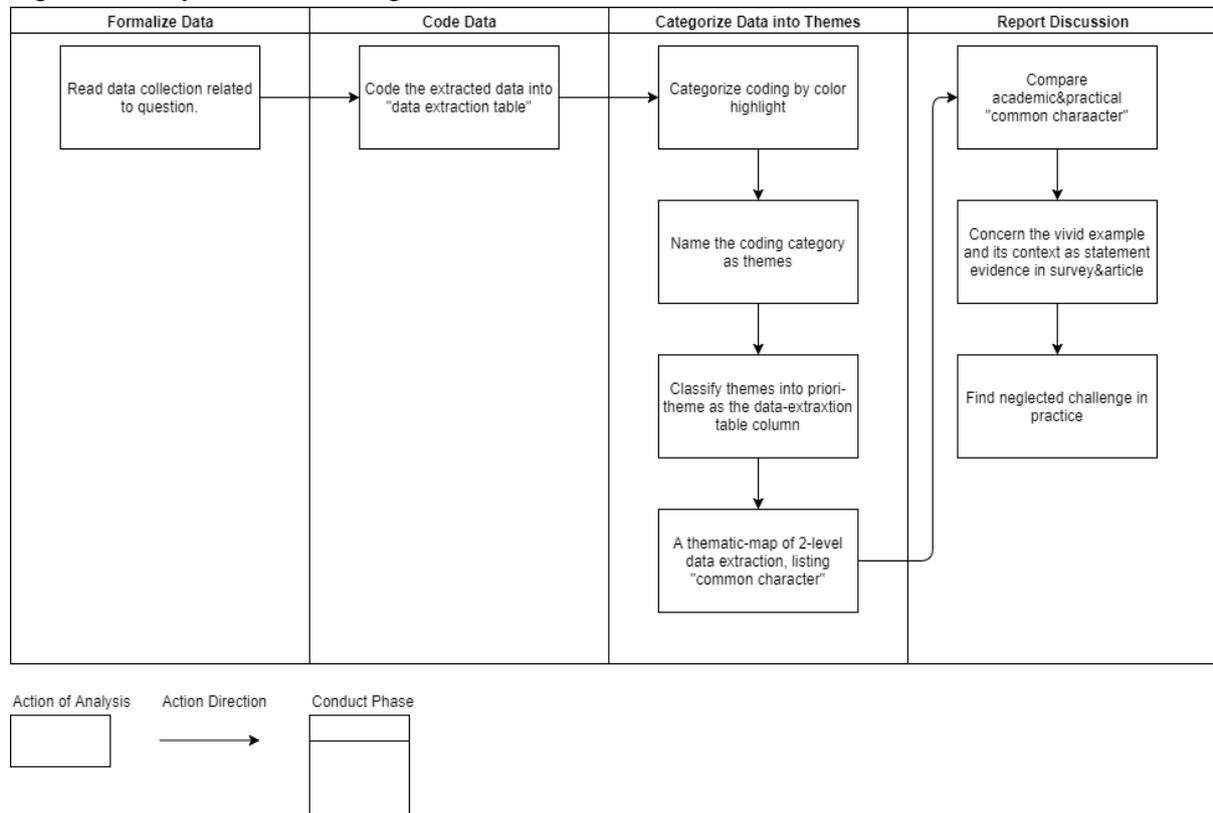
Theme Correlation

Here, in the thematic map that reports the relation of coding and themes, the priori-theme in the extraction-table column can be the higher second level and the "common character" refined from named theme of coding is the lower firstly level. This minimal hierarchy-model can help obtain a rigorous discussion on theme correlation.

Figure 3: Thematic Map of Data Extraction
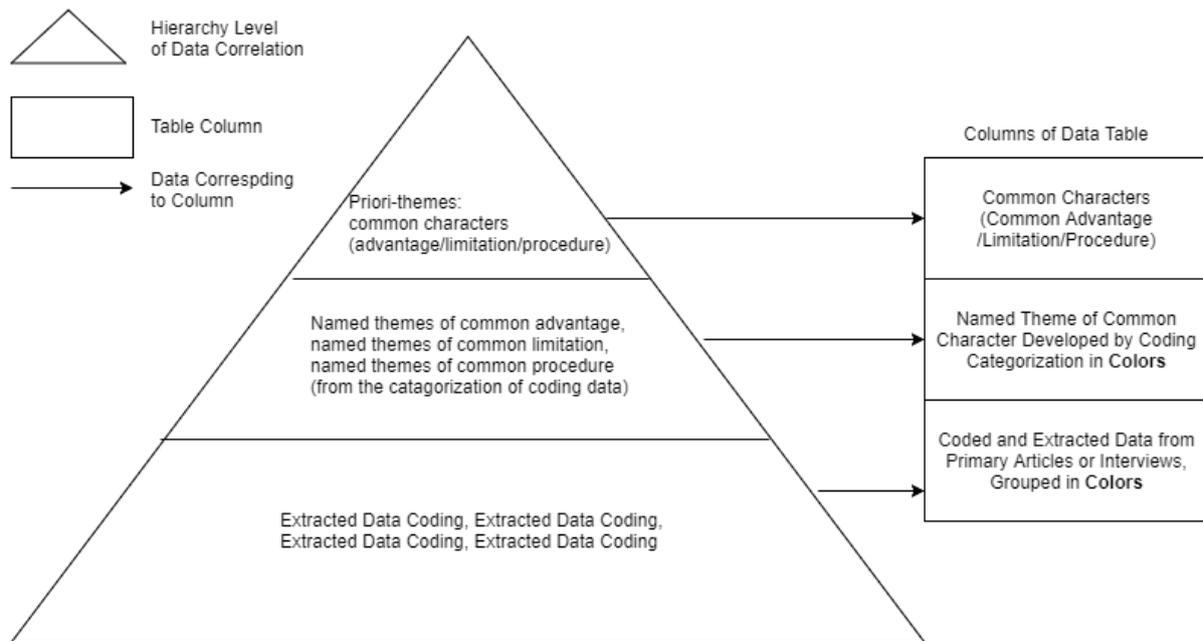
Code and Categorize

Specifically, we extract and generalize data from selected articles or interview transcript for classification and synthesis. In the mapping study, the extracted texts expressing similar concepts are coded in the same color, and then different colors classifies different coding into various themes to generate "common character". In the same way for survey, the meaningful words of interview transcript are extracted in red color and get coded. Then coded texts expressing similar concepts are grouped in one kind of colors as a theme and filled into the corresponding column. Besides, the extracted data has been highlighted in article and survey files.

To be noticed, if a coded and extracted data is not definite to be categorized, the context (table A9 and A2) and all the procedures of this model can be referred to, so that the categorization can meet the method context and consistency to its design.

Name Themes

The categorized theme of a "common character" (grouped texts in various colors) needs a name developed by refining the semantic of categorized coded-data. Specifically, these characters (procedures/advantages/limitations) that other methods have are grouped into a cluster, which is defined as "common character". This is mainly by qualitatively synthesizing the similar sematic of these character data, extracted from primary articles or interview.

Meanwhile, during categorizing the "common character", the workflow and context are also studied to ensure the grouped data of a theme is consistent to its background or does not deviate from its original design or semantics. For instance, if one method limitation cannot be judged into any category, the context of the method article can be referred to.

Though this refinement depends on the analyst's ability and this may induce the reliability for same categorization, it does not matter because under these sufficient evidences of data extraction, the beneficial categorization of "common character" can always be developed by any researcher.

Report Discussion

In terms of the discussion, it needs to clearly report the story of theme prevalence within and across the themes by rigorous discussion, rather than a model of higher-order themes [46] [47]. This must provide sufficient evidence of the themes within the data to ensure the trustworthiness: choose particularly vivid examples in primary article content, not just list the coded data. Moreover, the special context of a method also can be involved in the discussion to ensure the conclusion rigor.

Strategy Motivation

Firstly, the priori-theme combined into our thematic analysis is reasonable, because it has been reasonably used in the template analysis (a form of thematic analysis [50]). Moreover, the "common character" (concerning the advantage, limitation and procedure) that the research question specifically requires can be regarded as the theme defined in advance to the data coding.

Secondly, the colorful coding table in SMS is meaningful to achieve the synthesis goal of reducing the data amount for more contrast analysis, because it can be regarded as a visualized process to generate themes in thematic map. It identifies the inter-correlation of coded data to develop category themes. Specifically, it groups similar procedures across methods into a category theme that can represent this kind of procedure.

Thirdly, in terms of not using the model of higher-order theme, we will not conduct the synthesis or analysis in a way of hierarchy development thoroughly, because the gathered data already revealed the main information we were aiming to analyze and the novel theory about challenges of practicing requirement prioritization methodology we desire to develop is not too complicated and profound [34].

Besides, the data in SMS and survey is extracted in tables, rather than written in paragraphs, because this way can visualize data in a more structured form, which is more beneficial to discuss and analyze large amount of data. But in the essence, the data extraction table is equal to the written paragraphs.

3.8 Threats and Validity
1.Internal Validity
Internal validity concerns the unexpected factor of causal relations influencing on the research [6].This in our research article concerns the isolation of model context and model integrality. When we do the synthesis by thematic analysis, different contexts of model or methods are not categorized or compared as a separate analysis point. But this doesn't seriously affect our study quality, because if the character much involves the context of model, this character must not be common enough. In other words, more common a step in the model process exists, or more serious the influence of evaluation can generate, this character can occur in more kinds contexts. In the same way, although the continuity of model workflow is separated into common stages, it cannot be serious either because here we purely study the evaluation about how easily the step-in model workflow can be practiced in the real industry case. In other words, when a practitioner is applying a prioritization method, he more cares about the usability of this method. Even though there is still potential risk of this validity.

2.Construct Validity
This validity concerns the to what extent the research method can present what the research question intends to study [6]. In the survey, the interview sometimes could not correctly understand what we asked in interview. Firstly, some concepts or methods, like model automation, interviewees did not know or apply before. This induces some questions are blank. Secondly, sometimes they confused requirement prioritization with elicitation or specification. But it is unavoidable because in real world

the requirement engineering is always practiced with various scopes mixed. In a way, the compound actually helps us discover more. But both still induce the data analysis is not perfectly complete.

3.External Validity

This validity concerns to what extent the findings can be worth to be consulted by other people, much related to the sampling representative [6]. In our study, the survey is restricted in not large amount of cases, because the qualitative analysis and synthesis for deeper details cannot support a large scale of sampling data. However, our overall goal does not intend to generalize a universal theory for the whole industry with categorized cases, but acquire some insights or counter-examples based on the evidence to identify the neglected gap between academic and practice. Besides, these investigated cases are still under various contexts, which also ensures the representation of studied findings. However, deeper understanding to the conclusion requires more studies under wider range of samples.

4.Reliability Validity

This concerns to what extent the data and the analysis depend on the specific researchers [6]. Specifically, to what extent another study conducted in the same way can generate similar outcomes. In our study, the qualitative analysis much depends on the ability of analyst, so that the discussion cannot find all contribution inside the data. Different people may get different code and theme in synthesis. To mitigate the analysis depending on intuition, we extract the data into structured table to improve visualization. Than we use a more rigorous qualitative analysis method to mitigate the impact of the analyst's ability. But this threat cannot be fully eliminated. However, as the thematic analysis is based on evidence and there are so many grouped themes, even if another researcher gets different data categorization, these grouped data will be still similar and therefore the conclusion can be similar too.

4 RESULTS

4.1 Systematic Mapping Study

4.1.1 Conduct Record

Figure 4: Process of Mapping Study
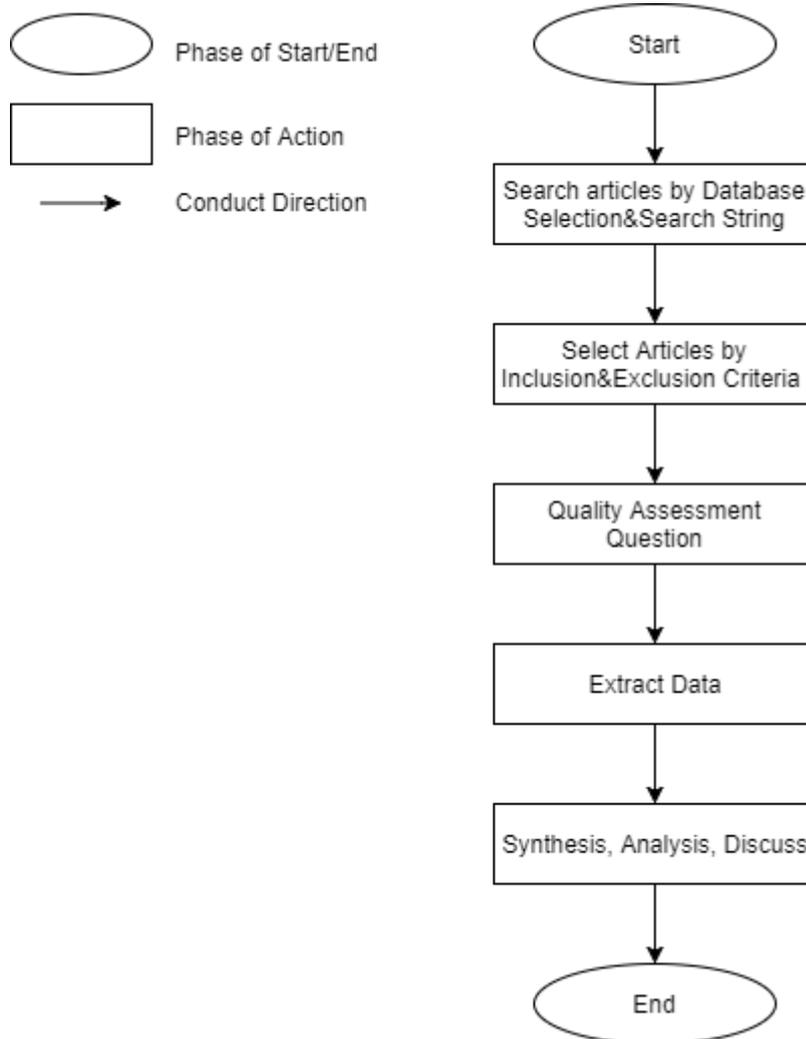
1.Database selection and search string strategy

Database Selection

We make the database selection tightly relative to our topic of software and computer science. Therefore, we finally choose ScienceDirect, ACM, IEEE, Wiley and Springer. ScienceDirect can represent the peer-reviewed and most leading articles in Elsevier. IEEE and ACM are more professional than others in software and computer. Willey can provide the long-term archive article, which is more appropriate for us to study the model evaluation. Springer is a leading global database of science and business researches.

Also, there are other good publishers, but they are less representative than this selection. For instance, Scopus includes the articles from above database and other not relevant publishers, so it can output some duplicate and extra articles. So, Scopus is not selected. Inspec mainly concerns physics, electrical engineering, information system electronics, according to its website, and its articles are included in Elsevier, which the ScienceDirect can include

Search String Strategy

The research question 1 studies the "common character" of various and representative prioritization methods, so first section is any form of "requirement" ((requirement OR requirements) or (requirement*)), and second section is any form of "priority" ((prioritization OR prioritize OR prioritizing OR priority) or (priorit*)). The reference management tool, Zotero, was used to remove duplicates articles and manage the large number of references. We design the search string for title: requirement* AND (prioritization OR prioritize OR prioritizing OR priority). The difference of forms is because some forms cannot work in the different search discipline of database engines. Some database needs the string searched in its "title row".

Table 1: Database selection and search string strategy

E-database	Searching String	Amount of Articles
ACM	acmdlTitle:(requirement OR requirements) AND (prioritization OR prioritize OR prioritizing OR priority)	81
IEEE	(("Document Title":requirement*) AND "Document Title":priorit*)	146
ScienceDirect	Title: requirement* AND (prioritization OR prioritize OR prioritizing OR priority)	32
Springer	Title: requirement* priorit*	44
Wiley	Title: requirement* AND (prioritization OR prioritize OR prioritizing OR priority)	27

2.Selection criteria of inclusion and exclusion

We read title and abstract and use the "inclusion & exclusion criteria" to filter the selected article. The criteria ensure articles intensive on "requirement prioritization in software engineering". Some other areas, like business or testing, also study the requirement prioritization, so we set the 5th inclusion criteria and 3th exclusion criteria. And the study aim discovers the challenge in practice, so we set the 4th exclusion criteria to get the data from practice evaluation.

The following criteria are applied to titles and abstract.
Inclusion

- The article must be English.
- The full text must be accessible.
- The article is peer reviewed.
- The article is published articles or book chapters in the journal publisher database.
- The article must be in the field of software engineering.
- The article proposes, compares or evaluates one or multiple methods.

Exclusion

- Articles do not meet the inclusion criteria.
- Duplicated studies must be excluded among multiple databases.
- The article does not focus on the requirement prioritization model/method in software engineering, but other scopes, like "test case prioritization".

- Exclude the non-industrial study that doesn't use case study, experiment, industrial report, action research, interview or survey to evaluate the proposed method.

With these criteria, we choose the research article which are more representative and straightforward. The selected articles are in table 3. Above conduct steps of research article selection are presented as the following:

Figure 5: Thesis Selection Process
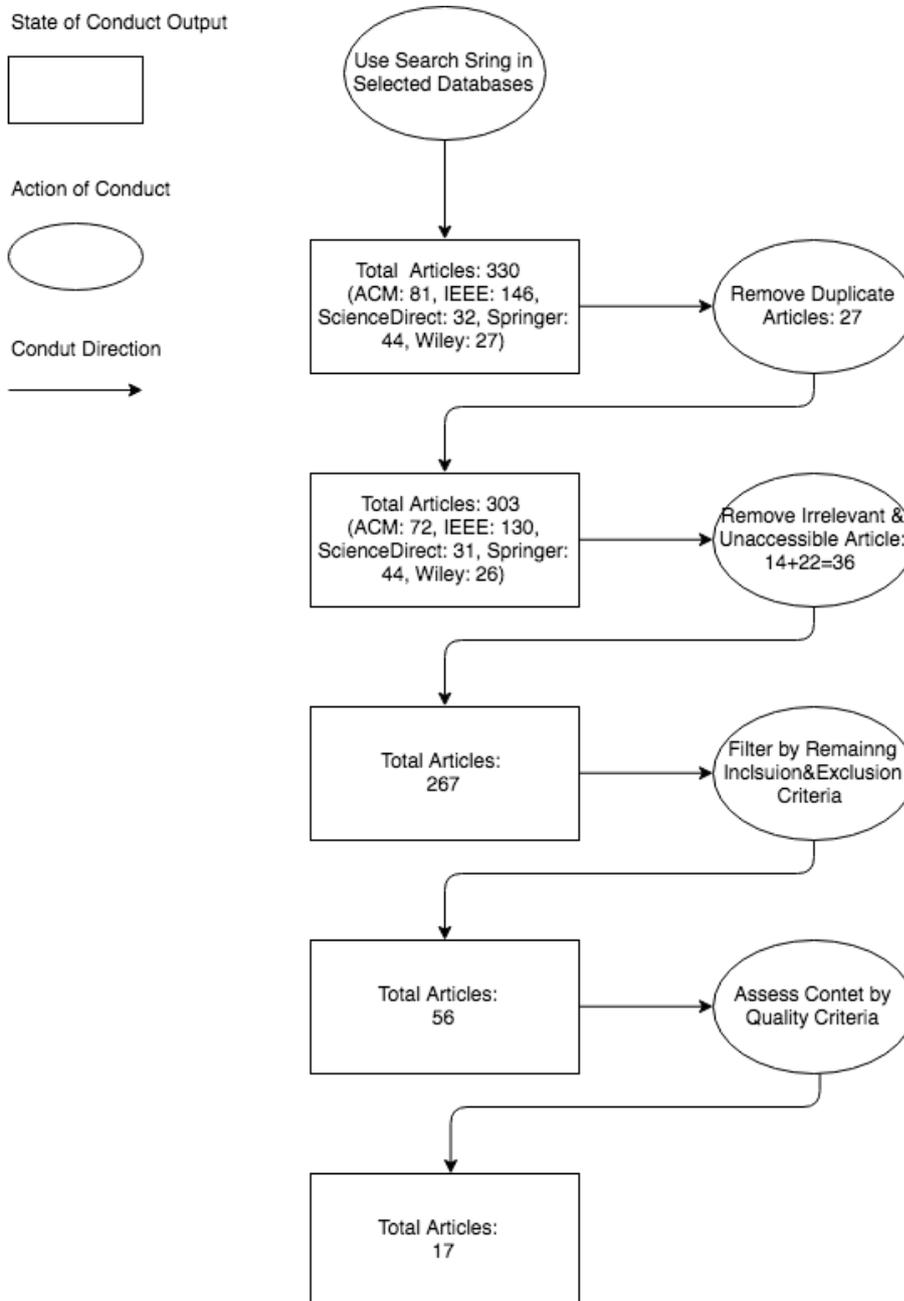
3. Assess the quality of selected studies

We read the full content of articles and use the quality criteria to extract and assess the article content. It can be the pilot guide of data extraction to understand the limitation of each article before beginning the formal data extraction. And if the quality criteria are a part of the selection criteria, the quality

assessment may lead to some primary studies removed [6], like the 5th and 6th criteria. We conduct the quality assessment by the question answering checklist, because it is most used mean, when mapping for overview does not need the strict assessment of article selection [6] [45].

The first 4 criteria ensure the data extraction intensive on the topic and help understand the limitation for the article assessment. The last 2 criteria further ensure the article quality appropriate to study the practice. And they may lead to some article removed.

And 2 peers review these selected articles. According to our research question 1, these following questions are asked "Yes" or "No" to assess the article quality and whether the sufficient information is available to be extracted:
- If the design of requirement prioritization method/model is clearly described, like procedures to conduct this model.
- Whether the aim and context of the proposed method is clearly introduced.
- If the context setting of article proposition is based on other relevant studies or industrial cases.
- If the article clearly presents the improvement benefits, limitation and advantage of the studied method.
- If the article studies a method in an empirical way, like case study, experiment, industrial report, action research, interview or survey.
- If the method/model purely focuses on improving requirement prioritization under software engineering, rather than other area, such as using a requirement prioritization method to improve bug testing, or requirement prioritization of economy market, etc.

4.Extract the data into the form appropriate to analyze the research question
The data extraction form of SMS is designed to support the analysis method study the RQ1. It can be regarded as a kind of "classification matrix template" in our analysis method (more the section 3.7). As well, the design of data extraction form refers to other articles, like article [1], [2], [44] and etc.

Here we don't use the "article classification scheme" to categorize articles, because the RQ1 does not need to classify articles and article [5] also says it is not always necessary. Specifically, the "common character" in RQ1 actually needs to extract and generalize data into higher abstract-theme level to effectively compare various methods. Otherwise, the data is too large scale and complex for topic overview. The "article classification scheme" is useless for this.

The extraction form is firstly piloted on a few of selected research article by one author and then 2nd author reviews the extracted data to evaluate whether this form can answer the 1st research question [5].

The final data extraction of article general information is as the following. More detailed extraction for per research question aspect is in the section 4.1.2 and 4.1.3. The result of extracted data and its synthesis is in the Appendix.

Table 2: Article General Information (corresponding data: Table A1 in Appendix)

Data Item	Value Definition
Reference ID	[s + Integer]
Article Title	Name of the selected article.
Year	The year number of article publication.

Study Method	Whether the method conducted in this article is of the range defined in the inclusion & exclusion criteria: case study, experiment, industrial report, action research, interview or survey.

Table A1: Selected Articles

Reference ID	Article Title	Year	Study Method
[s1]	RFP based Requirement Prioritization – A One-Step Solution	2017	Case study
[s2]	An Empirical Study to Compare the Accuracy of AHP and CBRanking Techniques for Requirements Prioritization	2007	Experiment
[s3]	Value-Based Requirements Prioritization: Usage Experiences	2013	Case study
[s4]	Multi-person Decision-making for Requirements Prioritization Using Fuzzy AHP	2013	Experiment
[s5]	A Quality-Based Requirement Prioritization Framework Using Binary Inputs	2010	Case study & Experiment
[s6]	DRank: A semi-automated requirements prioritization method based on preferences and dependencies	2017	Experiment
[s7]	Handling stakeholder conflict by agile requirement prioritization using A priori technique	2017	Experiment
[s8]	Functional and non-functional requirements prioritization: empirical evaluation of IPA, AHP-based, and HAM-based approaches	2016	Experiment
[s9]	Towards a Functional Requirements Prioritization with Early Mutation Testing	2018	Experiment
[s10]	A Conceptual Model of Client-driven Agile Requirements Prioritization: Results of a Case Study	2010	Case study
[s11]	Maintainability-Based Requirements Prioritization by Using Artifacts Traceability and Code Metrics	2013	Case study
[s12]	Capturing user requirements and priorities for innovative interactive systems	1998	Case study
[s13]	A formal approach to the analysis of priorities of imprecise conflicting requirements	1995	Case study
[s14]	A cost-value approach for prioritizing requirements	1997	Case study

[s15]	Latent Semantic Centrality Based Automated Requirements Prioritization	2014	Experiment
[s16]	Towards automated requirements prioritization and triage	2009	Case study & Experiment
[s17]	Adaptive Requirements Prioritization (ARP): Improving Decisions between Conflicting Requirements	2015	Case study

4.1.2 RQ1 Aspect1

1.1The execution procedures of proposed requirement prioritization models and methodologies.

To answer this aspect of research question 1, we extract the steps of model from its articles. Some steps in a model are very complicated to describe, so we generalize its design to name this step. The "general description" tries to tell what the model is in only one sentence.

Table 3: Data Extraction of Execution Procedure for RQ1 Aspect1 (corresponding data: Table A2 in Appendix)

Data Item	Value Definition
Reference ID	The ID of the selected primary study
Model Name	The name of the method/model proposed in the article
General Description of Method & Context	It generally describes "under what kind of context, how the proposed method solves what problems.
Execution Procedure	The procedure to execute the method, extracted from the method design.

4.1.3 RQ1 Aspect2

1.2 Refine and summarize the academic evaluation to proposed models, like their advantages, disadvantages and etc., also about execution procedures.

We conclude the advantage and limitation of a model from its evaluation and what this model focuses on improving. The conclusion is conducted from the view of execution, because our research goal is to discover the challenge of practicing the methodology

Table 4: Data Extraction of Model Evaluation for RQ1 Aspect2 (corresponding data: Table A3 in Appendix)

Data Item	Value Definition
Reference ID	The ID of the selected primary study
Advantage Under the Context	It generally describes "under what context, the method has what advantage or benefits for the method aim".
Limitation Under the Context	It generally describes "under what context, the method has what limitation".

4.1.4 RQ1 Aspect3

1.3 The common characteristic in these proposed methods and models (like design, execution step or shortage), which will be refined and classified.

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We make the classification to the model according to the execution procedure or evaluation of a model. The result is extracted and synthesized in a qualitative way, so the illustration of synthesis is structured into table column to correspond the concept theme classified for question answer. More discussion on the analysis method is in section 3.7.

Specifically, if 2 models have common steps or encounter some similar challenges, qualitative analysis will refine the common characteristic. The key words expressing similar concept are coded in the same color and are related to one themes according to its occurrence frequency and signification interaction among these selected research article. Specifically, firstly-this way actually highlights the different kinds of information into different themes by the thematic coding. The theme is classified by thematic Analysis according to the occurrence of the words expressing similar concept. Meanwhile, the thematic analysis also can interact these coded words of similar concept to classify them and create a new theme, which can be regarded as the contribution and help develop a new theory. By this way, the extracted data from aspect 1&2 can be refined to discover more valuable contribution and support the contrast with the real situation in survey.

However, when we are summarizing these models, we less concern the context where the methodology is proposed. But this doesn't matter, because here we study what the procedure in the model is more usable in practice and what influence of the model evaluation is more serious, which all are the concrete result of the model design. From this view, they are not much related to the proposition background.

In other words, if the character much involves the context of model, this character must not be common. Besides, although the continuity of process is separated, it doesn't matter either, because here we purely study how easily the step can be practiced in the real industry case.

Figure : Synthesis Process of Article Extraction

Table 5: Synthesis Extraction Form of Academic Common Procedure (corresponding data: Table A4 in Appendix)

Data Item	Value Definition
Academic Common Procedure ID (ACP_ID)	The ID of common procedure synthesized by extracted data from selected articles
Reference ID + Extracted Procedure	The primary article ID + extracted data evidence of method procedure from selected articles. The data is synthesized from corresponding columns in Table 3: Execution Procedure.
Description of Academic Common Procedure	The common procedure synthesized by extracted data from selected articles

Table 6: Synthesis Extraction Form of Academic Common Advantage (corresponding data: Table A5 in Appendix)

Data Item	Value Definition
Academic Common Advantage ID (ACA_ID)	The ID of common advantage synthesized by extracted data from selected articles
Reference ID +	The primary article ID + Extracted data evidence of method advantage from

Extracted Advantage	selected articles. The data is synthesized from corresponding columns in Table 4: Advantage Under the Context.
Description of Academic Common Advantage	The common advantage synthesized by extracted data from selected articles

Table 7: Synthesis Extraction of Academic Common Limitation (corresponding data: Table A6 in Appendix)

Data Item	Value Definition
Academic Common Limitation ID (ACL_ID)	The ID of common limitation synthesized by extracted data from selected articles
Reference ID + Extracted Limitation	The primary article ID + Extracted data evidence of method limitation from selected articles. The data is synthesized from corresponding columns in Table 4: Advantage Under the Limitation.
Description of Academic Common Limitation	The common limitation synthesized by extracted data from selected articles

4.2 Interview-based Survey
4.2.1 Sampling
Besides using the convenience sampling to instantly contact interviewee, we also use the snowballing method to let the interviewee call some other interviewees, like interviewee 1 calling interviewee 2. We contact these interviewees and hold meeting by social network (Social-Network audio-call), such as Wechat(most popular APP in China) and Facebook, and face-to-face. The transcript data of interview is stored in the appendix and internet application.

Table 8: Sampling Background

Interview ID	Company Name	Company Main Business	Job	Experience Year	Contact method
Interview 1	Zhejiang Public Information Industry Co., Ltd.	Information Technology Software R&D, System Integration, IT Support Services	Java Development Engineer	6	Social-Network
Interview 2	HuaWei	Telecom/IT service, equipment & device	Senior Engineer	5	Social-Network
Interview 3	Xiamen Meitu Technology Co., Ltd.	Automatic beauty and intelligent beauty	Image Algorithm Engineer	2	Face to face
Interview 4	Sydostpressarna Printing factory	Print newspapers	Senior Software Engineer	2	Face to face
Interview 5	Hangzhou QiYi technology Co., Ltd.	Taxi service	CEO	2	Social-Network
Interview 6	China Telecom	Telecom service & infrastructure	Project Manager	20	Face to face
Interview 7	Netease	Game&Internet Service	Product Manager	1	Social-Network
Interview 8	Haier	Electric service & equipment	Java Developer	2	Social-Network
Interview 9	(Name is privacy)	Net browser and internet service.	Product Manager	1	Social-Network
Interview 10	Inspur Group	IT service & server equipment	Product Manager	2	Social-Network
Intervie	Chaitin Tech	IT security	Security Developer	3	Social-Network

w 11					
Intervie w 12	State Street Corporation	Financial services	Frontend Developer	2	Social-Network
Intervie w 13	Haier	Electric service & equipment	Product Manager	3	Social-Network
Intervie w 14	Dice	Online ticket sale	Mobile Web Full Stack Developer	4	Social-Network

4.2.2 Conduct Record and Question Design

Design Motivation

Chiefly, the question must be proposed corresponding to the research question and aspects. The correspondence between the research question and interview question of final version can be seen in the figure 6.

Secondly, the question in interview is designed with the referring to the result from mapping study, such as the question related to model automation. Meanwhile, the question design cannot be restricted totally by the mapping study. Otherwise, the interview cannot catch our gap between the academic and practice within a wider range:

Thirdly, the question words must be polished. The interview question should be definite but not too detailed in case of limiting interviewee's thinking. Meanwhile, there also need to be some terms of restriction, or the interviewee may think into deviation. Questions of same type need to be merged in case of being verbose. As well, the question cannot be ambiguous, or the interviewee cannot understand the question. Finally, it can be seen that the interview question must suffer from trade-off and trial to acquire a list of question effective to dig the actual condition.

Fourthly, some questions ask one aspect by different ways of views in multiple times to acquire more and deeper description. This is because our topic, "challenges in practice requirement prioritization methods", involves a wide and open range of discussion and the way of semi-structured interview also requires to be conducted with some open discussion. However, multiple descriptions to one aspect may induce the chaos of data integration and analysis. But as our sample amount is not immense, a fundamental qualitative analysis can burden the interaction of data. Likewise, the not immense amount of samples also is reasonable to deeply explore the actual condition for RQ2 within limited efforts and time, rather than try to find a universal generalization to this area in industry.

Table 9: Initial Interview Question

Interview Question No.	Question
1	1.What is the model/method you use when doing requirement prioritization? Please describe its using process.
2	2.Does your method give priority value to per requirement item, or in other words,

	grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?
3	3.Do you build your requirement prioritization method/model into a software tool to automate its usage, like using Trello, Teambition? If so, do you think this tool makes your requirement prioritization model/method more efficient? Even, if there is no this tool, you won't use your model/method anymore because it is too complex?
4	4.What is the advantage of the requirement prioritization method you use?
5	5.What is the disadvantage of the requirement prioritization method you use?
6	6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?
7	7.What factor do you think is important for a prioritization method/model in practice?
8	8.Please generally discuss what factor you think most needs improving in the requirement prioritization method.

Interview Question Improvement

1.After the 1st interview

It can be found that as the 1st question in draft is not specific, the interviewee's answer is brief and it's tough to conclude the design of the author's method/model. Therefore, we change the 1st question into the following:

1.What is the model/method you use when doing requirement prioritization? Please describe its process/design.

We also find most requirement prioritization method provides some algorithm to calculate the priority value for sequencing the requirement items. However, the 1st question cannot notify the interviewee to definitely describe the priority calculation in his requirement prioritization method. So, we add another question as the 3rd as following:

3.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?

2.After the interview 1st-5th and with the result of mapping study

we find the automatic tool for automatic model usage is also a hot area and under potential issues. So we add the 4th question:

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?

3.As well, the 1st and 2nd question are repetitive, so we combine both.

1.What is the model/method you use when doing requirement prioritization? Please describe how to apply it.

Meanwhile, the 4th and 5th question are relative but disperse, so we combine both for more efficient asking. And this question also needs some limited factor to promote the interviewee's thinking. Otherwise, the answer cannot concern the beneficial aspect.

5.What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?

The 3rd question is also too complicated and induces the deviation of the interviewee's thinking. So we improve it as the new one.

4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?

The question 7 and 8 are also repetitive, too general and similar with the question 4&5, so we combine both and add some example to guide the interviewee's thinking.

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?

Final Question

The final question paper is as the following and we use it to interview the remained people.

Table 10: Final Interview Question

Interview Question No.	Question
1	1.What is the model/method you use when doing requirement prioritization? Please describe how to apply it.
2	2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?
3	3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?
4	4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?
5	5.What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?
6	6.What requirement prioritization method/model have ever you referred to from

	book, article or research article? How do you tailor and apply it into your used method/model?
7	7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?

In the following sections, we'll extract and initially analyze the result of interview transcript for further discussion and conclusion by thematic coding method (we have discussed the analysis method reasonable in section 3.7). Therefore, the relationship between the studied research question and interview question must be sorted out. The final relation based on the final interview question is illustrated as the following figure for clear understanding (Figure 6). With the study on interview and aspects of research question 2, we can get a meaningful discussion to answer the whole research question.

Besides, the initial version of interview question can also support the research aspect by involving the updated final version. Of course, some interviewee's answer in one question may involve another question. We also classify these information under corresponding theme when we meet it under this question.

Figure 6: Relation Between Interviews and Research Questions
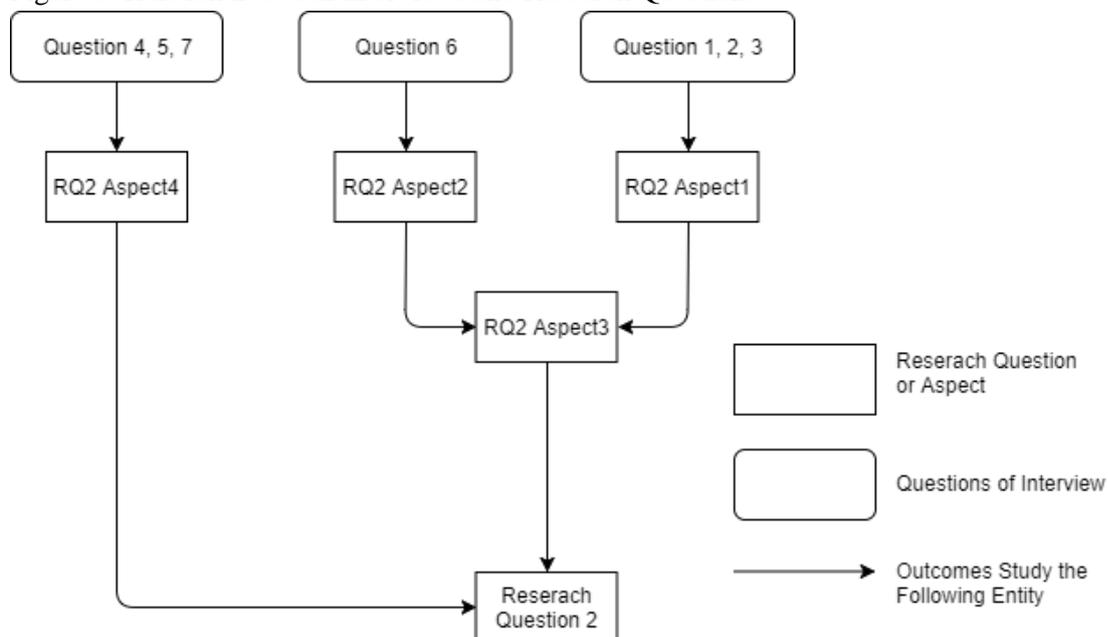
4.2.3 RQ2 Aspect 1&2

   2.1 The currently applied methods in IT company to practice requirement prioritization. -- (interview question 1，2，3)

   2.2 Models that practical methods are based on if they have references, and if so how these practical methods tailor the model basis for better execution. -- (interview question 6)

Table 11: Data Extraction Form of Practical Method from Interview (corresponding data: Table A7 in Appendix)

Data Item	Value Definition	Related Interview Question
Interview ID	Identification number of interview.	-
Execution Procedure	The procedure to execute the method, extracted from the interview transcript.	1
Priority Calculation	The procedure to calculate priority in the method, extracted from the interview transcript.	2
Automatic Usage	How the usage of prioritization method is automated by tool.	3
Academic Reference Tailor	Generally describe how the academic basis of the practical method is tailored for practice, such as what steps are picked from the academic model to practice and why other steps are not referred to.	6

The aspect 1 and 2 are combined for more convenient analysis. Every column can answer the corresponding research aspect according to the relation between research question and interview question: "Execution procedure" for interview question 1, "Priority Calculation" for interview question 2, "Automatic Usage" for interview question 3 and "Reference Tailor" for interview question 6.

The aspect 2.2 is independently asked by "academic reference tailor", because it very matches our study goal about the contrast between the academics and practice. To study this more, we will discuss further on the research question 3 with all the result.

4.2.4 RQ2 Aspect 3

2.3 Refine and classify the common characteristic of the practical requirement prioritization methods in IT company, from the view of execution procedures.

Here, we will generalize the aspect 1 and 2 of RQ2 by its table. The way of refinement is same as the RQ1 Apsect3. The listed column in table of aspect 1&2 can be generalized into the common step as the common characteristic. What factor with over 2 times occurrence can be regarded as a common step and generally described.

Table 12: Synthesis Extraction Form of Common Procedure of Practical Model (corresponding data: Table A8 in Appendix)

Data Item	Value Definition
Practical Common Procedure ID(PCP_ID)	The ID of common procedure synthesized by extracted data from practitioner's practical method.
Interview ID + Extracted Procedure	The interview ID + extracted data evidence of method procedure from practitioner's practical method. The data is synthesized from corresponding columns in Table 13: Execution Procedure, Priority Calculation
Description of Practical Common Procedure	The common procedure synthesized by extracted data from practitioner's practical method.

4.2.5 RQ2 Aspect 4

2.4 Refine and classify the feedback towards these practical prioritization methods in IT company, related to their advantages and disadvantages in execution procedures. -- (interview question 4, 5, 7)

We will generalize the key words of interview transcript into column as a way of classification and refinement: interview question 4 with "Practice Cases", interview question 5 with "Advantage" and "Limitation", interview question 7 with "Vital Challenge to Improve".

We think the current data extraction and synthesis can generally illustrate the challenge by this survey. Firstly, the data collected from interview involves multiple views under different practice cases, which are worth to be studied. Secondly, the subject amount of survey is not immense but representative enough to support a generalization of actual situation. Finally, as challenges of practice are our main study gap, we need to elicit the detail for deeper insight, rather than acquire a profound conclusion with the limited range of samples.

Table 13: Data Extraction Form of Evaluation to Practical Method (corresponding data: Table A9 in Appendix)

Data Item	Value Definition	Related Interview Question
Interview ID	Identification number of interview	-
Practice Cases	Projects/cases where this practitioner's method has been practiced and how it works well.	4
Advantage	The important advantage of the requirement prioritization method	5
Limitation	The important disadvantage of the requirement prioritization method	5
Vital Challenge to Improve	Challenge that is most important to improve for this practitioner's method/model	7

Table 14: Synthesis Extraction Form of Common Advantage of Practical Method (corresponding data: Table A10 in Appendix)

Data Item	Value Definition
Practical Common Advantage ID (PCA_ID)	The ID of common advantage synthesized by extracted data from practitioner's practical method.
Interview ID + Extracted Advantage	The interview ID + extracted data evidence of method advantage from practitioner's practical method. The data is synthesized from corresponding columns in Table 15: Advantage.
Description of Practical Common Advantage	The common advantage synthesized by extracted data from practitioner's practical method.

Table 15: Synthesis Extraction Form of Common Limitation of Practical Method (corresponding data: Table A11 in Appendix)

Data Item	Value Definition
Practical Common Limitation ID (PCL_ID)	The ID of common limitation synthesized by extracted data from practitioner's practical method.
Interview ID + Extracted Limitation	The interview ID + extracted data evidence of method limitation from practitioner's practical method. The data is synthesized from corresponding columns in Table 15: Limitation.

Description of Practical Common Limitation	The common limitation synthesized by extracted data from practitioner's practical method.

Table 16: Synthesis Extraction Form of Common Challenge of Practical Method (corresponding data: Table A12 in Appendix)

Data Item	Value Definition
Practical Common Challenge ID (PCC_ID)	The ID of common challenge synthesized by extracted data from practitioner's practical method.
Interview ID + Extracted Vital Challenge	The interview ID + extracted data evidence of method advantage from practitioner's practical method. The data is synthesized from corresponding columns in Table 15: Vital Challenge to Improve.
Description of Practical Common Advantage	The common challenge synthesized by extracted data from practitioner's practical method.

5 ANALYSIS AND DISCUSSION

5.1 Research Question1

- **RQ1.** What are the "common characteristic" of the proposed requirement prioritization model or methodology from the view of execution procedures?

Expected Outcome: The grid refining and classifying the proposed requirement prioritization methods in academics based on their execution procedure

To study this question, we synthesized the common character based on the extracted evidence. The synthesis tries to study the limitation and advantage from whether its usage in practice performs well enough, which can be regarded from the view of execution procedure.

Table 17: Academic Common Characters (Data and Evidence Copied From Table A4, A5, A6)

Academic Common Procedure	Academic Common Advantage	Academic Common Limitation
ACP_1 Collect and identify the requirement in a form from some algorithm, artifact or stakeholder. **ACP_2** Compare requirements in pairs to generate priority, like decision matrix. **ACP_3** Set essential factor, criteria or metric (like size, complexity, coupling, cohesion, change, etc.) to evaluate requirement priority or choose a priority calculation method **ACP_4** Calculate the requirement priority by an algorithm, or based on preference, goals, parameter of other steps, criteria, dependency or map. **ACP_5** Develop requirement criteria based on the necessary factor or objectives, like risk, effort, value. **ACP_6** Classify requirement into subset/cluster. **ACP_7** Get requirement specification and priority from identified scenario. **ACP_8** Plot estimated factors or dependency on graphs to support priority analysis. **ACP_9** Set cost-estimation as vital factor. **ACP_10** Consider the perspective of various stakeholder, including developer, which may be useful to requirement conflicts or changes. **ACP_11** Set the weight number on the requirements. **ACP_12** Link requirements to concepts (such as scenarios) or other activities (such as testing) to help analysis.	**ACA_1** The model helps determine the most prominent technology and key features of requirement prioritization. **ACA_2** Produce the more relative, accurate or optimal requirement prioritization. **ACA_3** Method can get information from more stakeholders or aspects in a more structured process to support prioritization. **ACA_4** The proposed model is easy and flexible to use. **ACA_5** Determine the requirement prioritization by algorithm or automated tool for some improvement, like labor saving, accuracy of large scale. **ACA_6** The method can support analysis on wider range of factors, like change, important value, and dependency. **ACA_7** Consider quality attributes.	**ACL_1** The reliability or accuracy of the method needs further validation by more data. **ACL_2** Different constrains or situations induce the method difficult to meet requirements systematically in most extent. **ACL_3** The increased scale or accuracy of requirement prioritization will induce to increase violent complexity or time cost. **ACL_4** The subjective factors of customer induce changes or pointing-deviation of requirement in the prioritization method. **ACL_5** Procedure complementarity: the method cannot be precise enough because its procedure design lacks requirement specification. **ACL_6** The model design cannot effectively support the "analysis", lack of detailed way to select essential factors, goal-level setting, or automation tool for dependency visualization. **ACL_7** The prioritization method cannot effectively deal with dependencies among requirements or even with other factors (like business). **ACL_8** The design of method still cannot ensure the prioritization precision.

Discussion of Common Procedure

From the evidence in the above table, correctly and effectively identifying requirements are important for prioritization (though it is another phase of requirement engineering), like common procedures ACP_1 and 7. This may need a definite specification form, stakeholders' cooperation, scenario analysis, estimation on artifact source, or some algorithm.

Many factors in a project can be the parameters or criteria to estimate or calculate priority, like dependency, change, risk, market value, cost, effort and etc., which can be seen in ACP_3, 4, 5 and 9. The article [s1] and [s14] of ACP_9 regard "cost" as a vital factor to determine the following priority steps, which can help solve complexity, time limitation, stakeholder conflicts in requirement prioritization (see table A2&A4).

The priority calculation and analysis also need some support by methods, strategy or tools, like comparison-pair matrix, dependency-graph, algorithm with input of factor estimation, setting weight-value, dividing requirement into subset and etc., which can be seen in ACP_2, 4, 6, 8, 11. Moreover, prioritization analysis also needs analysis-strategy, like ACP_12 linking requirement to scenario or activity.

The stakeholder is also emphasized as a key in many procedures, like ACP_1 and 10. In ACP_10, by better cooperation with stakeholders, article [s4] [s6] [s10] try to improve weight estimation, dependency conflicts or obtaining more sights (see table A2&A4).

Discussion of Common Advantage

Academic trend to pursue many improvement, which are to some extend corresponding to the above common procedures. Firstly, the academic method pursues to generate higher quality of prioritization in many aspects, like accuracy, more flexible easier usage, less cost and etc., which are in ACA_2, 4, 5. The methods in ACA_5 utilizes the automated tool or algorithm for both cost-saving and accuracy (see table A2&A4).

Secondly, for better decision-making in prioritization, the academic method pursues wider range of factor analysis, like change, quality, value, tech choice, dependency, which are in ACA_1, 3, 6, 7. The methods in ACA_3 also emphasize "information from stakeholder" by a more structured workflow.

Discussion of Common Limitation

Academic methods neglect or do not pay enough attention to some points, which may be induced by procedure design. Firstly, in ACL_1, 2 and 3, complex and various project cases induce it tough for a method to meet any situation, such as more validation for method reliability, different constrains, increased scale resulting in cost and complexity, and etc.

Secondly, in ACL_5, 6 and 8, the incompletion of method design induces defect for prioritization, like no specification procedure, no analysis on many factors, no automation or visualization tool and etc.

Besides, in methods of ACL_4 and 7, issues from customer and dependency are emphasized by researches again. Specifically, customer can induce not definite requirement identification or change. As well, dependencies among requirements or estimation factors are still a problem in prioritization method.

5.2 Research Question2

- **RQ2.** What is the actual status in the real world when practicing requirement prioritization?

Expected Outcome: The research and its analysis on how in IT company to practice requirement prioritization methods and models.

Table 18: Practical Common Characters (Data and Evidence Copied From Table A8, A10, A11, A12)

Practical Common Procedure	Practical Common Advantage	Practical Common Limitation	Practical Common Challenge
PCP_1 Determine high requirement priority based on vital customer specification, not by algorithm or model. **PCP_2** More stakeholders participate and hold a form of meeting to ensure the consensus agreement, or	**PCA_1** The method can more satisfy the customer's perspective. **PCA_2** Models can be used flexibly **PCA_3** There is no complicated process, just a meeting to discuss.	**PCL_1** The method usage encounters manpower issues: high labor cost, skill learning, labor estimation, cooperation. **PCL_2** The customers will affect prioritization and specification. **PCL_3** Trade-off of	**PCC_1** Human resource issue: cost, cooperation, learning-curve, practitioner ability, team together participation, and consensus agreement (not compromise). **PCC_2** Impact and specification of Stakeholder's

directly vote the priority in number or not. **PCP_3** The functional requirement has higher priority. **PCP_4** Estimate Cost (enough labor, time, effort, complexity workload), impact or worth of requirement as priority metric. Prefer the easier implementation. **PCP_5** Prioritize requirement according to requirement dependency that one ends and then one starts. **PCP_6** Use levels/scales, consisting of importance, emergency, difficulty or dependency, as priority metric. **PCP_7** Requirements are divided into different metric levels/degrees in ordinal or interval scale. **PCP_8** Use a developed tool/model to support analysis on more scopes for prioritization, like business or market. **PCP_9** Estimate workload by artifact data for prioritization, like code line or historical project record. **PCP_10** Prioritize requirements depending on practitioner's experiences on job.	**PCA_4** The model is fast or has fast iteration. **PCA_5** The method is easy, concise and intuitive to identify priority.	requirement dependency is a challenge. **PCL_4** The stakeholder cannot be all knowledgeable enough, which may induce the communication limited in a circle. **PCL_5** The method lacks the rigorous form to record requirement specification. **PCL_6** The model design is not competed in many aspects for its usage: high cost, poor change flexibility, tough usage management, no self-reflection phase.	will. **PCC_3** Trace the requirement management. **PCC_4** Vital factor control for method conduct: cost, time, risk, change estimation. **PCC_5** Requirement elicitation and specification. **PCC_6** Easy using but also accurate.

Academic Tailor

In table A7 and interview transcript in appendix, most interviewees do not refer to or do not know any method from academic articles, like interview 2, 3, 4, 5, 6, 8, 9, 10 and 11. Only interview 14 mentioned their analysis model for business requirements refers to articles. Interview 13 refer to the bestseller book, not academic.

Some practitioners in survey think academic method is not practicable, though they just know a few professional concepts for requirement prioritization, like interview 7 and 12. The interviewee 12 declares the agile management needs dedicated participation of skillful practitioner.

Automation Usage

By table A7 and interview transcript in appendix, it can be seen that the automated tool for requirement prioritization is worth to be studied further for its practice. Firstly, most interviews do not need an automated tool for requirement prioritization, or even think it not necessary, like interview 1, 3, 5, 6, 7, 9, 10, 13. Moreover, interviewees 7, 9 and 13 think using an automatic tool actually wastes extra time because prioritization is not tough for them.

Secondly, many interviews use a team coordination software, but mainly to trace task management and not specialized for requirement prioritization, which may be not effective enough for prioritization, like Trello, Excel, Jira or customized system, in interviews 4, 8, 11, 12, 14. Besides, interview 12 mentioned they don't strictly follow the tool, which means the usage of automatic tool in prioritization needs further study. Only Interview 2 uses a model tool to estimate 8 factors for priority (like cost, easy usage, performance and etc.).

Discussion of Common Procedure

Workflows of many practitioner's methods stress coping with issues of "human factor", like priority depending on customer's will, meeting for stakeholder's consensus agreement or voting, prioritization by practitioner's experiences, in PCP_1, 2 and 10.

Priority estimation utilizes various factors as metric to choose easier implementation, like cost, impact, importance, emergency, dependency, complexity or value, in PCP_4, 6 and 9. Especially, articles of PCP_4 (see table A8) actually estimate any forms of "cost" for priority, like labor effort, complexity, time or etc.

Meanwhile, the metric estimation for priority needs some means as support, like levels/degrees in ordinal or interval scale, analysis tool/model for more scopes and estimating the archive data in project record, in PCP_7, 8 and 9.

Besides, there are some principles in prioritization procedures. For instance, PCP_3 prioritizes functional requirement higher and PCP_5 cares about the requirements that can start after others and ends.

Discussion of Common Advantage

The impression of merits pursued by practical methods can be "easy-using but good for any cases", mainly about "easy, fast and flexible". In PCA_1 to 5 of survey (see table 18 and A10), the merits of practitioners' methods can be generalized as "satisfying to customers, flexible, easy-using, fast iterative, concise, intuitive, and just by a meeting".

Discussion of Common Limitation

Firstly, "human factor" is still one vital issue, related to labor resource limitation, skill learning, experience level, labor-cost estimation, not definite specification and cooperation, in PCL_1, 2 and 4 (see table A11). For instance, in interviews of PCL_2 (see table A11), customer may try to seriously affect prioritization. In interviews of PCL_4 (see table A11), difference knowledge-level of stakeholders blocks the communication.

Secondly, the design of prioritization workflow still has defect for usage or is not complete, like poor flexibility for change and etc., in PCL_5 and 6. Specifically, methods of PCL_5 do not have rigorous form of requirement specification.

Besides, requirement dependency is still a challenge in practice, like interview 1 and 14 of PCL_3 (see table A11). It needs to drop some requirements or control their relations.

Discussion of Common Challenge

These challenges in prioritization practice can be regarded as more serious limitation emphasized by interviewee. In table 18, some points of challenge that the interview emphasized can be generalized as following: human factor (PCC_1 and PCL_1), stakeholder's will (PCC_2 and PCL_2), definite specification of requirements (PCC_5 and PCL_5).

Besides, PCC_3 and PCC_4 mentioned that the management trace and vital factor control is still the challenge during the prioritization method conduct.

Meanwhile, there is an interesting paradox found by PCC_6: being both "easy-using" and "accurate" simultaneously is both the challenge expected to be improved and available advantage (above section "Discussion of Common Advantage") of these practitioners' method. This is worth to be studied further. Maybe the definition of "accurate" and "easy-using" should be more definite.

5.3 Research Question3

- **RQ3.** What challenges the models or methodologies of requirement prioritization are suffering from when to practice them in IT company?

  3.1 The gap of prioritization method between the academic proposition and real practice, such as what different emphasis between the academic methods and workshop practice.

  3.2 The potential challenge worth to be studied further to discover more unknown, such as one bad design in prioritization method may cause bad impact.

  Expected Outcome: The current and potential challenges in the execution procedure of practicing a requirement prioritization method in workshop by comparing the gap of execution procedure design between the academics and practical methods.

To study this question, there are 3 aspects as contributions, of which analysis is based on the collected evidence relative to the method procedures or their advantages and limitations:

1. Insights on the valuable challenges in practice neglected by academic articles but emphasized by practitioners. (for Aspect 1)
2. Valuable insights or assumption on challenges worth to be studied further. (for Aspect 2)
3. New proposition for future: new definition, conceptual model and potential scenario, all worth to be studied further. (for Aspect 2)

Generally, these statements identify the counter-example towards available academic conclusions by evidences to prove and identify the existence of gap between academic and practice.

5.3.1 Insights on Challenges

The rigorous analysis and discussion give the most valuable statements to identify the challenge between the academic and practice, as the following:

1.Statement: There needs "human factor" based prioritization method to mainly deal with or depend on "human factor" (like customer's will or stakeholder's level) across the whole prioritization workflow, rather than just set it as one of estimation factors or one procedure of workflow.
Discussion: Issues related to "human factor" is emphasized as a core problem for practice in practical methods of survey, which needs to be solved or depended on separately, while the academic articles we have studied just do not put "human factor" in the chief place of prioritization procedures.

The academic method in our study does not design more procedures to handle or trace the issues about "human factor" across its whole workflow to improve prioritization, such as organize meeting and voting, systematically trace the client's feedback. Specifically, procedures of academic methods in ACP_1 and ACP_10 (see table 17 and A4) only consider "stakeholders" as important measurement, such as the expert estimates conflicts and change, or the customer identifies requirements. As well, there are many issues related to "human factor", and academic methods also have procedures to dominate the human arrangement or stakeholder communication.

Procedures of practical methods in PCP_1, 2 and 10 (see table A12 and 18) set "human factor" across the whole workflow of prioritization method, like the stakeholder meeting for consensus agreement

on priority, prioritization based on stakeholder's specification (not just a factor) and prioritization depending on subjective experiences.

Relying on "human" cannot be a good choice, but the interviewees of these methods think their method is "easy, fast and flexible" (see section "RQ2 Discussion of Common Advantage). Thus, "human factor" based prioritization is worth to be studied further.

2.Statement: The practitioners in survey very emphasize the method practicability, like learning-curve or easy usage, but the studied academic research does not pay enough attention to study it as main aim.
Discussion: Chiefly, the practitioners very emphasize the method practicability. The section "RQ2 Discussion of Common Character" rigorously indicates the paradox: "easy, fast and flexible" is both the challenge and merits of the existing practitioners' methods in survey. This means that the practitioner really prefers a method "easy-using but also accurate" and think their methods are of this kind but seriously not enough to extent.

However, the academic methods in this study don't solve "easy, fast and flexible" thoroughly in a chief place, but merely regard it as some of estimation factors, instead of the mainly academic aim to be improved. The RQ1 discussion of "Common advantage" indicates that the academic methods in this study pursue higher quality of prioritization in many aspects (like accuracy and flexibility) and decision-making by wider range of factors (like change and dependency). Specifically, "easy, fast and flexible" is not considered as a chief place. It is just of some estimation factors to improve the prioritization under a specific case. For instance, though academic advantage of method, ACA_4, is "easy and flexible to use", the articles [s5], the context of [s6], [s7], [s14] and [s17] of ACA_4 (see table 17, A5) are dedicated to improving identification of quality criteria, stakeholder conflicts, large scale of requirement, dependency, decision or range by algorithm or analysis model, instead of improving "easy, fast and flexible".

As well, the section "Academic tailor" in RQ2 indicates that in this survey most practitioners do not practice any method from academic references and even some of them think academic methods are not practicable. This may be induced by the academic contempt on method practicability, "easy, fast and flexible".

3.Statement: Though the studied academic method has the elaborate calculation and estimation of requirement priority, its design does not sufficiently consider the extreme change inducing the large scale of adjustments, the value overflow of priority upper-limit or the temporary abandon on other priority factors. If the extreme change can occur and cannot be mitigated, in some way a rough prioritization may be better because it at least saves costs to be flexible and rework for change.
Discussion: In a model or algorithm, emergent change induces the priority or weight of a requirement to surge beyond the expected range or break the predesigned priority calculation onto the chief place. All other factors have to be delayed so that the prioritization schedule may needs a relatively large adjustment or abandon all other factor temporarily. This case is not studied further in the articles of this study.

According to section "RQ1 Discussion of Common Procedure", many factors are considered as parameters or criteria as estimation, including "change", but change is not emphasized as a main aim to improve and the unexpected impact of change is not studied enough, like articles of ACP_3 and ACP_10 (see table A4).

Specifically, among them, Cost-value [s14], Drank [s6] and ARP [s17] (see table A2) have very accurate priority calculation or estimation, but if the change has impact that is over than its estimated range in these methods, this may induce the rework or inaccuracy of prioritization. In this case, a rough prioritization actually is better choice because it at least saves costs to be flexible and rework for change.

For an assumption, in real market, there are many cases of change to induce the prioritization rework: if a company suffers from a security attack or a new client's will, and the upper limit value of security or business priority in this method is 10 (but now 100 is more reasonable), all its efforts have to be prioritized on these emergent changes and other factors of priority estimation can be temporarily abandoned.

In practice, interviews of PCC_4 and PCL_6 (see table A11 and A12) also have challenges to estimate or handle change, like better factor control for change estimation. In some way, the "flexible" pursued by practitioner methods is to deal with change. Thus, there is a necessity to study change in a more thorough extent.

4.**Statement:** The studied academic article needs a wider, larger and deeper scale research on how the automatic tool of a requirement prioritization method can be accepted by the practitioner and merged into the daily practice. Automated tools more specialized for requirement prioritization methods can be a future trend.

Discussion: Though the academic work uses many automatic tool or algorithm for its prioritization model, the interview in survey indicates that the practitioner does cannot apply an effective method. As well, the future trend of prioritization will be the method automation, indicated by the article [11] in related work, because of complexity and learning-curve.

The discussion "RQ2 Automation Usage" indicates the negative case of automated prioritization methods: 1. most interviews in this survey do not need an automated tool for requirement prioritization, or even think it not necessary; 2. many interviews use a team coordination software, but mainly to trace task management and not specialized for requirement prioritization; 3. interview 12 does not strictly follow the tool, which means the usage of automatic tool in prioritization needs further study.

The academic articles studied in RQ1 also do not study how to promote the usage of proposed automated method. The section "RQ1 Discussion of Common Procedure" indicates that the automated methods in this study support the analysis and calculation of requirement prioritization. But how the practitioner accepts these methods and what benefits these methods can provide to the practitioner's work-productivity both are not studied enough, though we have searched their relevant thesis in Google Scholar. This also needs a larger scale study.

To study the usage of automated prioritization may involve not only requirement prioritization engineering, but also requires wider study to support the practice of automation requirement prioritization model in future, like the human resource learning-curve, etc.

5.**Statement:** The studied academic prioritization method neglects a more systematic and rigorous structure or scheme for its meeting-holding to improve the consensus agreement and communication in its method practice.

Discussion: The meeting is important for estimation voting, requirement specification or stakeholder communication, both in academic and practical methods. The section "RQ2 Common Procedures" indicates the interviewees use meeting to solve issues of "human factors", like stakeholder agreement, especially in procedures of PCP_2 (see table A8).

In meeting, the communication for consensus agreement is important to be achieved. For instance, interview 7 and 13 indicate that the good decision of prioritization needs team consensus agreement, instead of team compromise, and without consensus agreement, there will be unexpected risks or deviation from stakeholder's conflicts.

Thus, there needs a more systematic and rigorous structure and scheme for meeting-holding, which can instruct the prioritization conduct more effectively by more handling the meeting procedures. For instance, interviews of PCC_2 and PCL_2 in survey (see A11 and A12) identify if there are more meetings with customer, such as in the agile management, the customer will have more opportunities to dominate the prioritization too much and different knowledge-levels of stakeholders also will make the meeting communication not effective. But the meeting tactic is still simple, such only plan-poker voting is mentioned.

The academic method in this research does not illustrate in detail how to effectively organize the meeting to support their prioritization workflow, though its workflow is described in detail. Specifically, based on the primary content and its extracted data of articles (see table A2&A4), articles describe the workflow about what to vote in meeting, but it is not described in detail how to hold the meeting in the way effective for the prioritization model design. Just a plan-poker meeting may not be enough. Thus, the meeting design in a prioritization method practice is worth to be studied further.

6.Statement: The requirement prioritization method needs to more effectively trace and control the trivial change of requirement management and the priority factor, when using a prioritization method.
Discussion: The practitioner's method in PCC_3&4 (see table A12) indicates that the challenge to control priority factor and trace the requirement management both is important for method practice, like estimating change or record the completion time.

Chiefly, most procedures of academic and practical methods estimate factor metric or manage the requirement in some way. This can be seen in above discussion (RQ1&2 "Discussion of Common Procedures") and data in table 17 & 18 above. Thus, the factor control and requirement trace both are important to practice these methods.

However, there must be challenges for practitioner to trace and control the requirement management and priority factor when using an academic method, because the merit of academic and practical methods is conflicting: one purses accuracy, one purses easy-usage. The academic method, like AHP, Drank, etc. in PCP_3, 4, 5 (see table 17), uses more factor-estimation for more accuracy, but complex to be controlled and traced. By contrast, the practical method is "easy, fast and flexible" (identified by RQ2 discussion).

As well, the above academic methods most don't provide a tool or scheme to trace and manage the change of requirement and its priority factor (see table 17 and A4). Currently, there are only automatic algorithms or visualized models to promote the priority calculation or requirement analysis with factors of wider scopes.

Thus, it is necessary to design procedures to trace and control the trivial change of requirement management and the priority factor into these available academic methods, which pursues the higher quality outcome and wider range of factor analysis (identified in RQ1 discussion).

7.Statement: The priority algorithm in academic methods needs more evaluation on its reliability, as well as more understandable introduction writings (not academic articles) to popularize its practitioner's trust and practice, and then obtain the evaluation of its productivity.

Discussion: According to the discussion "RQ2 academic tailor" and data in table A8, no practitioner in this study practiced a method of math model or algorithm, even though there are many automated methods in the academic article.

There can be a reason that the practitioner lacks knowledge and trust to the academic proposition. For instance, the interview 7 insists that assigning value to a requirement priority is complicated, because the difference between 66 and 65 in the priority-scale range 0-100 cannot be told. Thus, for the proposed prioritization algorithm, it even needs to popularize its math principle to gain the practitioner's trust.

As well, the reliability of a math prioritization method also needs to be more evaluated to ensure it reliable enough for practitioner's trust, according to methods in ACL_1 (see table A6). In related work, the article [42] also indicates that the accuracy and other attributes of prioritization methods needs more evaluation under a broader discussion.

Using math model on prioritization is common in academic methods, so there should be a work to evaluate the reliability of these methods. The academic method in this study utilizes many kinds of math model and estimation scale, like kinds of AHP or comparison matrix ([s2], [s6], [s8], [s12], [s13], [s14], etc. in table A2 and A4).

5.3.2 New Proposition for Future

Here, our improvement and assumption proposed below are based on the studied research question on both academic and practical areas. We hope our potential identification to future is worth to be studied further to help other researchers generate more valuable studies.

1.New Definitions and Conceptual Model for Future Solution
Practicable Requirement Prioritization Engineering (PRPE)
Here, based on our study, we propose the new definition, Practicable Requirement Prioritization Engineering (PRPE), which is worth to be studied further. As well, we also think PRPE can be reasonably extended to be a Practicable Requirement Engineering (PRE), of which the definition is same as PRPE as well as include not only prioritization but also other sections in software engineering.

Practicable Requirement Prioritization Engineering: *a set of criteria to predict whether a proposed academic model of requirement prioritization can be practiced in real world, be a guidance to identify the research direction of requirement prioritization and help practitioners select appropriate methods, according to whether this model can fit the cooperation among different teams of different sizes, be more market-driven, promote the distant allocation team and other more standards that the practitioner needs to practice a prioritization method, which will promote industry productivity.*

Modularized Requirement Prioritization Model (MRPM)

Definition

To implement the PRPE, we think the requirement prioritization model proposed in the future can be in a specific form. Here, based on our study, we proposed another new definition, a conceptual model, Modularized Requirement Prioritization Model (MRPM), to support the PRPE. But we also think it can be reasonably extended to be a Modularized Requirement Engineering Model (MREM) for PRE in future.

Modularized Requirement Prioritization Model (MRPM): *The requirement prioritization model can be designed in an extremely easy-using way, like a set of definite strategies, principles or skills based on practical experiences, so to solve the requirement prioritization under a definite minimal case, with its automation SaaS tool. The practitioner can refer to it instantly and merge it with other MRPMs. The automation tool makes it easier to alter and use the algorithm without understanding the algorithm, and trace the procedure execution during the method conduct. The compound usage of MRPMs can deal with the always complicated cases of real world.*

A Case and A Possible Example

For a specific case, the practitioner may use emergency level of requirement implementation to assess the priority of requirement, when the delivery is urgent. Sometimes, the requirement prioritization needs to consider the market revenue by grading the point of the requirement market value. However, when a company encounters the difficulty of market revenue and has to emergently publish a new version, the company will prioritize requirements with merging both the emergency level and market value. In that case, the practitioner can prioritize the requirement most urgent to deliver and then prioritize these most urgent requirements based on their market value grades. The stakeholder can participate to grade the weight value of market and delivery emergency by using an automated tool, like SaaS software or iOS app, without much understanding to the prioritization method. Finally, the priority value from both emergency level and market value can be calculated by the algorithm online web application.

The figure 7 illustrates one possible implementation design of MRPM example for the above case.

Figure 7: An Example of MRPM System under the Case of Merging Both Priorities of Emergency-Level and Market-Value
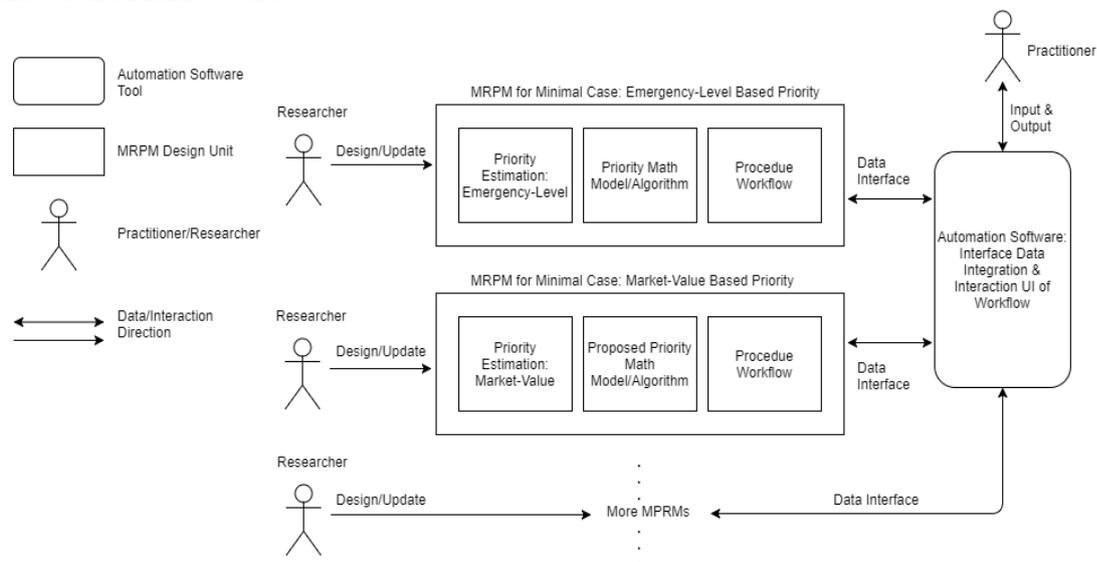
Here, one MRPM is one automated requirement prioritization method, containing 3 design units, which can be developed as a Restful service or system modular. Both MRPMs are specialized for both minimal cases: market-value and emergency-level based priority. Inside it, the "priority estimation" identifies what factor estimates the priority in one minimal cases and how to estimate priority. The "priority math model/algorithm" identifies how to calculate the priority. The "procedure workflow" identifies what procedure is in the workflow of a prioritization method and how to conduct the workflow. The "automation software" can be a SaaS software system to process the data from interface by its backend and user's interaction by its UI frontend. The MRPM and "automation software" can interact with each by the designed data interface, like Restful API or modular interface.

The practitioner can interact with the MRPM through the "automation software", so that the practitioner only needs to practice the method of MRPM by clicking the software GUI, with little learning curve to hold the priority estimation, workflow conduct and priority calculation.

Meanwhile, the researcher can design his proposed method as a MRPM and update it easily, so to promote his academic method into practice productivity.

Implementation Challenge
The challenges to implement this conceptual model, MRPM, can be the interface design for data interaction and data integration with other MRPM. Maybe not all MRPMs can work together well.

Merit and Benefit
This way makes requirement prioritization model and its tool easier using for higher productivity to solve the case that the practitioner is lazy to use requirement model and tool as its high cost and less value, like interview 12. As well, the academic researcher can iteratively promote and improve his proposed method into practice

Thus, the MRPM is very worth to be studied and improved further and can be extended into many practice cases, like requirement prioritization by OA system and remote-work.

Rationality of Above Proposition
Firstly, our new definition can reduce the learning curve so to motivate the participation of all stakeholders. The above analysis indicates that in practice the participation of all stakeholders of different groups is very important. In our opinion, the current academic model more suits the analysis of high abstract level on requirement prioritization from the view of the management, business or architecture, but does not consider the method practice, like procedure conduct and team consensus agreement. As well, the manager and architect may not fully understand the development, use-case and technology, so that the analysis and conduct of requirement prioritization deviate from the actual condition.

Specifically, when the business type changes, the prioritization method also needs change. The instant change requires the new method easy using and of low learning-curve. To achieve this, wrapping the prioritization method into MRPM is a good choice. Meanwhile, this way also helps the distant working as well. Though the interview 12 mentioned that his team progress does not conform the plan schemed by a tool, but we think this is because his work does not require a more delicate prioritization method for an immense workload, or existing method is not easy-using enough.

Secondly, the requirement prioritization method should be as easier as possible to be adopted and merged with other methods for the composite case in real world. Only using one method is not possible, because one method only focuses on one or two specific cases. From above, we can see that in practice the requirement prioritization encounters numerous and various challenges. For instance, some projects require priority point for accuracy, but others only want emergency level as measurement for early delivery. Change is always there in real world.

Moreover, it can be seen that in practice the actual situation cannot allow the ideal case where the academic model only solve one specific challenge. There are multiple challenges mixed together. For instance, many interviewees confuse the requirement prioritization with elicitation or specification. In practice, it is tough to separate them. However, if a model tries to cope with multiple cases, the model must become big and complex so not easy using. Thus, to merge multiple simple method used together is a better way, working as software modular API, like Restful API.

Of course, these new definitions still need further empirical studying in the future.

2. The Potential Situation to Study
Definition
Requirement Prioritization of Compounded-Business Software (RPCBS): *Requirement prioritization of the business, where the software is "developed for developer, used by customer, but not sold for customer", like Amazon shopping, Alibaba shopping or Spotify free music.*

Motivation
In practice, it is common that the type of business affects the design or selection of requirement prioritization method, such as the inside or outside customer. For instance, the interview 12 mentioned that their methods prioritize the requirement from outside customer effectively. But when they develop a project used by his company inside, this prioritization method does not work well. Likewise, many requirement prioritization methods in this study are for bespoke software, which is developed and sold to an outside customer for profits.

Overall, according to our research, commonly there are 2 kinds of software business: 1. "developed for customer, used by customer and sold for customer"; 2. "developed for developer, used by developer and not sold for customer".

However, for some enterprises, like Amazon shopping, Alibaba shopping or Spotify free music, its software business can be regarded as a compound of above 2 kinds: their service works for its own business, in other words, for developers themselves; however, users are not developer themselves, but the software is not sold to customer either. About this 3rd kind of business, the requirement prioritization method for it needs further study in future. We name this situation, Requirement Prioritization of Compounded-Business Software (RPCBS).

6 CONCLUSIONS AND FUTURE WORK

The contribution of this study has existed in the research result and illustrated in the analysis and discussion, especially in research question 3. Here, we will conclude these contributions in our research about the proposition of new things and insight of the present status between the academic and industry.

The contribution concluded from research question can be as the following:

1. Procedures, limitations and advantages in academic methods that the requirement prioritization method in the selected articles commonly have, which can be regarded as academic "common character". (RQ1)

2. The actual condition for practitioners to practice their requirement prioritization methods: academic reference usage, automatic tool usage and "common character" of these methods. (RQ2)

3. Insights on the valuable challenges in practice neglected by academic articles but emphasized by practitioners. (RQ3 Aspect 1)

4. Valuable insights or assumption on challenges worth to be studied further. (RQ3 Aspect 2)

6. New proposition for future: new definition, conceptual model and potential scenario, all worth to be studied further. (RQ3 Aspect 2)

6.1 Conclusion to Analysis and Discussion

General Description

What our study has elicited can be referred to as a kind of strategy, principle or instructive standard which brings the value to inspire the industry for designing and applying productive requirement prioritization methodology.

The overall objective of our study reveals the neglected challenge in the gap between the academic and actual status for practitioner to practice requirement prioritization method. In RQ1, we extract the valuable data about the method characteristic from rigorously selected articles. In RQ2, we conduct the interview-based survey to research the actual challenges for practitioners to practice the requirement prioritization in the real world. In RQ3, with the contrast of the result from above, we analyze what challenges induce that the academic requirement prioritization model still could not effectively solve the problem arising, when the practitioner practices the requirement prioritization. In this way, the research finally perfectly studies the overall research objective.

Research Question 1&2

By the synthesized data in table 17, 18 and others, we get some conclusions for the common procedures, advantages and limitations among academic methods and practitioner's methods. As well, in RQ2, the status where the practitioner uses the academic reference and automation tool is discussed. These conclusions help understand the status in the academic and practice and support the analysis on RQ3.

For the detailed conclusion for RQ1&2, please separately see section 5.1 and 5.2.

Research Question 3: Challenges in Practice

Based on the discussion of RQ1&2 and data in Appendix tables, we get some statements that identify valuable challenges to practice requirement prioritization neglected by the academic research. As well, these statements include some potential challenges worth to be studied further. Conclusions of both help identify "the neglected challenges for practitioners to practice requirement prioritization method".

For the detailed conclusion for RQ3, please see the section 5.3.1.

6.2 Proposition for Future Trend

Finally, in RQ3, to study the overall objective further, based on the data and statement, we proposed two definitions and a potential situation worth to be studied for the future trend, as the following. For the detailed of this, please see the section 5.3.2.

Firstly, based on the studied result and analysis, we propose the new definition, Practicable Requirement Prioritization Engineering (PRPE), which can help the practitioner select a requirement prioritization model more possibly to be practiced successfully, and then also inspire the academic to research and design the requirement prioritization methodology the industry more requires.

Secondly, to support the implementation of the PRPE definition, we propose the second new definition about potential trend of solution design, Modularized Requirement Prioritization Model (MRPM). It can be designed extremely easy-using for the practitioner to apply it instantly with merging other MRPMs so to deal with the complicated real world. We also propose an implementation example of MRPM for illustration.

Finally, we also find a potential situation not deeply studied yet, Requirement Prioritization of Compounded-Business Software (RPCBS). As various business requires companies to use various requirement prioritization methods, the prioritization in the company whose service is "developed for developer, used by customer, but not sold for customer", like Alibaba shopping, Spotify free music or Amazon shopping, may requires a more appropriate requirement prioritization methodology, different from most proposed models in the academic.

6.3 Future Work

Firstly, our generalized common character in the academic and practice requires the evaluation under a wider range to get polished or enriched, so to become the more authoritative reference for the industry. In the future, we can pick some of these common characteristics to study with more articles or interviews, according to the reader's feedback towards our studied common steps, advantages and limitations.

Secondly, some statements refined between the actual and academic also requires more samples to illustrate more detail related to real world, or to be studied deeper. For instance, how to assess and achieve the team consensus agreement in requirement prioritization is worth to be studied with more interviews and academic researches. As well, how to deal with changes commanded by customer needs to be studied further.

Thirdly, we also need to evaluate the 2 definitions, PRPE and MRPM, to enrich them more rigorous in empirical research, or even design a requirement prioritization method conforming to the idea of both definitions. Then we can study how to extend both definitions to the whole requirement engineering, not only in the requirement prioritization. Finally, we can trial our proposed requirement prioritization method under the case of compounded-customer business, like Amazon's e-commerce both used by purchaser and himself.

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APPENDIX

Data Extraction of Systematic Mapping Study

Table A1: Selected Articles

Reference ID	Article Title	Year	Study Method
[s1]	RFP based Requirement Prioritization – A One-Step Solution	2017	Case study
[s2]	An Empirical Study to Compare the Accuracy of AHP and CBRanking Techniques for Requirements Prioritization	2007	Experiment
[s3]	Value-Based Requirements Prioritization: Usage Experiences	2013	Case study
[s4]	Multi-person Decision-making for Requirements Prioritization Using Fuzzy AHP	2013	Experiment
[s5]	A Quality-Based Requirement Prioritization Framework Using Binary Inputs	2010	Case study & Experiment
[s6]	DRank: A semi-automated requirements prioritization method based on preferences and dependencies	2017	Experiment
[s7]	Handling stakeholder conflict by agile requirement prioritization using A priori technique	2017	Experiment
[s8]	Functional and non-functional requirements prioritization: empirical evaluation of IPA, AHP-based, and HAM-based approaches	2016	Experiment
[s9]	Towards a Functional Requirements Prioritization with Early Mutation Testing	2018	Experiment
[s10]	A Conceptual Model of Client-driven Agile Requirements Prioritization: Results of a Case Study	2010	Case study
[s11]	Maintainability-Based Requirements Prioritization by Using Artifacts Traceability and Code Metrics	2013	Case study
[s12]	Capturing user requirements and priorities for innovative interactive systems	1998	Case study
[s13]	A formal approach to the analysis of priorities of imprecise conflicting requirements	1995	Case study
[s14]	A cost-value approach for prioritizing requirements	1997	Case study

[s15]	Latent Semantic Centrality Based Automated Requirements Prioritization	2014	Experiment
[s16]	Towards automated requirements prioritization and triage	2009	Case study & Experiment
[s17]	Adaptive Requirements Prioritization (ARP): Improving Decisions between Conflicting Requirements	2015	Case study

Table A2: Execution Procedure for RQ1 Aspect1

Reference ID	Model Name	General Description of Method & Context	Execution Procedure
[s1]	a One-step Simple Solution Model	The model must be able to reduce the complexity as much as possible in determining the essential factors and propose the best priority technology. This model is used to perform requirement prioritization based on the non-functional requirements indicated in the RFP (Request for proposal) submitted by the customer.	1.Receive and scan the RFP requirement obtained from the client. 2.Find whether "cost" is important criteria. 3.If cost is vital, use EVOLVE method; If not, continue following steps. 4.Investigation other essential factors mandatory for the project, like risk, value, time, dependency, etc. 5.Based on the essential factors contained in the prioritization technique, choose one method from VOP, Cost Value, AHP, CV, SERUM, PG
[s2]	CBRanking	Questions about when a prioritization technique should be preferred to another one or how to characterize and measure their properties arise. The Case-Based Ranking (CBRanking) technique utilizes machine learning algorithms to guide the user's preferences in the prioritization process.	1.Input the specified requirements. 2.The user uses Pair Sampling to evaluate the importance of the sample requirements and outputs preferences (select a pair from the sample; evaluate the relative importance of the requirements in the pair.). 3.Iteratively evaluate all pairs in the sample. 4.Calculate the approximation of the ranking function based on the preference.
	AHP	Analytic Hierarchy Process (AHP) is a multi-standard decision technique based on pairwise comparison method.	1.Develop a set of requirements. 2.Define a AHP matrix (whose rows and columns are the requirements so that each element is a pair of requirements and will be assigned a value representing the user preference on the corresponding pair). The user performs a set of activities designed to achieve a pairwise assessment of the entire set of requirements. 3.The order is calculated by the AHP algorithm, which first calculates the eigenvalues of the matrix.
[s3]	A VBRP/decision-Analysis Framework based on TOPSIS	Integrated into a web-based distributed project management platform for company-wide deployment. The author created a TOPSIS (Technique of Ordered Preference by Similarity to Ideal Solution)-based tool and executed a test pilot to determine its value and use it to prioritize. Based on feedback, the tool is modified to handle the prerequisites of requirement dependencies and the ability to perform hierarchical prioritization.	1.Value-centered approach planning activities criteria, such as: effort, risk, complexity of implementation, familiarity with technology etc. 2.Prioritize various needs against the goals of the project. 3.Assess the impact of specific criteria on the related activity. 4.The final priority helps the project manager sort the requirements in the decision-making process.

[s4]	A Novel Approach to Prioritize the Conflicting Requirements Using Fuzzy Analytic Hierarchy Process and An Alpha Cut	Since the requirements of stakeholders are separately improved and lead to conflicts. In order to avoid conflict preferences of stakeholders, this paper proposes a new method, using fuzzy analytic hierarchy process and alpha cut to determine the priority of conflict demand.	1.Develop a list of stakeholders and assign weights to each stakeholder by comparison matrix. 2.Using fuzzy language terminology to identify stakeholder concerns over conflicting requirements in pairwise comparison matrices. 3.Using the matrix and the algorithm to calculate the aggregate fuzzy weight for each requirement. 4.Finding an alpha value based on an algorithm can achieve a compatible total ordering to ensure that the conflicting requirements agreed by all stakeholders are finally resolved.
[s5]	A Quality-Based Requirement Prioritization Framework Using Binary Inputs	Current method is too complex to use or too simple to have structure and consistency. The proposed approach can quantify the quality of requirements to provide a measurement that is representative of all quality criteria identified for a specific software project and can be the metric for requirement priority.	1.After requirements elicited, identify quality attributes as quality criteria and define them as quality features. 2.Determine which quality feature is to be present or not. 3.Once all requirements identified, use a simple binary scale (0 or 1) to evaluate each requirement against each feature. 4.Once all requirements have been evaluated and measured by all features, the approach uses desirability functions to fuse all measurements into one unified value.
[s6]	DRank	There are many types of dependencies between software requirements, but current requirement prioritization methods rarely consider these dependencies because it is difficult for stakeholders to consider their priorities and dependencies between requirements. In order to make the demand priority more practical, a method called DRank is proposed.	**Done by stakeholder:** 1.Select the Selected Evaluation Attributes (SEAs) as ranking criteria. 2.Select a scale value representing their subjective evaluations for each requirement on each SEAs. 3.Stakeholders are asked to select and prioritize a certain number of requirement pairs as the sampled requirement pairs (Srps). **Done by system development:** 4.Generate a subjective requirement prioritization (SubjRP) by the RankBoost algorithm with the parameters obtained in step 2 and 3. 5.Generate requirement dependency graphs (RDGs) based on the contribution and business dependencies. 6.Analyze contribution order (CO) according to their contribution values, acquired by PageRank-Req algorithm with the weight from RDG step5. 7.Integrate the final requirement prioritization (FinalRP), obtained by adjusting the SubjRP based on the CO and RDG.
[s7]	Apriori Algorithm	Existing methods that prioritize requirements do not address stakeholder conflicts. To overcome this problem, author propose an idea to use the Apriori algorithm to find the most common problems, which in turn helps to reduce stakeholder conflicts.	1.List of requirements. 2.Count the requirement occurrence based on the requirement classification. 3.Compare with minimum value. If requirement is less than the minimum value, eliminate this requirement. 4.Generate frequent requirement set. 5.Generate parameter association rules for Apriori algorithms. 6.Find strong parameter association rules for Apriori algorithms.
[s8]	Integrated Prioritization Approach (IPA)	Although various methods are currently proposed to perform demand prioritization, the main features of these methods are not evaluated, so it is not possible to decide which method can be chosen for a given priority problem. Therefore, a detailed assessment of the recently proposed method is required in an empirical manner. In this paper, we conducted two consecutive controlled experiments to evaluate the current demand priority approach.	1.Identify FRs and NFRs. 2.Build decision matrix of FRs and NFRs. 3.Select a pair (FR vs NFR). 4.Elicit the importance degree of an NFR for a given FR. 5.If all pairs are elicited, calculate NFRs ranking. Otherwise, go back to step 3. 6.Calculate FRs ranking.
[s9]	Priority Strategy	Researchers have proposed a number of prioritization techniques to help decision makers choose the best	1.Evaluation of the test suite adequacy. 2.Ranking of the test suites. 3.Adequacy score selection (low adequacy score should be selected).

		combination of requirement priorities. However, most of them are defined based on ordinal or nominal scales and which are not reliable because they are limited to simple operations of sorting or ordered requirements. This paper proposes the use of early mutation testing and dependency analysis to help determine the importance of requirements.	4.Scenarios identification (The test scenarios are identified by recognizing the faulted test case). 5.Mapping test cases to requirements (For each faulted test case, the related functional requirement is identified as it can be seen in table.) 6.Dependencies analysis. 7.Prioritization of Requirements. (The requirement with the greatest number of dependencies and lower adequacy score represent the most critical requirement.)
[s10]	A Conceptual Model of the Iterative Prioritization Process	In agile requirement engineering, very little is known about prioritization. Because of the lack of a conceptual model in this process, leading practitioners and researchers could not reason in the decision-making requirements at inter-iteration time. This paper uses several case studies to generate a conceptual model of the iterative prioritization process.	1.Set Project Context as model variation, like project size as context. 2.Based on the project context, set Prioritization Criteria by estimating business value, negative value and risk. 3.Estimate size/effort for requirement priority-value based on functional size. 4.Input from developer: consider the developer's perspective. 5.Input of "external change" (about event happening during the project or impacting the company). 6.Input of "learning experiences" (new insights from developer or client during project). 7.Input of "project constrains", like duration, deadline or resource. 8.Prioritize the project backlog (the ordered list of requirements) and its sub-set (sprint backlog) for the next iteration implementation.
[s11]	A Tool to Determine Requirements	Most existing requirements prioritization techniques and tools focus on user and non-functional requirements, and only a few attempts can consider the actual way to implement the requirements. This article presents a tool to determine requirements and a set of code-based metrics by using artifact traceability information.	1.Collecting software artifacts, like source code, natural-language requirements. 2.Recovering traceability links. Links among software artifacts are recovered by applying an IR-technique. 3.Computing code metrics: For each requirement (size, complexity, coupling, cohesion, scattering and tangling degree). 4.Maintainability index estimation. Metrics are used in a (simple) software quality model. 5.Determining a requirement ordering. A requirement ordering according to their estimated maintainability index.
[s12]	A New Method for Capturing Requirements and Priorities	Current interactive system development cannot simply be seen as a gradual improvement of existing products, so it is not possible to identify user requirements based on empirical techniques. This paper presents a new approach to capturing requirements and priorities for the development of highly innovative interactive systems.	1.Identify the possible technical opportunity in a more specific form, "Will product P, developed for context C and users U, work as product P' in context C' for users U' ". 2.Modelling the context: draw rich picture interview and conceptual model in vivid cartoon to help understand context. 3.developing scenarios (a narrative form that can capture use and context) to support design, like representation of contextual factors. 4.Analyzing models: mapping pieces of scenario text to activities in the conceptual model. 5.Identifying and recording user needs in scenarios with users. 6.Formulating a matrix.to map the quality function and customer desires. 7.Lead a set of requirements and weight them. 8.The final demand prioritization is derived.
[s13]	A Formal Approach for Reasoning about the Relative Priority	Priority analysis is one of the most important issues in the analysis of imprecise conflict requirements. Requirement analysts need to not only know the relative ranking requirements based on importance, but also the importance of requirements for effective trading. This paper proposes a formal approach for reasoning about the relative	1. A requirement may be associated with a weight to reflect its priority. The weight can be a real number or a linguistic value. 2. Multiple imprecise requirements with criticality can be combined using Fuzzy compromise operator. 3.Analyzing relative priorities based on cases with Fuzzy logic.

		priority. In the case of uncertainty, case analysis is used to determine the relative priority reasoning.	
[s14]	Cost-value Approach	In real-world software development, there are usually more requirements than implementation due to stakeholder time and resource constraints. The authors developed a cost-value approach to prioritize requirements.	1. Requirements engineers carefully review candidate requirements. 2.AHP is applied by customers and users (or suitable alternatives) to assess the relative price of demand. 3.Experienced software engineers use AHP's pairwise comparisons to estimate the relative cost of implementing each candidate requirement. 4.Plots the relative value and implementation cost on the cost-value map. 5.Stakeholder use cost-value map for analysis and discussion to get final prioritization.
[s15]	A Method based on Latent Semantic Centrality	This article focuses on the issue of assigning relative priorities to requirements specified in natural language. The proposed method is used to process plain text requirement specifications, extract multidimensional statistical features, and estimate the potential semantic cohesion between requirements and the specific information contained in the requirements. Suitable for automated tool support.	1.Input the natural language Text requirement. 2.Pre-processing: POS tagging and use term consisting of one or more words. 3.Feature extraction: generation of Latent Semantic Model and Latent semantic analysis. 4.Requirement prioritization: a. Define priorities based on the relationship between requirements and requirements. b. Requirement-based relative information specificity (IS) assigns priorities to requirements. 5.Requirement clustering. 6.Prioritizing Requirements Clusters: Semantic Centrality based Ranking.
[s16]	Approach for Automating a Significant Part of the Prioritization Process	Existing prioritization technology cannot provide enough automation to have hundreds of stakeholders and potentially conflicting requests and requirements of large-scale projects. This article describes a new approach to automating important parts of the priority process. Use data mining and machine learning techniques to prioritize requirements based on stakeholder interests, business goals, and cross-cutting concerns such as security or performance requirements.	1.Clusters of identified requirements are passed to various automated clustering algorithm modules (including 8 steps). 2.Use the data mining tool (NFR classifier) to deal with the cross-cut of various requirements about architecture or interface design. 3.Add additional criteria of requirement clustering prioritization, defined by stakeholders, like risk factors. 4.Triage: classify requirements into group list. (Top 20% is put into "must have", then next 20% to "recommend having", and so on to "nice to have", "can live without" and "defer".)
[s17]	Adaptive demand Prioritization (ARP) method	Existing techniques are ineffective for realistic sets of requirements and consequently their adoption by practitioners is scarce, particularly for hardware-intensive systems. This study proposes an adaptive demand prioritization (ARP) method to improve decision-making between conflict requirements due to its multi-dimensionality, objective basis principles, usability of openness.	Definition Phase: 1.Input the requirement and priority types. 2.Establish requirement subsets(cluster) of the total requirement. 3.Establish priority dimensions (The definition of different priority level) according to the project background. 4.Assess priorities structures in one or more levels by iteratively checking if it needs to resolve lower level conflicts. Operational Phase: 5.Determin the decision objective. 6.Choose priority dimension. 7.Select highest priority requirements set.

Table A3: Refined Evaluation

Reference ID	Advantage Under the Context	Limitation Under the Context
[s1]	1.A simple solution model proposed by the author helps identify the most prominent technologies and key features of demand priorities.	1.The model proposed by the author does not describe in detail how to determine the essential factors of an IT company project.

	2.Ensuring that the right best priority technology is selected based on any RFP submitted by the customer.	
[s2]	1.When ordering accuracy is the main problem and the number of requirements is small, AHP takes precedence over CBRanking. 2.When the effort takes precedence over the ranking accuracy, CBRanking is preferred.	1.In the CBRanking method, the ordering accuracy is the main problem, and the number of requirements is relatively small. 2.During the experiment, the small number of statistics will also affect the reliability of the data.
[s3]	Provide valuable insights on overall prioritization. It also provides a model to help compare newly discovered requirements (or change requests) with existing requirements to better determine their overall value.	The limitation mainly about the automation tool: 1.The model has no enough hierarchies of goal levels for information analysis and therefore waste extra labor to set goal-level. 2.The automation tool of the model cannot visualize the prerequisite/dependency of requirement, but rely on comma separated list of requirements.
[s4]	This prioritization method utilizes the eigenvalue to acquire the weights of stakeholders. It adopts Fuzzy AHP to gain the comparison matrices. Finally obtain the integrated matrix which reflecting all stakeholders' expectations.	1.Since the different system has different constraints, so that it cannot meet the stakeholder's all expectation. 2.The author thinks the project manager could use preference ordering to ascertain the integrated. However, it still cost a lot of time and lack of accuracy.
[s5]	1.The proposed methodology creates a unified measurement to meet the quality attribution for the project and requirement. 2.It is easy to use by using a simple spreadsheet. 3.It's easy to extend to other quality attribution which is not considered.	1.When a customer asks to impose a requirement, the requirement becomes a priority requirement, and the method proposed by the author will be invalid. It shows that this method cannot handle the change.
[s6]	1. DRank improves the ease of use by its "ranking criteria selection". 2. DRank uses a machine learning algorithm (RankBoost) to reduce the human labor cost. 3. DRank exploits the contribution dependencies between requirements to measure the requirement criticality. 4. DRank improves the requirement prioritization process by combining subjective preferences and objective requirement relationships, which improves the quality of the prioritization sequence and reduces the influence from stakeholder's experience.	1.DRank requires the requirement dependencies to be identified and evaluated beforehand, which is a difficult task. 2.DRank only supports contribution dependencies and business dependencies, no other types of dependencies.
[s7]	The main advantage of using this method is to 1.correct a large amount of data, 2.easy to implement, 3.easy to parallelize.	1.Although the accuracy could be guaranteed while the number of requirements increased, it still takes a lot of time, because as requirements increases, the complexity will also increase ($O(n^2)$).
[s8]	1.IPA can prioritize functional and non-functional requirements for faster execution and can produce reliable results. 2.Because IPA calculates the non-functional demand priorities associated with functional requirements, this can improve the accuracy of the final results.	1.Incompleteness: only considers the fact that there is no relationship between functional and non-functional requirements. 2.The prioritization method proposed in this paper does not consider the dependency.
[s9]	1.Use early mutation testing and dependency analysis to prioritize functional requirements.	1.At present, only a priority strategy is proposed, and there is a lack of evaluation of a large number of experiments and software projects.
[s10]	1.The author uses GT to derive a conceptual model from the case study data to clarify the RP in the agile project, which fills the gaps in the current agile RE literature. 2.The authors also found that "priority standards" and "commercial value", as well as some changes appear related to the project background characteristics.	1.This paper only proposes conceptual model which is not supposed to be validated against the data that has been used for the development of the model，lack of accuracy and reliability.
[s11]	1.Tools are useful in software maintenance tasks such as driving code for improvement activities and regression testing.	1.Because the proposed method and the existing method lack complementarity, it is impossible to accurately realize the current user's needs and the system's demand priority.
[s12]	1.The approach we propose provides a structure for the	1.The soft system technology and scenario-based design

	process of conceiving and analyzing hypothetical uses. 2.Soft system technology provides an abstract description of the activities that are critical to the working environment of the hypothetical opportunity.	used do not systematically support user requirements, technical solutions, and their interrelationships.
[s13]	Requirement analysts uses this technology to: 1.Identify the relative order of requirements based on the importance of the requirements. 2.Identify the importance of the requirements and achieve an effective trade-off between conflicting requirements.	1.Because of the complex relationship between the customer, the customer is often difficult to point out the importance of demand accurately.
[s14]	1.The cost approach complements the traditional approach (AHP, dusty-as-laboratory approach) because it is more visual and easier to use. 2.Through cost-value diagrams, which let management take action to maximize stakeholder satisfaction.	1. When the user performs a pairwise comparison of requirements, it will be tedious and sometimes distracting. 2. As the number of pairwise comparisons is O (n2), more demand will increase the complexity of the problem.
[s15]	1.The proposed method extracts multidimensional statistical features and assess specific information contained between requirement and requirement, it is particularly suitable for the development of automated tool support for requirements management and analysis.	This method is based on assumptions that the eventual objectives are implicitly captured and correlated with the latent semantic and informational characteristics of the requirements. But it may not always be true and information characteristics will affect the relative priorities of the requirements.
[s16]	1.This paper proposes a technique for automating priority requirements and original feature requests for large projects with thousands of requirements, which can automatically perform low-level and arduous classification tasks.	1.Since the method is based on data mining and information retrieval techniques, these techniques are inherently probabilistic and therefore have no high precision.
[s17]	1. Provide multidimensional priority information, so that the correct standard in any decision-making. 2. Determine priority in the structure, in order to more effectively use the existing technology by reducing the demand for priority must be processed. 3. Provide flexibility to suit specific project requirements.	1.Changes in decision objectives during system development may lead to defects in the prioritization method.

Table A4: Common Procedure of Academic Model

Academic Common Procedure ID (ACP_ID)	Reference ID + Extracted Procedure	Description of Academic Common Procedure
ACP_1	s1.1Receive and scan the RFP requirement obtained from the client. s2.1Receive and scan the RFP requirement obtained from the client. s3.1Develop a set of requirements. s7.1List of requirements. s8.1Identify FRs and NFRs. s11.1Collecting software artifacts: like source code, natural-language requirements. 12.1Identify the possible technical opportunity in a more specific form, "Will product P, developed for context C and users U, work as product P' in context C' for users U' ". S14.1Requirements engineers carefully review candidate requirements. s15.1Input the natural language Text requirement. s15.2Pre-processing: POS tagging and use term consisting of one or more words. S15.3Feature extraction: generation of Latent Semantic Model and Latent semantic analysis. s17.1Input the requirement and priority types	Collect and identify the requirement in a form from some algorithm, artifact or stakeholder.
ACP_2	s2.2[AHP]Define an AHP matrix (whose rows and columns are the requirements so that each element is a pair of requirements and will be assigned a value representing the user preference on the corresponding pair). The user performs a set of activities designed to achieve a pairwise assessment of the entire set of requirements.	Compare requirements in pairs to generate priority, like decision matrix.

	s5.3Once all requirements identified, use a simple binary scale (0 or 1) to evaluate each requirement against each feature. s8.2Build decision matrix of FRs and NFRs. s8.3Select a pair (FR vs NFR). s12.6 Formulating a matrix.to map the quality function and customer desires. s13.2Multiple imprecise requirements with criticality can be combined using Fuzzy compromise operator. s14.2 AHP is applied by customers and users (or suitable alternatives) to assess the relative price of demand.	
ACP_3	s1.4Investigation other essential factors mandatory for the project, like risk, value, time, dependency, etc. s1.5Based on the essential factors contained in the prioritization technique, choose one method from VOP, Cost Value, AHP, CV, SERUM, PG. S2.2[CBRanking]The user uses Pair Sampling to evaluate the importance of the sample requirements and outputs preferences (select a pair from the sample; evaluate the relative importance of the requirements in the pair.). s2.3[CBRanking]Iteratively evaluate all pairs in the sample. s3.3Assess the impact of specific criteria on the related activity. s5.2Determine which quality feature is to be present or not. s7.2Count the requirement occurrence based on the requirement classification. s7.3Compare with minimum value. If requirement is less than the minimum value, eliminate this requirement. s7.4Generate frequent requirement set. s8.4Elicit the importance degree of an NFR for a given FR. s9.3Adequacy score selection (low adequacy score should be selected). s10.1Set Project Context as model variation, like project size as context. s10.3Estimate size/effort for requirement priori-value based on functional size. s10.5Input of "external change" (about event happening during the project or impacting the company). s10.7 Input of "project constrains", like duration, deadline or resource. s11.2Recovering traceability links. Links among software artifacts are recovered by applying an IR-technique. s11.3Computing code metrics: For each requirement (size, complexity, coupling, cohesion, scattering and tangling degree). s11.4Maintainability index estimation. Metrics are used in a (simple) software quality model.	Set essential factor, criteria or metric (like size, complexity, coupling, cohesion, change, etc.) to evaluate requirement priority or choose a priority calculation method
ACP_4	s2.4[CBRanking]Calculate the approximation of the ranking function based on the preference. s2.3[AHP]The order is calculated by the AHP algorithm, which first calculates the eigenvalues of the matrix. s3.2Prioritize various needs against the goals of the project. s3.4The final priority helps the project manager sort the requirements in the decision-making process. s5.4Once all requirements have been evaluated and measured by all features, the approach uses desirability functions to fuse all measurements into one unified value. s6.4Generate a subjective requirement prioritization (SubjRP) by the RankBoost algorithm with the parameters obtained in step 2 and 3. s6.6Analyze contribution order (CO) according to their contribution values, acquired by PageRank-Req algorithm with the weight from RDG step5. s6.7Integrate the final requirement prioritization (FinalRP), obtained by adjusting the SubjRP based on the CO and RDG. s7.5Generate parameter association rules for Apriori algorithms. s7.6Find strong parameter association rules for Apriori algorithms. s8.5If all pairs are elicited, calculate NFRs ranking. Otherwise, go back to step 3. s8.6Calculate FRs ranking. s9.2Ranking of the test suites. s9.6Dependencies analysis. s9.7Prioritization of Requirements. (The requirement with the greatest number of dependencies and lower adequacy score represent the most critical requirement.) s11.5Determining a requirement ordering. A requirement ordering according to their estimated maintainability index. s13.3Analyzing relative priorities based on cases with Fuzzy logic.	Calculate the requirement priority by an algorithm, or based on preference, goals, parameter of other steps, criteria, dependency or map.

	s14.5Stakeholder use cost-value map for analysis and discussion to get final prioritization. s15.4Requirement prioritization: a. Define priorities based on the relationship between requirements and requirements. b. Requirement-based relative information specificity (IS) assigns priorities to requirements. s15.6Prioritizing Requirements Clusters: Semantic Centrality based Ranking. s16.2Use the data mining tool (NFR classifier) to deal with the cross-cut of various requirements about architecture or interface design. s17.4Assess priorities structures in one or more levels by iteratively checking if it needs to resolve lower level conflicts. s17.7Select highest priority requirements set.	
ACP_5	s1.2Find whether "cost" is important criteria. s3.1Value-centered approach planning activities criteria, such as: effort, risk, complexity of implementation, familiarity with technology etc. s5.1After requirements elicited, identify quality attributes as quality criteria and define them as quality features. s6.1Select the Selected Evaluation Attributes (SEAs) as ranking criteria. s10.2Based on the project context, set Prioritization Criteria by estimating business value, negative value and risk. s16.3Add additional criteria of requirement clustering prioritization, defined by stakeholders, like risk factors. s17.5Determin the decision objective.	Develop requirement criteria based on the necessary factor or objectives, like risk, effort, value.
ACP_6	S10.8Prioritize the project backlog (the ordered list of requirements) and its sub-set (sprint backlog) for the next iteration implementation. s15.5Requirement clustering. s16.1Clusters of identified requirements are passed to various automated clustering algorithm modules (including 8 steps). s16.4Triage: classify requirements into group list. (Top 20% is put into "must have", then next 20% to "recommend having", and so on to "nice to have", "can live without" and "defer".) s17.2Establish requirement subsets(cluster) of the total requirement.	Classify requirement into subset/cluster.
ACP_7	s9.4 Scenarios identification (The test scenarios are identified by recognizing the faulted test case). s12.3developing scenarios (a narrative form that can capture use and context) to support design, like representation of contextual factors. s12.5Identifying and recording user needs in scenarios with users. s17.3Establish priority dimensions (The definition of different priority level) according to the project background.	Get requirement specification and priority from identified scenario.
ACP_8	s6.5 Generate requirement dependency graphs (RDGs) based on the contribution and business dependencies. s12.2 Modelling the context: draw rich picture interview and conceptual model in vivid cartoon to help understand context. s14.4 Plots the relative value and implementation cost on the cost-value map.	Plot estimated factors or dependency on graphs to support priority analysis.
ACP_9	s1.3If cost is vital, use EVOLVE method; If not, continue following steps. s14.3Experienced software engineers use AHP's pairwise comparisons to estimate the relative cost of implementing each candidate requirement.	Set cost-estimation as vital factor.
ACP_10	S4.1Develop a list of stakeholders and assign weights to each stakeholder by comparison matrix. s4.2Using fuzzy language terminology to identify stakeholder concerns over conflicting requirements in pairwise comparison matrices. s4.4Finding an alpha value based on an algorithm can achieve a compatible total ordering to ensure that the conflicting requirements agreed by all stakeholders are finally resolved. s6.3Stakeholders are asked to select and prioritize a certain number of requirement pairs as the sampled requirement pairs (Srps). s10.4Input from developer: consider the developer's perspective. s10.6Input of "learning experiences" (new insights from developer or client during project).	Consider the perspective of various stakeholder, including developer, which may be useful to requirement conflicts or changes.
ACP_11	S4.3Using the matrix and the algorithm to calculate the aggregated fuzzy weight for each requirement.	Set the weight number on the

	S12.7 Lead a set of requirements and weight them S13.1 A requirement may be associated with a weight to reflect its priority. The weight can be a real number or a linguistic value.	requirements
ACP_12	S9.5 Mapping test cases to requirements (For each faulted test case, the related functional requirement is identified as it can be seen in table.) S12.4 Analyzing models: mapping pieces of scenario text to activities in the conceptual model.	Link requirements to concepts (such as scenarios) or other activities (such as testing) to help analysis

Table A5: Common Advantage of Academic Model

Academic Common Advantage ID(ACA_ID)	Reference ID + Extracted Advantage	Description of Academic Common Advantage
ACA_1	s1.1 A simple solution model proposed by the author helps identify the most prominent technologies and key features of requirement priorities. s2.1 When ordering accuracy is the main problem and the number of requirements is small, AHP takes precedence over CBRanking. s2.2 When the effort takes precedence over the ranking accuracy, CBRanking is preferred. s15 The proposed method extracts multidimensional statistical features and assess specific information contained between requirement and requirement, it is particularly suitable for the development of automated tool support for requirements management and analysis.	The model helps determine the most prominent technology and key features of requirement prioritization.
ACA_2	s1.2 Ensuring that the right best priority technology is selected based on any RFP submitted by the customer. s8.1 IPA can prioritize functional and non-functional requirements for faster execution and can produce reliable results. s8.2 Because IPA calculates the non-functional demand priorities associated with functional requirements, this can improve the accuracy of the final results. s13.1 Identify the relative order of requirements based on the importance of the requirements. s16 This paper proposes a technique for automating priority requirements and original feature requests for large projects with thousands of requirements, which can automatically perform low-level and arduous classification tasks. s17.1 Provide multidimensional priority information, so that the correct standard in any decision-making.	Produce the more relative, accurate or optimal requirement prioritization.
ACA_3	s4 This prioritization method utilizes the eigenvalue to acquire the weights of stakeholders. It adopts Fuzzy AHP to gain the comparison matrices. Finally obtain the integrated matrix which reflecting all stakeholders' expectations. s12.1 The approach we propose provides a structure for the process of conceiving and analyzing hypothetical uses. s12.2 Soft system technology provides an abstract description of the activities that are critical to the working environment of the hypothetical opportunity. s14.2 Through cost-value diagrams, which let management take action to maximize stakeholder satisfaction. s17.2 Determine priority in the structure, in order to more effectively use the existing technology by reducing the demand for priority must be processed.	Method can get information from more stakeholders or aspects in a more structured process to support prioritization.
ACA_4	s5.2 It is easy to use by using a simple spreadsheet. S6.1 DRank improves the ease of use by its "ranking criteria selection". s7.2 easy to implement. S7.3 easy to parallelize. s14.1 The cost approach complements the traditional approach (AHP, dusty-as-laboratory approach) because it is more visual and easier to use. S17.3 Provide flexibility to suit specific project requirements.	The proposed model is easy and flexible to use.
ACA_5	S6.2 DRank uses a machine learning algorithm (RankBoost) to reduce the human labor cost.	Determine the requirement

	s7.1correct a large amount of data, s9Use early mutation testing and dependency analysis to prioritize functional requirements. s10.1The author uses GT to derive a conceptual model from the case study data to clarify the RP in the agile project, which fills the gaps in the current agile RE literature. s11Tools are useful in software maintenance tasks such as driving code for improvement activities and regression testing.	prioritization by algorithm or automated tool for some improvement, like labor saving, accuracy of large scale.
ACA_6	s3 Provide valuable insights on overall prioritization. It also provides a model to help compare newly discovered requirements (or change requests) with existing requirements to better determine their overall value. s6.3DRank exploits the contribution dependencies between requirements to measure the requirement criticality. S10.2The authors also found that "priority standards" and "commercial value", as well as some changes appear related to the project background characteristics. S13.2 Identify the importance of the requirements and achieve an effective trade-off between conflicting requirements.	The method can support analysis on wider range of factors, like change, important value, and dependency.
ACA_7	s5.1The proposed methodology creates a unified measurement to meet the quality attribution for the project and requirement. s5.3It's easy to extend to other quality attribution which is not considered. s6.4 DRank improves the requirement prioritization process by combining subjective preferences and objective requirement relationships, which improves the quality of the prioritization sequence and reduces the influence from stakeholder's experience.	Consider quality attributes.

Table A6: Limitation

Academic Common Limitation ID (ACL_ID)	Reference ID + Extracted Limitation	Description of Academic Common Limitation
ACL_1	s2.2During the experiment, the small number of statistics will also affect the reliability of the data. s9At present, only a priority strategy is proposed, and there is a lack of evaluation of a large number of experiments and software projects. s10This paper only proposes conceptual model which is not supposed to be validated against the data that has been used for the development of the model，lack of accuracy and reliability. s15.1Using only one case study analysis, there will be errors, not detailed and inaccurate.	The reliability or accuracy of the method needs further validation by more data.
ACL_2	s4.1Since the different system has different constraints, so that it cannot meet the stakeholder's all expectation. s12The soft system technology and scenario-based design used do not systematically support user requirements, technical solutions, and their interrelationships.	Different constrains or situations induce the method difficult to meet requirements systematically in most extent.
ACL_3	s7Although the accuracy could be guaranteed while the number of requirements increased, it still takes a lot of time, because as requirements increases, the complexity will also increase (O(n^2)). s14.1When the user performs a pairwise comparison of requirements, it will be tedious and sometimes distracting. s14.2 As the number of pairwise comparisons is O (n2), more requirements will increase the complexity of the problem.	The increased scale or accuracy of requirement prioritization will induce to increase violent complexity or time cost.
ACL_4	s5When a customer asks to impose a requirement, the requirement becomes a priority requirement, and the method proposed by the author will be invalid. It shows that this method cannot handle the change. s13.Because of the complex relationship between the customer, the customer is often difficult to point out the importance of demand accurately.	The subjective factors of customer induce changes or pointing-deviation of requirement in the prioritization method.

	s17Changes in decision objectives during system development may lead to defects in the prioritization method.	
ACL_5	s11Because the proposed method and the existing method lack complementarity, it is impossible to accurately realize the current user's needs and the system's demand priority. s15This method is based on assumptions that the eventual objectives are implicitly captured and correlated with the latent semantic and informational characteristics of the requirements. But it may not always be true and information characteristics will affect the relative priorities of the requirements.	Procedure complementarity: the method cannot be precise enough because its procedure design lacks requirement specification.
ACL_6	s1.1The model proposed by the author does not describe in detail how to determine the essential factors of an IT company project. s3.1The model has no enough hierarchies of goal levels for information analysis and therefore waste extra labor to set goal-level. s3.2The automation tool of the model cannot visualize the prerequisite/dependency of requirement, but rely on comma separated list of requirements.	The model design cannot effectively support the "analysis", lack of detailed way to select essential factors, goal-level setting, or automation tool for dependency visualization.
ACL_7	s6.1DRank requires the requirement dependencies to be identified and evaluated beforehand, which is a difficult task. s6.2DRank only supports contribution dependencies and business dependencies, no other types of dependencies. s8.1Incompleteness: only considers the fact that there is no relationship between functional and non-functional requirements. s8.2The prioritization method proposed in this paper does not consider the dependency.	The prioritization method cannot effectively deal with dependencies among requirements or even with other factors (like business).
ACL_8	s2.1In the CBRanking method, the ordering accuracy is the main problem, and the number of requirements is relatively small. s4.2The author thinks the project manager could use preference ordering to ascertain the integrated. However, it still cost a lot of time and lack of accuracy. s16.Since the method is based on data mining and information retrieval techniques, these techniques are inherently probabilistic and therefore have no high precision.	The design of method still cannot ensure the prioritization precision.

Data Extraction of Survey

Table A7: Practical Method from Interview

Interview ID	Execution procedure	Priority Calculation	Automatic Usage	Academic Reference Tailor
1.	1. Based on the customer's requirements and cost estimates 2. Determine whether the requirements are emergent. 3. Estimated value and influence.	a.4 factors get its score ranging from 1 to 5. b.Add up the five factors of the requirement, get the final score, prioritize the requirement by the total score. c.The priority should be reversed through your understanding of the needs. Then you can adjust the order slightly.	-	KANO model. But it doesn't suit the monopoly industries, only a few customers. In toC, requirement priority is more vital.
2.	1. Important customer requirement regard as urgent requirements. 2. Using own development processes (called the IPD development process).	a.we conduct requirement analysis using the $APPEALS tool, which is used to understand customer needs and determine the product's position in the market through the IPD model.	"$APPEALS" is a combination of 8 factors. We use these 8 factors to understand the needs of our products: Price, Availability, Packaging, Performance, Easy to use, Assurances, Life cycle of cost, Social acceptance. Briefly, is to refine the needs of a particular feature point to the home system.	-
3.	1. Communicate with customers, understand and determine requirements. 2. Priority of requirements is sorted by customer definition	a.The priority of general requirements is sorted by the customer definition. Implement the requirements one by one.	-	-
4.	1. According to the functional requirements and non-functional requirements, the functional requirements are first and the non-functional requirements are later. 2. The specific ordering is based on the importance of the requirements and is divided by the dependency relationship.	a.Make a sort of order list and make a rank for requirements(rank1-rank5). b.Judge based on individual subjective experience. c.Divide requirements into several chunks, such as basic requirement, and then sort each requirement into the chunks.	Trello tool for a while. But Trello's requirement tracking did not meet the expectations.	-
5.	Prioritize based on major or secondary features of the product	a.Referencing to "DiDi", What are the daily operations, as the main requirement.The rest are secondary needs.	-	-
6.	1. the superior unit, such as a group or national government department, proposed requirement	a.Function point method: estimate according to the function number and	-	-

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	has the highest priority; 2. For other requirements, from the generality and complexity of the assessment, the complexity is mainly assessed by the software development workload. (1) Priority of general-purpose functions and complexity; (2) Non-generic features, personalized needs, and high complexity, with the lowest priority.	technical influence factor of the software, and measure the software scale based on the user requirement perspective. b.Code method: Estimate the number of lines of source code of software products, which is related to development language, and used for internal accounting of manufacturers. c.Analogy: Estimate workload through comparison between new projects and historical projects, reasoning based on historical cases. d.Expert Judgment Method: Quantitative assessment based on expert scoring, relying on subjective experience of experts.		
7.	1. Everyone sorts the requirements. 2. Summarize the rankings and eliminate the final result through consolidation.	a.It is rare to assign values to requirements, which are usually sorted directly.	No tool. Tool wastes time. Prioritization should not be tough.	Rarely use academic method in practical work, even I know the 100-dollar method.
8.	1.Based on the dependency between models, identify models that needs finishing firstly or other cannot be started 2. As the project progresses, the correlation between modules will decrease. This time mainly based on customer's satsfaction.	a.No algorithm or value point. Customer dominates the priority.	Only Excel to list requirement items.	-
9.	1.Hold meeting with all stakeholder to get their detailed requirement description. 2.Plan poker: per stakeholder show a num as priority value. 3.Show the number and discuss for team satisfaction. 4.Get consensus and arrange the sprint backlog by requirement priority.	a.Ask each of stakeholder to show his value (0,1,2,3...) b.Through the meeting to discuss and figure out the value satisfy everyone. c. Start job from bigger value to smaller value.	No necessary to do so. As once you figure out how to use it, you don't actually need the tool.	-
10.	The requirements are prioritized by Project management, technology principal, product management and customer representative meeting together and discussing.	a.The prioritization ranking is based on the customer importance, Product value and implement time, the requirement could be divided into general/special requirement, or short-term implementation / Next-version implementation / long-term until mature technology implementation	-	-
11.	1. Evaluated by four ranking level, consisting of urgent level/important level/not urgent level/not important level. 2. Concerned whether the development cycle and	a.Consisting of urgent level/important level/not urgent level/not important level.	Use our company-internal developed system to manage the tasks	-

	development employees are enough. 3. Give priority to the requirement of the company's important bidding projects and company's key customer.			
12.	1.After requirement sent from customer, we prioritize the requirement by degree of importance or urgency, such as requirement needs to done ahead or other cannot start. 2.Mix small requirement of low effort expense into high priority requirement. 3.Consider how long to finish this requirement. 4.Potential dependency: whether the requirement only can start after another requirement finished.	a.Briefly grade priority based on customer's saying. Normally, bug fix is the highest priority, while new feature and improvement is lower.	Jira. Usage efficiency depends on teams and user. Tool takes extra time to use, but actually we don't strictly follow the plan schemed by this tool.	Agile management, and our requirement prioritization method is from Agile development. But it needs a dedicated requirements analyst.
13.	1. The degree of importance (1>2>3) 2. The degree of urgency (1>2>3) 3. The degree of Difficulty (1<2<3); 4. The degree of Cost (time required*days *personal*number of people); value (1>2>3). 5. Disagreement requirement will be negotiated by the team.	a.The important degree(1>2>3) , urgency (1>2>3), Difficulty (1<2<3), Cost (Time/days * staff input/Number of people), value (1>2>3). Give importance, urgency to score 1-3, 1 is the most important; while the degree of difficulty from 1-3, 3 is the most difficult.	No tool. Small team doesn't need.	"Inspired: How To Create Products Customers Love", the value generated from REs should be considered into assessment meeting.
14.	1.Develop a (urgent/important) two-dimensional table based on business goals 2.After the requirements are usually obtained, a requirement refinement session is performed with the product team. 3.Set the human resources required for each requirement and give each requirement the equity. 4. Set up the required human resources for each requirement, and generally give each requirement effort.	a.Divide requirements into 3 level: high, medium, low.	Use trello to integrate all the requirements.	The urgent and important 2D charts is learn from the articles.

Table A8: Common Procedure of Practical Model

Practical Common Procedure ID(PCP_ID)	Interview ID + Extracted Procedure	Description of Practical Common Procedure
PCP_1	2.1Important customer requirement regard as urgent requirements. 3.1Communicate with customers, understand and determine requirements. 3.2 Priority of requirements is sorted by customer definition 3.a The priority of general requirements is sorted by the customer definition. Implement the requirements one by one. 4.b Judge based on individual subjective experience. 6.1 the superior unit, such as a group or national government department, proposed requirement has the highest priority; 8.2As the project progresses, the correlation between modules will decrease. This time mainly based on customer's satisfaction.	Determine high requirement priority based on vital customer specification, not by algorithm or model.

	8.a.No algorithm or value point. Customer dominates the priority. 11.3Give priority to the requirement of the company's important bidding projects and company's key customer. 12.a Briefly grade priority based on customer's saying. Normally, bug fix is the highest priority, while new feature and improvement is lower.	
PCP_2	7.1. Everyone sorts the requirements. 7.2Summarize the rankings and eliminate the final result through consolidation. 7.a.It is rare to assign values to requirements, which are usually sorted directly. 9.1.Hold meeting with all stakeholder to get their detailed requirement description. 9.2 Plan poker: per stakeholder show a num as priority value. 9.3 Show the number and discuss for team satisfaction. 9.4.Get consensus and arrange the sprint backlog by requirement priority. 9.a Ask each of stakeholder to show his value (0,1,2,3...) 9.b Through the meeting to discuss and figure out the value satisfy everyone. 10.The requirements is prioritized by Project management, technology principal, product management and customer representative meeting together and discussing. 13.5Disagreement requirement will be negotiated by the team. 14.2After the requirements are usually obtained, a requirement refinement session is performed with the product team.	More stakeholders participate and hold a form of meeting to ensure the consensus agreement, or directly vote the priority in number or not.
PCP_3	4.1. According to the functional requirements and non-functional requirements, the functional requirements are first and the non-functional requirements are later.	The functional requirement has higher priority.
PCP_4	1.1. Based on the customer's requirements and cost estimates 1.3. Estimated value and influence. 6.aFunction point method: estimate according to the function number and technical influence factor of the software, and measure the software scale based on the user requirement perspective 6.2. For other requirements, from the generality and complexity of the assessment, the complexity is mainly assessed by the software development workload. (1) Priority of general-purpose functions and complexity; (2) Non-generic features, personalized needs, and high complexity, with the lowest priority. 11.2 Concerned whether the development cycle and development employees are enough. 12.2Mix small requirement of low effort expense into high priority requirement. 12.3Consider how long to finish this requirement. 13.4. Cost (time required*days *personal*number of people); value (1>2>3). 14.3Set the human resources required for each requirement, and give each requirement the equity. 14.4. Set up the required human resources for each requirement, and generally give each requirement effort.	Estimate Cost (enough labor, time, effort, complexity workload), impact or worth of requirement as priority metric. Prefer the easier implementation.
PCP_5	8.1.Based on the dependency between models, identify models that needs finishing firstly or other cannot be started. 12.1After requirement sent from customer, we prioritize the requirement by degree of importance or urgency, such as requirement needs to done ahead or other cannot start. 12.4.Potential dependency: whether the requirement only can start after another requirement finished	Prioritize requirement according to requirement dependency that one ends and then one starts.
PCP_6	1.2. Determine whether the requirements are emergent. 1.3 Estimated value and influence. 4.2 The specific ordering is based on the importance of the requirements and is divided by the dependency relationship. 10.aThe prioritization ranking is based on the customer importance, Product value and implement time, the requirement could be divided into general/special requirement, or short-term implementation / Next-version implementation / long-term until mature technology implementation 11.1. Evaluated by four ranking level, consisting of urgent level/important level/not urgent level/not important level. 11.a Consisting of urgent level/important level/not urgent level/not important level. 13.4The degree of Cost (time required*days *personal*number of people); value (1>2>3). 13.a The important degree (1>2>3)，urgency (1>2>3), Difficulty (1<2<3), Cost (Time/days * staff input/Number of people), value (1>2>3). Give importance, urgency to score 1-3, 1 is the most important; while the degree of difficulty from 1-3, 3 is the most difficult.	Use levels/scales, consisting of importance, emergency, difficulty or dependency, as priority metric.
PCP_7	1.a 4 factors get its score ranging from 1 to 5. 1.b.Add up the five factors of the requirement, get the final score, prioritize the requirement by the total score. 4.a Make a sort of order list and make a rank for requirements(rank1-rank5).	Requirements are divided into different metric levels/degrees in ordinal or interval scale.

	4.c Divide requirements into several chunks, such as basic requirement, and then sort each requirement into the chunks. 5. Prioritize based on major or secondary features of the product 9.cStart job from bigger value to smaller value. 13.1. The degree of importance (1>2>3) 13.2. Urgency (1>2>3), 13.3The degree of Difficulty (1<2<3); 14.a Divide requirements into 3 level: high, medium, low.	
PCP_8	2.a we conduct requirement analysis using the $APPEALS tool, which is used to understand customer needs and determine the product's position in the market through the IPD model. 2.2Using own development processes (called the IPD development process). 14.1Develop a (urgent/important) two-dimensional table based on business goals	Use a developed tool/model to support analysis on more scopes for prioritization, like business or market.
PCP_9	6.bCode method: Estimate the number of lines of source code of software products, which is related to development language, and used for internal accounting of manufacturers. 6.cAnalogy: Estimate workload through comparison between new projects and historical projects, reasoning based on historical cases.	Estimate workload by artifact data for prioritization, like code line or historical project record.
PCP_10	1.c.The priority should be reversed through your understanding of the needs. Then you can adjust the order slightly. 5.a.Referencing to "DiDi", What are the daily operations, as the main requirement. The rest are secondary needs. 6.dExpert Judgment Method: Quantitative assessment based on expert scoring, relying on subjective experience of experts.	Prioritize requirements depending on practitioner's experiences on job.

Table A9: Evaluation to Practical Method

Interview ID	Practice Cases	Advantage	Limitation	Vital Challenge to Improve
1.	Deal with emergencies and to report periodically to make customers satisfied.	Customers will be more satisfied with the job for urgency or stage report.	1. Cost is relatively large. 2. The project is easy to be influenced by the customer. 3. In order to fulfill some of the requirements and give up some other requirements	1. In toE, client is the biggest, so prioritization needs to balance the stage goal and the customer concern. This will help construct the design versatility for a long-term development.
2.	1. The industry's unified standard is that this feature is common to everyone and you must develop it. 2. Customer requirement, will not be completely in accordance with customer requirements development. 3. Testing or certification, after these tests or certification.	-	1. The method is not suitable for the small corporation, because the method need large manpower. 2. Model is not suitable for development scenarios that are full of variables and challenges. 3.It is difficult to solve the problem that the technical level of developers is different.	1. Control the progress and risk.
3.	The company is focused on image processing, it refers many apps, such as beauty applications APP, Mito Xiu Xiu APP and so on.	1. Our approach is more intuitive 2. There is no complicated process. Because there are few people, we can open a small meeting. 3. Staff in different positions can discuss each other.	1. Since the simplicity, the rigor of the requirements is not high, there are obstacles to realizing the requirements. It takes a long time to solve the problem.	1. The human resources need to be increased because a small number of people cannot increase the requirement.
4.	The company using the Trello tool in the production of newspapers.	You can customize some rules to manage your own requirements.	Communicate with team members and told them how to use Trello. This will	It is difficult to manage the requirements to record the circumstances of its

			add extra time and human resources.	completion and the planned time.
5.	A kind of Taxi App, similar to the DiDi or Uber App.	It is convenient and very cheap for our customer.	Currently, the App is only an initialization software, it is a prototype. We need to keep testing and adding new function by asking new requirement from customers.	-
6.	Internet service, Mobile communication service, Broadband network services	-	-	-
7.	A small game app and a H5 app.	1. The advantage is that it includes all relevant opinions and ideas. 2. Method is very fast.	People who give you their prioritization order won't try their best to cooperate with you. They just give you a random sequence and then do their own thing.	During the prioritization, we can't work individually, this will have a personal inclination, we need to work together.
8	Related to company business (Privacy).	-	-	1. Time cost control is vital. 2. Good project manager with professional knowledge on development.
9	Global working team projects. Its challenge is different time zones	Flexible to arrange, quick.	1.To conduct it, all members should be experienced enough. 2.Consensus is reached by leader and the junior is neglected.	1. New worker need enough training to understand how to conduct the method
10	this model is suitable for the software project which is greater tolerance for product deviation.	-	The model is hard to manage, currently, we use excel form to make record.	1. Requirement prioritization model should be easy to use, accurate and efficient evaluation model. 2. It also can estimate the changing requirements, 3. Reduce the deviation between requirement changes and goal implementation.
11	Produce the security product	1. We can do whatever we need to do. 2. We have fast iteration.	There is less time for self-reflection.	1. summary the true requirement from the large amount of clue 2. between product requirement and coding in practice, trace development progress
12	Also some internal projects managing internal stuffs. Under this case, the method is not applicable and we put the job in low priority.	The advantages of our approach are more flexible and more compatible with the current project characteristics.	No standard. The method only records information of requirement easily described, but miss the tough to described.	To understand several REs or to quantify REs, such as how to weight the requirements. In practice, a customer's description says that this requirement is important, but he also says that another requirement is also more important, so which of the two requirements has priority.
13	Requirement will be adopted when there are disagreements within the team.	-	-	1. Discovering a requirement, make judgments on the requirement. 2. A whole team needs to

				participate in requirement assessment. More often to judge the requirement. 3. If the final decision is from compromise, the compromised scheme doesn't feel suitable for everyone.
14	Mobile and web app, as well as the server side.	1. Concise, the elements of weighing the requirements are very simple. 2. It is easy to distinguish the priority level.	1.Manpower arrangements cannot be measured. 2.Dependencies between individual requirements are difficult to control.	1. Less cost. 2. Integrated manpower.

Table A10: Common Advantage of Practical Method

Practical Common Advantage ID(PCA_ID)	Interview ID + Extracted Advantage	Description of Practical Common Advantage
PCA_1	1Customers will be more satisfied with the job for urgency or stage report. 5.It is convenient and very cheap for our customer. 7.1The advantage is that it includes all relevant opinions and ideas.	The method can more satisfy the customer's perspective.
PCA_2	4.You can customize some rules to manage your own requirements. 9.Flexible to arrange, quick. 11.1 We can do whatever we need to do. 12 The advantages of our approach are more flexible and more compatible with the current project characteristics.	Models can be used flexibly
PCA_3	3.2There is no complicated process. Because there are few people, we can open a small meeting. 3.3Staff in different positions can discuss each other.	There is no complicated process, just a meeting to discuss.
PCA_4	7.2Method is very fast. 9 Flexible to arrange and quick. 11.2. We have fast iteration.	The model is fast or has fast iteration.
PCA_5	3.1. Our approach is more intuitive 14.1. Concise, the elements of weighing the requirements are very simple. 14.2It is easy to distinguish the priority level.	The method is easy, concise and intuitive to identify priority.

Table A11: Common Limitation of Practical Method

Practical Common Limitation ID(PCL_ID)	Interview ID + Extracted Limitation	Description of Practical Common Limitation
PCL_1	2.1The method is not suitable for the small corporation, because the method needs large manpower. 4 Communicate with team members and told them how to use Trello. This will add extra time and human resources. 14.1 Manpower arrangements cannot be measured.	The method usage encounters manpower issues: high labor cost, skill learning, labor estimation, cooperation.
PCL_2	1.2The project is easy to be influenced by the customer. 5 Currently, the App is only an initialization software, it is a prototype. We need to keep testing and adding new function by asking new requirement from customers. 7.People who give you their prioritization order won't try their best to cooperate with you. They just give you a random sequence and then do their own thing.	The customers will affect prioritization and specification.
PCL_3	1.3 In order to fulfill some of the requirements and give up some other requirements 14.2dependencies between individual requirements are difficult to control.	Trade-off of requirement dependency is a challenge.
PCL_4	2.3 It is difficult to solve the problem that the technical level of developers is different. 9.1 To conduct it, all members should be experienced enough. 9.2Consensus is reached by leader and the junior is neglected.	The stakeholder cannot be all knowledgeable enough, which may induce the communication limited in a circle.
PCL_5	3.1 Since the simplicity, the rigor of the requirements is not high, there are obstacles to realizing the requirements. It takes a long time to solve the problem. 12No standard. The method only records information of requirement easily described, but miss the tough to described.	The method lacks the rigorous form to record requirement specification.
PCL_6	1.1 Cost is relatively large. 2.2 Model is not suitable for development scenarios that are full of variables and challenges. 10 The model is hard to manage, currently, we use excel form to make record. 11There is less time for self-reflection.	The model design is not competed in many aspects for its usage: high cost, poor change flexibility, tough usage management, no self-reflection phase.

Table A12: Common Challenge of Practical Method

Practical Common Challenge ID(PCC_ID)	Interview ID + Extracted Vital Challenge	Description of Practical Common Challenge
PCC_1	3.1 The human resources need to be increased because a small number of people cannot increase the requirement. 7.During the prioritization, we can't work individually, this will have a personal inclination, we need to work together. 8.2Good project manager with professional knowledge on development. 9.1New worker need enough training to understand how to conduct the method 13.2A whole team needs to participate in requirement assessment. More often to judge the requirement. 13.3If the final decision is from compromise, the compromised scheme doesn't feel suitable for everyone. 14.2Integrated manpower.	Human resource issue: cost, cooperation, learning-curve, practitioner ability, team together participation, and consensus agreement (not compromise).

PCC_2	1.1 In toE, client is the biggest, so prioritization needs to balance the stage goal and the customer concern. This will help construct the design versatility for a long-term development. 12 To understand several REs or to quantify REs, such as how to weight the requirements. In practice, a customer's description says that this requirement is important, but he also says that another requirement is also more important, so which of the two requirements has priority.	Impact and specification of Stakeholder's will.
PCC_3	4 It is difficult to manage the requirements to record the circumstances of its completion and the planned time. 11.2. between product requirement and coding in practice, trace development progress	Trace the requirement management.
PCC_4	2.1 Control the progress and risk. 8.1. Time cost control is vital. 10.2 It also can estimate the changing requirements, 10.3 Reduce the deviation between requirement changes and goal implementation. 14.1 Less cost.	Vital factor control for method conduct: cost, time, risk, change estimation.
PCC_5	11.1 Summary the true requirement from the large amount of clue 13.1 Discovering a requirement, make judgments on the requirement.	Requirement elicitation and specification.
PCC_6	10.1 Requirement prioritization model should be easy to use, accurate and efficient evaluation model.	Easy using but also accurate.

Extracted Interview Transcript

Interview 1

1.What is the model/method you use when doing requirement prioritization? Please describe its using process.

Requirement finite ordering generally, we will use the following methods to determine the priority of the requirement:

I. Whether it meets the goals of the project at this stage?

Generally, the projects we do are relatively large, and the entire requirements, design, development, migration, and operation and maintenance are continuously iterative.

For example, the BSS project is divided into many centers such as business acceptance, customer, CPC center, billing, and marketing. When undertaking such projects, the first goal of going online in stages is to complete the landing of data entry: Business acceptance. , customers, billing, related basic data and basic models related to these three centers are also the main objectives of this stage. Follow-up based on the new business model and data model to complete data analysis, continue to center marketing and other landing

II. Second, is it urgent to solve?

It based on emergency level

III. Third, how much value and impact will be generated after the completion?

Also, for example, in the center of business acceptance, customer center, billing, etc., directly related to some basic business models that need to be configured, the associated CPC center may need to complete most of the relevant requirements at this stage. Design, development work.

IV. Fourth, how much does it cost? (human resources, money, time)

The four factors are used to prioritize the requirements, and each factor scores the requirement based on importance/emergency/easiness. The score ranges from 1 to 5 (5 points, 10 points, 100 points). Then add up the five factors of the requirement, get the final score, prioritize the requirement according to the total score, and then there may be a situation, even though the total score of requirements is higher than the other, you should feel that the priority should be reversed through your understanding of the needs. Then you can adjust the order slightly.

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?

(No answer)

3.Do you build your requirement prioritization method/model into a software tool to automate its usage, like using Trello, Teambition? If so, do you think this tool makes your requirement prioritization model/method more efficient? Even, if there is no this tool, you won't use your model/method anymore because it is too complex?

(No answer)

4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?

The above requirements sorting methods and steps are more suitable for the main business needs and will not add many new requirements. The final score is generally a high score for the propensity goal. If some other highly competitive industry, for example, the e-commerce system, at the same time will have to meet the requirements, we need to consider some charm to increase the flow characteristics of the system are introduced. At this time, the priority of the requirement may change greatly.

5.What is the advantage of the requirement prioritization method you use? & 6.What is the disadvantage of the requirement prioritization method you use?
The advantage is that in the whole operation process, customers will be more satisfied with the job for urgency or stage report. However, the cost is relatively large relative to the entire company. It is easy to be led by the customer. For some stage goals, some of the design's versatility was abandoned.

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?
Learn from the KANO model, but this model is relatively unsuitable for use in monopoly industries (Only a few monopolies customers who cannot reflect the value of your product), more suitable for toC scene.
In the scenario of toC, the requirement is very wide. The requirement priority directly affects whether the company can survive.

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?
The most important factor I think is the needs of the stage goals and the concern of customers. In toE, the client will be the biggest factor. In a long-term, the design versatility of the entire system can be used across industries and is an important factor for long-term development.

Interview 2
1.What is the model/method you use when doing requirement prioritization? Please describe.
Judging the priority of requirement based on whether the requirements is urgent or not, the requirement of important customers will generally be listed as urgent requirements.
At Huawei company, we have our own set of development processes called the ipd development process. The advantages are: the shortened development cycle; the reduced product cost and the product quality is generally improved.
For requirement analysis, we conduct requirement analysis using the $APPEALS tool, which is used to understand customer needs and determine the product's position in the market through the IPD model.

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?
(No answer)

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?

(No answer)

4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?
Feel are similar, usually from:
1. The industry's unified standard is that this feature is common to everyone and you must develop it.
2. Customer requirement, will not be completely in accordance with customer requirements development.
3. Testing or certification, after these tests or certification.

Large and small companies are similar, with products mainly about the relationship between the state, the requirement for new products is relatively small.

5. What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?
I never thought about the advantage.
But I think that Huawei's method does not apply to small companies because small companies do not have enough manpower.
And the existing requirement model is not suitable for development scenarios that are full of variables and challenges. Sometimes the first time you do not know how many pit road, and therefore can not give a progress schedule.
Huawei's solution is a radish pit. Everyone has their own duties and outputs are available at each stage. However, it is also unable to guarantee progress, and it is difficult to solve the uneven level of developers. In addition, changes in requirement will lead to overtime, resulting in higher costs. In addition, the progress of the project will become tight.

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?
(No answer)

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?
I think that for new products, of course, the first release of a usable basic version is the most urgent. It is the most important to update existing products, to ensure the stability of the original functions and to meet customer requirements. I think it is still the progress and risk control.

Interview 3
1.What is the model/method you use when doing requirement prioritization? Please describe how to apply it.
For the requirement prioritization model, we didn't understand too many models. We only communicated with customers, understood and determined the requirements, and then handed it to our programmers for implementation. The priority of general requirements is sorted by the customer definition.
Additional question: Could u told me some information about your company?
My company is focused on image processing, such as beauty applications APP, Mito Xiu Xiu APP and so on. The company scale is relatively small and employs about 60 people.

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?
(No answer)

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?
(No answer)

4. In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?
We are only responsible for completing it. Because for our APP, the requirement itself is not difficult, nor complicated. We only need to implement it one by one. When we encounter some functional requirements that cannot be achieved, we will negotiate with customers within a week and update the list of requirements.

5. What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?
Advantages: I think it is more intuitive and there is no complicated process. Because there are few people, we can open a small meeting. Staff in different positions can discuss each other.
Defects: Because of the simplicity, the rigor of the requirements is not high, and sometimes there are obstacles to realizing the requirements. It takes a long time to solve the problem. The efficiency of the employees will be very low during this period.

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?
(No answer)

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?
I think the most important factor in the development of requirement is communication. We don't have complicated formal development models, but we wins in few people. We can use sufficient time to understand each customer's needs and give their own ideas.
In terms of improvement, I think the human resources need to increase because the number of people cannot increase the requirement.

Interview 4
1.What is the model/method you use when doing requirement prioritization? Please describe how to apply it.
We divide the requirement into functional and non-functional requirements, with functional requirements first and non-functional requirements behind. The specific sorting is based on the importance of the requirement and is divided by the dependency relationship. For example, a system, he must have a login function to appear follow-up function.

Generally speaking, our consideration of requirements will begin with the most basic requirement, and will continue with the underlying requirement.

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?

In the case where the factory does not require a process, we generally do not have a document to record the requirement weight. Generally, we think that it is the first, or the factory set the priority. However, in a printing factory in Karlskrona, their managers were more rigorous and they would make a sort of order list and make a rank for requirement, with rank 5 being the highest and rank 1 being the lowest.

As to why we do not score the requirement, we usually judge based on our subjective experience. This is already relatively accurate. If you add another link to score the requirement, it will be very tedious and unnecessary. Of course, we also know that with the requirement specifications of consciousness subjective scoring more standardized, accurate than others.

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?

At the beginning, we did not use tools. Later, we also tried to use trello for a while, but we felt that trello's requirement tracking did not meet our expectations, so we didn't need it anymore.

We are using the trello tool in the production of newspapers. The effect was good in the early days. After a long period of requirement, I felt that the performance of the data was not clearly, so we give up.

4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?

Throughout the development process, as long as the project is not too small, it will generally exceed 100 requirements. But we will not put this hundreds of requirements scoring together, this is too complex and uncertain. Because when you complete a part of the requirement, some of the requirements need to be updated and adjusted. At this time, we need to re-order the entire requirements table, which will increase the extra workload.

Generally speaking, we will divide requirements into several chunks, such as basic requirement, and then we sort each requirement into the chunks.

Additional: Do you think that should or should not use software to help build the model, in the future development, will consider using another software to help.

In the future, we will consider increasing the use of software to record the requirement. This will be more convenient, because at present, we have encountered a small number of requirements, but we cannot guarantee that we will encounter hundreds or even thousands of them in the future. requirement.

5.What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?

Advantages: You can customize some rules to manage your own needs.

Disadvantage: Before using trello, you need to customize your own rules to communicate with team members and told them how to use trello. This will add extra time, human resources.

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?
No.

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?
The challenge is that it is difficult to manage the requirements to record the circumstances of its completion and the planned time. The reason is that people are not used to using tools to track related needs.

Interview 5
1.What is the model/method you use when doing requirement prioritization? Please describe how to apply it.
No, we haven't used any model.
After determining the product to be done in this area, we need to get some similar products' requirements.
With the market requirement for similar products to obtain relevant mature, prioritized according to the main secondary function of the product
Referencing to "DIDI" APP, What are the daily operations, as the main requirement. The rest are secondary needs

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?
No, we have not assessed the importance of requirement. In real status, we are less focusing on priorities.

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?
We have not considered using software tools. We know less about this kind of tools.

4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?
No, we haven't done any projects.

5.What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?
I don't know.

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?

No, i haven't.

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?

Currently, the App is only a initialization software, it is a prototype. We need to keep testing and adding new function by asking new requirement from customers.

Due to the new software development, we have faced a few challenge. In the future, once we face some challenge, we will talk together and try to fix it.

Interview 6

1.What is the model/method you use when doing requirement prioritization? Please describe how to apply it.

currently operators generally operate in the following manner

1) the superior unit, such as a group or national government department, proposed requirement has the highest priority;

2) For other requirements, from the generality and complexity of the assessment, the complexity is mainly assessed by the software development workload.

a. Priority of general-purpose functions and complexity;

b. Versatility, that is, personalized needs, and high complexity, with the lowest priority;

c. The universality function, the low complexity or the personalized function and the high complexity priority are between a and b.

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?

1. Function point method: estimate according to the function number and technical influence factor of the software, and measure the software scale based on the user requirement perspective

2. Code method: Estimate the number of lines of source code of software products, which is related to development language, and used for internal accounting of manufacturers.

3. Analogy: Estimate workload through comparison between new projects and historical projects, reasoning based on historical cases

4. Expert Judgment Method: Quantitative assessment based on expert scoring, relying on subjective experience of experts.

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?

I have never thought about it before.

4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?

I have never thought about it before.

5.What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?

I have never thought about it before.

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?

I have never thought about it before.

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?

Workload assessment also needs to be considered from the aspect of company strategy. Although some projects have low costs, they are in line with the development prospects of the company, but they will also be implemented first. For example, the current domestic government department is bidding for the cloud business.

Some items are sent free of charge, even as low as 1RMB. It is the company's strategic perspective, or these projects have a strong role in benchmarking.

Interview 7

1.What is the model/method you use when doing requirement prioritization? Please describe how to apply it.

The method of prioritizing requirements. Once I used one, I called all related people. Then let him each order the needs. Then I came up with a final result based on the sequence that each of them gave me.

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?

Rarely assign values to requirements, and generally they are directly sorted. Because assignment is a complicated matter, let me give you an example, if you want to give a value from zero to one hundred. Then you tell me what the difference is between 66 and 65.

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?

If you purely want to sort the needs, there is no need to use these tools. Tool just wastes your time. I think that sorting needs is a very simple matter.

4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?

I used this method in a small game project. Then also used the method on a question-answer H5 software.

In fact, the biggest challenge is that when you call someone who sorts them, they won't try their best to cooperate with you. They just give you a random sequence and then do their own thing.

5.What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?

The advantage is that it includes all relevant opinions and ideas. This output a comparatively average value. The key is that this method is very fast, and no one will be not convinced. Disadvantage is its challenge.

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?

If you look for these methods from a book or essay, let's say the classic one hundred dollars. Anyway, this method should be learned in your class. They are rarely used in practical work.

The book describes these methods very definitely. I think if I one day need them, I can just use it as what it is. But I have never tried to tailor them for usage.

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?

First of all, as for the prioritization model, first of all I do not recommend that a single person to use this model to output one conclusion, but also don't recommend that multiple people discuss together to output a result. What I suggest is that everyone prioritizes the requirement by themselves and then integrates each person's opinion into a final opinion. Because only one person sorts, there will be one's own tendency, but with multiple people together, the tendency will be controlled by one person who has the right to speak out in this group of people. Then you have to make sure that the people who do the sorting are all full of dedication on prioritization, not saying I just finish the sorting and can do his own thing.

When the team requires the requirement prioritization, then that is the real time you can start to do requirement prioritization. If you do it, then you need to finish it in one time, rather than divide the job into multiple days, just one time one day. Finally, the result must be published and announced.

Interview 8

1.What is the model/method you use when doing requirement prioritization? Please describe how to apply it.

Before we develop, when we make the RE sequence, we first look at the relevance and dependency between models. For example, these modules must be done first, or other modules cannot be started. In this case, we will first carry out this module. Then we must first do a more relevant module. Because if this module is not done, other modules will not be started. Overall, if one model is not finished, other cannot be started, and this model is of the highest priority.

In fact, there are not many related modules. Generally, only a few of the projects need to be developed at the beginning of the project. However, as the project progresses, the correlation between modules will decrease. The prioritization at this time is mainly based on customer requirements. Because we are now using agile development with customer together, sometimes the customer asks us which module to do first, so we must first do what module. We are mainly agile development, and customers will work with us to formulate requirements. However, the plans developed in the previous period are mostly disrupted by customers during the progress of the project.

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for

requirement sequence? If not, why not use the priority value to calculate the requirement sequence?

We don't make value point to calculate the prioritization. Our customers are very strong to us. The dominance of development belongs to us at the beginning and slowly it is grasped by customer, making the project progress very difficult. So how importantly a good manager we need!

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?

Only Excel to list requirement items.

4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?

Privacy.

5.What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?

I have never thought about it before.

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?

I have never thought about it before.

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?

Time cost is most important I think. Nowadays, project managers do not get any professional training. So when they prioritize requirements, they always do it in the easy way. However, I think they need to learn more professional knowledge of development or code for better prioritization.

(We insert question asking: What kind of prioritization method you may prefer? Is easy-using most important? Or a complicated method but it can work better?)

Depends on project. If the project is big, we can cost more on prioritization, but if small, we will choose the easier one.

Interview 9

1.   What is the model/method you use when doing requirement prioritization? Please describe how to apply it.

In our company, as we are doing our projects in an agile way. The prioritization method is called: planning poker. Generally speaking before each new sprint backlogs start, and we almost finished the previous sprint backlogs. we usually arrange one meeting including all the stakeholders. During the meeting we talk about the initial requirement description and modify it with more detailed info. Then each of us stakeholder shall play one card with a dedicated number which means priority. Then we all explained about why show this number, and will have a very serious discussion, in the end we will reach a consensus and arrange the several sprint backlogs according to its priority.

2.   Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for

requirement sequence? If not, why not use the priority value to calculate the requirement sequence?

Yes. We will value it. For this game the value we show is measured by each member's experiences based on the difficulty and time for conducting it. For the priority value here we use is static and defined already: 0, 1, 2, 3, 5, 8, 13, 20, 40 and 100.

The calculate way is: we ask each of the stakeholder to show his value (0,1,2,3,5,8,…) for each sprint backlog or task. Then of course we will have different opinions, so we discuss and figure out the value everybody satisfies. We mark them and in the end we make a desc order of all the value. We start our jobs from the bigger value to smaller.

3.   Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?

Once when I was a student in BTH, we have a course " Practical software management" tutored by Simon Poulding. I used the Trello for organizing the requirement prioritization process, but now when actually working. In company, there is no necessary to do so. As once you figure out how to use it, you don't actually need the tool. For me the tool is only for helping you understand how it works, it might help you organize your all sprint backlogs. But for us all are very experienced engineers so we actually no need to use it.

4.   In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?

Basically when conducting the global working team projects. We have several foreign client companies. When we do the projects for integration of the services for different platforms. We will launch an online zoom meeting. In such meeting the operation team, development team, Devops specialists, and the product owner will join together and choose using planning poker.

It is pretty good! If there is a challenge I would like to say: different time zones !

5.   What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?

Advantage: Flexible to arrange, quick!

Disadvantage: Need the team members all experienced enough to do so, and the sometimes the consensus will achieved and decided by the person who are most experienced or with higher title in a company. The opinion from junior engineer might not be addressed with enough attention. But sometimes such junior engineers are the people who understand the project in a very deeper way in details.

6.   What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?

Actually not in working, when I used to be a student. I did follow some, but not remember clearly now!

7.   What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?

Enough training for the new fresh employee. As such meeting really needs everyone fully join into it, and understand how to conduct it.

Interview 10

1.What is the model/method you use when doing requirement prioritization? Please describe its using process.

We don't use any model for prioritizing requirement. The requirements is prioritized by Project management, technology principal, product management and customer representative meeting together and discussing.

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?

The prioritization ranking is based on the customer importance, Product value and implement time, the requirement could be divided into general/special requirement, or short-term implementation/Next-version implementation/long-term until mature technology implementation and so on.

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?

In requirement, we doesn't use any tool or application, we have used teambition to arrange the working schedule.

4. In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?

In generally speaking, we will use the above model to our software project. I think this model is suitable for the software project which is greater tolerance for product deviation.

5.What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?

I don't know the specific advantage. And speaking to the disadvantage, in my view, i think the model is hard to manage, currently, we use excel form to make record.

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?

No, we havn't considered to learn from any books, essay or journy.

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?

I think a good requirement prioritization model should be easy to use, accurate and efficient evaluation model. It also can estimate the changing requirements, so to reduce the deviation between requirement changes and goal implementation.

Interview 11

1.What is the model/method you use when doing requirement prioritization? Please describe how to apply it.

Requirement prioritization model is evaluated by four ranking level, consisting of urgent level/important level/not urgent level/not important level. secondly is concerned whether the development cycle and development employees are enough. We also will considered important bidding project and important customers.etc.

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?
Not yet, we usually use our in-company developed system to manage the tasks, it's similar to the teambition.But we do not specifically to manage the requirements, more to think and discuss.

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?
No, I haven't think about it yet.

4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?
Our company is produce the security product, and the main project is similar to this kind of product.

5.What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?
Advantage: it meets the reality. we can do whatever we need to do. And we have fast iteration.
Disadvantage: We lack the individually thinking time, easily forced to do.

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?
Not exactly, haven't learned from any models from literature.

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?
We hope we can quick summary the true requirement from the large amount of clue, understand the different thinking between product requirement and coding in practice.
so, to trace development progress efficiently.

Interview 12
1.What is the model/method you use when doing requirement prioritization? Please describe how to apply it.
First of all, it's about how to prioritize. In our development process, after the requirement from the customer side is sent, we will first prioritize one sequence of requirement, which is the degree of importance, or the degree of urgency. For example, if a requirement needs to be used ahead, then the requirement must be completed first. For example, if a feature is dependent on other projects, it must be done first.
There is also the effort expense on this requirement. If the effort expense of requirement is relatively small, we can mix it in some higher priority needs. For example, if there is a thing that can be done in

a minute or two, then you can use this as a temporary task. Include it into some important high-priority tasks.

Then there is another indicator that we need to know how long time this thing will be finished. Finally, whether this project requires potential dependencies. For example, after other projects have been developed, this project can begin to develop.

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?

Although we do not have a clear measure to rank the requirement, we do grade the importance of the requirement. In general, customers will tell us which features are more important and which features are not important. Then, some of the requirements are an improvement, some of the requirements are a new feature, and some of the requirements are bug fixes. In general, bug fixes are ranked at the highest priority. With new features and improvements, we put it at a lower priority.

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?

We use Jira. We can create various tasks on Jira to prioritize tasks. As for whether he is convenient to use, in fact, this also depends on individuals or teams. In addition, there is no energy and time to maintain this tool, because this thing after all, it takes time to create and update. In reality, we are not very strict in following the plan developed by this tool.

4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?

We now have a single type of development project, but in some cases, our method may not be applicable. For example, it is like the project of some management company's internal staff, which is maintained by our internal personnel, and the customer is our own.

This requirement is usually put forward by ourselves and developed by us. The priority of such project requirements will be lower, because we have other projects that need to be done, and there is also a priority relationship between the projects.

5.What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?

The advantages of our approach are more flexible and more compatible with the current project characteristics. But the downside is that it is not standard enough. Some things should be done that we may not be able to do it. For example, our method can only write what of requirement easily described can be written into the plan, but some contents of requirement not easily described cannot be completely recorded in the plan.

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?

Agile method to help prioritize requirement. Then in agile development, there are also some better ways to conduct requirements management. But he will need a dedicated role analysis, such as a requirements analyst, to help us to sort or prioritize this requirement.

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?

I think that the most important thing for requirement prioritization is to understand several requirements, or to quantify requirements, such as how to weight the requirements. In practice, a customer's language description says that this requirement is important, but he also says that another requirement is also more important, so which of the two requirements has priority.

Interview 13

1.What is the model/method you use when doing requirement prioritization? Please describe how to apply it.

Firstly, we have requirement review meeting, our product will contact with development department, and then contact with Boss.

The review meeting is consist of several parts, the important degree(1>2>3) , urgency(1>2>3), Difficluty(1<2<3), Cost(Time/days * staff input/Number of people), value(1>2>3).
Generally speaking, if the opinions are inconsistent, it will be strictly played once. The core members of development, product, operation, boss, etc. will score.

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?

Will give importance, urgency to score 1-3, 1 is the most important; while the degree of difficulty from 1-3, 3 is the most difficult

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?

Without scoring with tools, I feel that the tool depends on the product stage. If it is a project of hundreds of people involved in research and development, we need to use tools to regulate it. We now have dozens of people and rely on communication.

4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?

Requirement will be adopted when there are disagreements within the team.

5.What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?

No concern.

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?

Inspired: How to Create Products Customers Love", the value generated from REs should be considered into assessment meeting.

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?

A scenario is when a product manager is digging and discovering a requirement, he self must make judgments on the requirement. On the other hand, more often, a whole team need to participate in requirement assessment. More often to judge the requirement, it more ought to be by a single person. When a team determine the decision, the general team began to review the differences. And if the final decision is from compromise, the compromised scheme doesn't feel suitable for everyone.

Interview 14

1.What is the model/method you use when doing requirement prioritization? Please describe how to apply it.

There is no special priority model,
The main priority is to develop urgent and important two-dimensional tables based on business goals.
After getting the requirement, it will perform a requirement refinement session with the product team.
Set the required human resources for each requirement (for example, requiring front-end programmers, data analysts, and system administrators to intervene), giving roughly every effort required.

2.Does your method give priority value to per requirement item, or in other words, grade the importance of priority? If so, how does your method calculate the priority value for requirement sequence? If not, why not use the priority value to calculate the requirement sequence?

There is no scoring. Each requirement is divided into three levels, high, medium, low.

3.Do you build and use your requirement prioritization method/model by a software tool, like Trello, Teambition, iThink? Without this software tool, will you abandon your model/method because your method is too complex to conduct?

Use trello to integrate all the requirements.
Meeting

4.In what kinds of projects you have practiced your method and how it works well? What challenge or factor affects your method under these cases?

Mobile and web app, as well as the server side.

5.What is the important advantage and disadvantage of the requirement prioritization method you use, like its design defect, time cost, extra equipment, human arrangement, geography distribution of participant, or etc?

Advantages: Concise, the elements of weighing the requirement are very simple, it is easy to distinguish the priority level, at a glance. Disadvantages: Manpower arrangements cannot be measured, and dependencies between individual requirements are difficult to control

6.What requirement prioritization method/model have ever you referred to from book, article or research article? How do you tailor and apply it into your used method/model?

The current model used is borrowed from the article. Both the urgent and important 2D charts are prioritized according to business requirements. Comprehensive business needs and product team (tech team) to the proportion of priorities

7.What stage or challenge do you think is most important to improve for a prioritization method/model in practice, like easy using, less cost, easy understanding, accurately or simple priority algorithm, meeting holding and etc?

Less cost. Requirement analysis and sorting take a lot of time and manpower.

- Integrated manpower. After integrating human resources and prioritizing according to the business goals, human resources may not be able to match. Many of the requirements depend on the completion of other requirements. Priority + dependencies + manpower considerations are time consuming.