

Master Thesis
Software Engineering
Thesis no: MSE-2013:135
June 2013



Analytics for Software Product Planning

Shishir Kumar Saha
Mirza Mohymen

School of Engineering
Blekinge Institute of Technology,
371 79 Karlskrona, Sweden

This thesis is submitted to the School of Engineering at Blekinge Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science in Software Engineering. The thesis is equivalent to 2*20 weeks of full time studies.

Contact Information:

Author(s):

Shishir Kumar Saha

E-mail: shsd10@student.bth.se

Mirza Mohymen

E-mail: mimo10@student.bth.se

Academic advisor:

Dr. Samuel A. Fricker

School of Software Engineering

School of Engineering
Blekinge Institute of Technology
SE-371 79 Karlskrona, Sweden
E-Mail: samuel.fricker@bth.se

Internet : www.bth.se/tek
Phone : +46 457 38 50 00
Fax : + 46 457 271 25

ABSTRACT

Context. Software product planning involves product lifecycle management, roadmapping, release planning and requirements engineering. Requirements are collected and used together with criteria to define short-term plans, release plans and long-term plans, roadmaps. The different stages of the product lifecycle determine whether a product is mainly evolved, extended, or simply maintained. When eliciting requirements and identifying criteria for software product planning, the product manager is confronted with statements about customer interests that do not correspond to their needs. Analytics summarize, filter, and transform measurements to obtain insights about what happened, how it happened, and why it happened. Analytics have been used for improving usability of software solutions, monitoring reliability of networks and for performance engineering. However, the concept of using analytics to determine the evolution of a software solution is unexplored. In a context where a misunderstanding of users' need can easily lead the effective product design to failure, the support of analytics for software product planning can contribute to fostering the realization of which features of the product are useful for the users or customers.

Objective. In observation of a lack of primary studies, the first step is to apply analytics of software product planning concept in the evolution of software solutions by having an understanding of the product usage measurement. For this reason, this research aims to understand relevant analytics of users' interaction with SaaS applications. In addition, to identify an effective way to collect right analytics and measure feature usage with respect to page-based analytics and feature-based analytics to provide decision-support for software product planning.

Methods. This research combines a literature review of the state-of-the-art to understand the research gap, related works and to find out relevant analytics for software product planning. A market research is conducted to compare the features of different analytics tools to identify an effective way to collect relevant analytics. Hence, a prototype analytics tool is developed to explore the way of measuring feature usage of a SaaS website to provide decision-support for software product planning. Finally, a software simulation is performed to understand the impact of page clutter, erroneous page presentation and feature spread with respect to page-based analytics and feature-based analytics.

Results. The literature review reveals the studies which describe the related work on relevant categories of software analytics that are important for measuring software usage. A software-supported approach, developed from the feature comparison results of different analytics tools, ensures an effective way of collecting analytics for product planners. Moreover, the study results can be used to understand the impact of page clutter, erroneous page representation and feature spread with respect to page-based analytics and feature-based analytics. The study reveals that the page clutter, erroneous page presentation and feature spread exaggerate feature usage measurement with the page-based analytics, but not with the feature-based analytics.

Conclusions. The research provided a wide set of evidence fostering the understanding of relevant analytics for software product planning. The results revealed the way of measuring the feature usage to SaaS product managers. Furthermore, feature usage measurement of SaaS websites can be recognized, which helps product managers to understand the impact of page clutter, erroneous page presentation and feature spread between page-based and feature-based analytics. Further case study can be performed to evaluate the solution proposals by tailoring the company needs.

Keywords: Software product planning, SaaS, Analytics, Feature usage, Page-based analytics, Feature-based analytics.

Acknowledgement

First and foremost, we would like to express our sincere gratitude to our university supervisor Dr. Samuel A. Fricker for his continuous support, insightful feedback, and great efforts he put to explain things clearly and simply. We could not have imagined having a better supervisor for the thesis.

Besides this, we are truly indebted and thankful towards the admirable teachers of the Software Engineering department of Blekinge Institute of Technology for developing our knowledge during our two-year Master program in Software Engineering. It is also encouraged us to pursue our master thesis on the arena of Software Product Planning.

We owe our loving thanks to our close friends and dear ones, for helping us to get through the difficult times by providing emotional support.

CONTENTS

ANALYTICS FOR SOFTWARE PRODUCT PLANNING.....	I
ABSTRACT	1
1 INTRODUCTION.....	8
1.1 PRACTICAL PROBLEM	8
2 BACKGROUND AND RELATED WORK	10
2.1 SOFTWARE PRODUCT PLANNING.....	10
2.2 ANALYTICS	14
3 OVERALL RESEARCH METHODOLOGY	17
3.1 AIM AND OBJECTIVES	17
3.2 EXPECTED OUTCOMES	17
3.3 RESEARCH QUESTIONS	18
3.4 RESEARCH PROCESSES.....	19
4 THE EFFECTIVE WAY OF COLLECTING ANALYTICS FOR SOFTWARE PRODUCT PLANNING.....	21
4.1 RESEARCH DESIGN	21
4.1.1 <i>Requirements of Analytics Tool Comparison Method</i>	21
4.1.2 <i>Reasons for choosing the Requirements</i>	22
4.2 METHOD TO COMPARE FEATURES OF DIFFERENT ANALYTICS TOOLS.....	22
4.3 RESULTS AND ANALYSIS.....	23
4.3.1 <i>Outcomes of feature comparison between Analytics Tools</i>	23
4.3.2 <i>Comparison Summary</i>	25
4.4 PROPOSED ANALYTICS TOOL.....	26
4.4.1 <i>Software Requirements Specification of Analytics Tool</i>	26
4.4.2 <i>UML Architecture</i>	29
4.4.3 <i>System Context Diagram</i>	31
4.4.4 <i>Use Case Diagrams</i>	31
4.4.5 <i>Class Diagram</i>	34
4.4.6 <i>Sequence Diagram</i>	35
4.4.7 <i>Track the SaaS website by prototype Analytics Tool</i>	36
4.5 DISCUSSION	37
4.5.1 <i>Threats to Validity</i>	39
5 COMPARE PAGE-BASED ANALYTICS AND FEATURE-BASED ANALYTICS	40
5.1 RESEARCH DESIGN	40
5.1.1 <i>Active measurements on simulation platform</i>	41
5.1.2 <i>Simulation setup and methodology</i>	42
5.2 RESULTS AND ANALYSIS.....	44
5.2.1 <i>Impact of page clutter on page-based analytics and feature-based analytics</i>	44
5.2.2 <i>Impact of feature spread on page-based analytics and feature-based analytics</i>	48
5.2.3 <i>Impact of erroneous page representation on page-based analytics and feature-based analytics</i>	51
5.3 DISCUSSION	54
5.4 THREATS TO VALIDITY	58
5.4.1 <i>Conclusion Validity</i>	58
5.4.2 <i>Internal Validity</i>	59
5.4.3 <i>Construct Validity</i>	59
5.4.4 <i>External Validity</i>	59

6	SUMMARY AND CONCLUSIONS	59
6.1	RQ1: WHAT IS AN EFFECTIVE WAY TO COLLECT ANALYTICS FOR SOFTWARE PRODUCT PLANNING? 59	
6.2	RQ2: HOW DO FEATURE-BASED ANALYTICS COMPARE WITH PAGE-BASED ANALYTICS?	60
6.2.1	<i>RQ2.1: What is the impact of page cluttering on page-based analytics and feature-based analytics?</i>	<i>60</i>
6.2.2	<i>RQ2.2: What is the impact of feature spread on page-based analytics and feature-based analytics?</i>	<i>60</i>
6.2.3	<i>RQ2.3: What is the impact of erroneous page representation on page-based analytics and feature-based analytics?</i>	<i>60</i>
6.3	LESSON LEARNED	61
6.4	FUTURE WORK.....	61
6.5	CONCLUSIONS.....	61
7	REFERENCES.....	63
8	APPENDIX A	69
9	APPENDIX B	73
10	APPENDIX C	74
11	APPENDIX D	81
12	APPENDIX E	87

TABLE OF FIGURES

Figure 1: Structure of Current Study	10
Figure 2: Frameworks of software product managements (Copyright I. van de Weerd et al.) [12].....	11
Figure 3: Overall research process.....	21
Figure 4: Compare capability of Analytics Tools to provide decision-support for Software Product Planning	23
Figure 5: UML Architecture Diagram of Analytics Tool	30
Figure 6: System context diagram of Analytics Tool	31
Figure 7: Use case diagram of Visitor	32
Figure 8: Use case diagram of Product Manager.....	33
Figure 9: Use case diagram of Developer.....	34
Figure 10: Class Diagram of Analytics System.....	35
Figure 11: The sequence diagram of analytics tool, visitor, product manager and SaaS website interaction	36
Figure 12: Simulation Setup of Research Question2.....	43
Figure 13: Accuracy by Page clutter measurement for page-based analytics and feature-based analytics	45
Figure 14: Precision by Page clutter measurement for page-based analytics and feature-based analytics	45
Figure 15: Accuracy by Page clutter measurement for page-based analytics and feature-based analytics	47
Figure 16: Precision by Page clutter measurement for page-based analytics and feature-based analytics	47
Figure 17: Accuracy measurement for page-based analytics and feature-based analytics.....	49
Figure 18: Precision measurement for page-based analytics and feature-based analytics.....	50
Figure 19: Accuracy of Error count measurement for page-based analytics and feature-based analytics	52
Figure 20: Precision of Error count measurement for page-based analytics and feature-based analytics	53
Figure 21: The measurement information model ISO/IEC 15939:2002, adapted from [72]	55
Figure 22: Dashboard of the Prototype Analytics Tool	74
Figure 23: Create new Indicators in the Analytics Tool.....	75
Figure 24: Manage Indicators in Analytics Tool	75
Figure 25: Create sub-Indicators in the Analytics Tool.....	76
Figure 26: Manage sub-Indicators in the Analytics Tool	76
Figure 27: Create new Features in the Analytics Tool	77
Figure 28: Manage Features in the Analytics Tool.....	77
Figure 29: Create new Requirements in the Analytics Tool.....	78
Figure 30: Manage Requirements in the Analytics Tool.....	78
Figure 31: Map Requirements with GUI elements in the Analytics Tool	79
Figure 32: Compare Features Analytics in the Analytics Tool.....	80
Figure 33: Set Admin Configurations in the Analytics Tool.....	80
Figure 34: Defined Features and Requirements of the SaaS Website	81

Figure 35: Create Feature (Click on ‘Manage Feature’, then ‘Add Feature’ and then enter Feature Info).....	82
Figure 36: Create Requirement (Click on ‘Manage Requirement’, then ‘Add Requirement’ and then enter Requirement Info)	83
Figure 37: Set Admin Status as Active (Click on ‘Set Admin Status’ and select Active)	84
Figure 38: Map the GUI element of the SaaS webpage with created Requirement of Analytics Tool to track feature (Click on ‘Add an event’ on the SaaS webpage, then select Requirement from pop-up window and press ‘MAP GUI Element’ button to map)	85
Figure 39: Compare feature usage by interactive graphs (Select Features, sub-Indicators, To-From Date & Graph Type to generate graph)	86
Figure 40: Scenario1 in Page-based Analytics: Web Page (P1), Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4)	88
Figure 41: Scenario1 in Feature-based Analytics: Web Page (P1), Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4)	89
Figure 42: Scenario2 in Page-based Analytics: Web Page (P1), Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4)	91
Figure 43: Scenario2 in Feature-based Analytics: Web Page (P1), Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4)	92
Figure 44: Scenario3 in Page-based Analytics: Web Page1 (P1), Web Page2 (P2), Web Page3 (P3), Web Page4 (P4), Web Page1 Feature1 (F1.E1), Web Page2 Feature1 (F1.E2), Web Page3 Feature1 (F1.E3) and Web Page4 Feature1 (F1.E4)	94
Figure 45: Scenario3 in Feature-based Analytics: Web Page1 (P1), Web Page2 (P2), Web Page3 (P3), Web Page4 (P4), Web Page1 Feature1 (F1.E1), Web Page2 Feature1 (F1.E2), Web Page3 Feature1 (F1.E3) and Web Page4 Feature1 (F1.E4)	96
Figure 46: Scenario4 in Page-based Analytics: Web Page (P1), Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4)	98
Figure 47: Scenario4 in Feature-based Analytics: Web Page (P1), Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4)	99

LIST OF TABLES

Table 1: Research Questions and their Aims	19
Table 2: Characteristics of Research Methodologies in the study	19
Table 3: Comparison of different analytics tools.....	25
Table 4: Stakeholder descriptions of Analytics System	28
Table 5: Page clutter for page-based analytics and feature-based analytics.....	44
Table 6: Page clutter on real feature usage for page-based analytics and feature-based analytics (Appendix E, Figure40 & Figure41)	46
Table 7: Page clutter for page-based analytics and feature-based analytics.....	46
Table 8: Page clutter on real feature usage for page-based analytics and feature-based analytics (Appendix E, Figure42 & Figure43)	48
Table 9: Feature spread measurement with respect to page-based analytics and feature-based analytics	49
Table 10: Feature Spread on real feature usage for page-based analytics and feature-based analytics (Appendix E, Figure44 & Figure45)	50
Table 11: Measure Accuracy and Precision of Erroneous Page in terms of Feature-based and Page-based analytics	51
Table 12: Erroneous page presentation on real feature usage for page-based analytics and feature-based analytics (Appendix E, Figure46 & Figure47).....	53
Table 13: Feature usage measurement system for Page Clutter	56
Table 14: Feature usage measurement system for Feature Spread	56
Table 15: Feature usage measurement system for Erroneous Page Representation.....	57
Table 16: Results of Literature Review	71
Table 17: Definition of Feature Metrics	73

1 Introduction

1.1 Practical Problem

Software product planning involves product lifecycle management, roadmapping, release planning, and product requirements engineering [1].

Software product management encompasses strategic decision-making for the evolution of software products that are offered to produce a large value of customers and users. Requirements are collected and used together with criteria to define short-term plans, release plans, and long-term plans, roadmaps. Maintenance lifecycle is an important process of product development, where a product is evolved based on the changes of customer need [2]. The different stages of the product lifecycle determine whether a product is mainly evolved, extended, or simply maintained. User-driven design is needed to perceive different aspects of users' behaviors and refine user analytics in order to perform more effective product design [3].

When eliciting requirements and identifying criteria for software product planning, the product manager is confronted with statements about customer interests that do not correspond to their needs [4]. Requirements are elicited from stakeholders that act as intermediaries to the customers, hence further bias information with their own concerns [5]. Requirements further can be elicited through traditional ways of conducting survey, workshop or interview within individuals, groups or organizations, hence risk being anecdotal, rather than representing the whole market.

Analytics summarize, filter, and transform measurements to obtain insights about what happened, how it happened, and why it happened [6]. The analytics-based insights ground software product planning on real data about product usage. This would allow the product manager to create prototypes for testing new features, for example with A/B testing [7]. Moreover, current products could be monitored to react to changes in the market place. To enhance the ability of eliciting user preference and identify the new service opportunities, a process, user-centric service map, is developed based on user-centric and technology-centric information [8]. While several characteristics and properties e.g. link traffic, user click, page rank, individual entropy and session size statistics are utilized to anticipate analytics of user interaction [9]. Moreover, some web based tools e.g. Google analytics, Piwik, Yahoo! Web Analytics, Crazy Egg are developed to monitor user surfing behavior of products.

Analytics have been used for improving usability of software solutions [6], for monitoring the reliability of networks, servers, and software-based services, and for performance engineering [10], and for analyzing web-based marketing campaigns [11]. These uses of analytics give information about specific quality features or for steering publicity for a software solution. However, how to use analytics for software product planning is unrevealed.

Traditional ways of collecting market-driven requirements (e.g., survey, workshop or interview within individuals, groups or organizations, competitor analysis) for product evolution fail to measure product usage and hence utilize the measurement of product usage for product planning. Product planning based on representative data that accurately reflects user interaction and interests, is important for a company to make their products successful. It would allow experimenting with prototypes for product innovation. It would also allow continuous evaluation of feature usage to support decision-making for enhancing or removing the features. If we are unable to support product planning with analytics, product managers obtain anecdotal data that is likely to be invalid, instead of the user representative inputs and cannot recognize which features of the product are useful for the customer.

This study focuses on find out the usage information of features and key indicators to enable decision support for software product planning. So, the study would perform search on existing analytics tools whether that are enough to measure feature usage and support software product planning. If existing tools are not enough then propose a feature measurement concept and implement a prototype analytics tool. The prototype analytics tool can be applicable to measure feature usage and support product managers for product planning.

The structure of the current master thesis is divided into six chapters as represented in Figure1. The thesis starts with an Introduction, i.e., “Problem”, “Background and Related Work” and “Overall Research Methodology” chapters respectively. Chapter 4 describes Research Question1 i.e., the method of an effective way to collect analytics for decision support regarding the addition, extension or removal of features. Research Question2, a software simulation is presented in chapter 5, which focuses on feature usage measurement and the impacts of page clutter, feature spread and erroneous page presentation in terms of page-based analytics and feature-based analytics. Chapter 6 discusses future work, summary and conclusions.

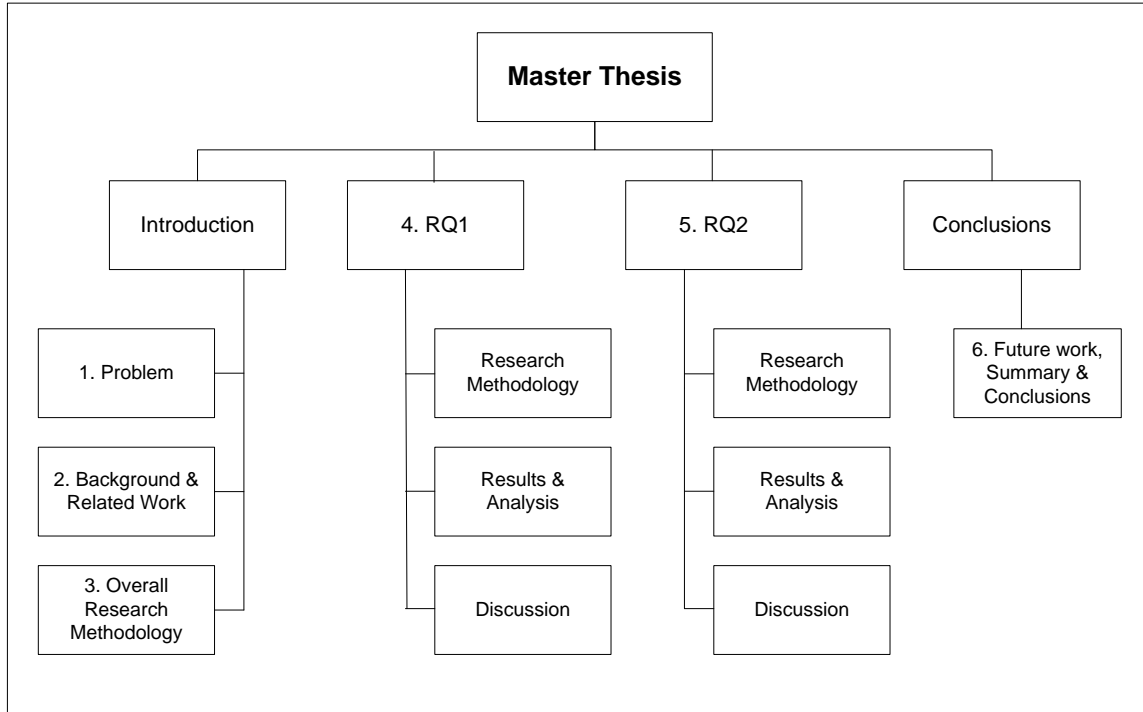


Figure 1: Structure of Current Study

2 Background and Related Work

2.1 Software Product Planning

Product management is the management process to managed product features, requirements, releases with the assistance of internal and external stakeholders to align product business [1] [12]. I. Van de Weerd et al [12] provided a product management reference model (Figure2) which contains four parts: product portfolio management, product roadmapping, release planning and requirements management. The study [1] depicts product planning as a part of product life cycle management, product roadmapping, release planning and product requirement engineering. Product life cycle management is the planning of product life cycle which changes with market demand. Roadmapping makes the long term plan from product strategy to visualize the needs of the change of product features, resources and technology. Release planning is the process to plan which requirements bundles or features should release and when features should release. Product requirements engineering is the process to identify and select requirements from stakeholders to develop the software.

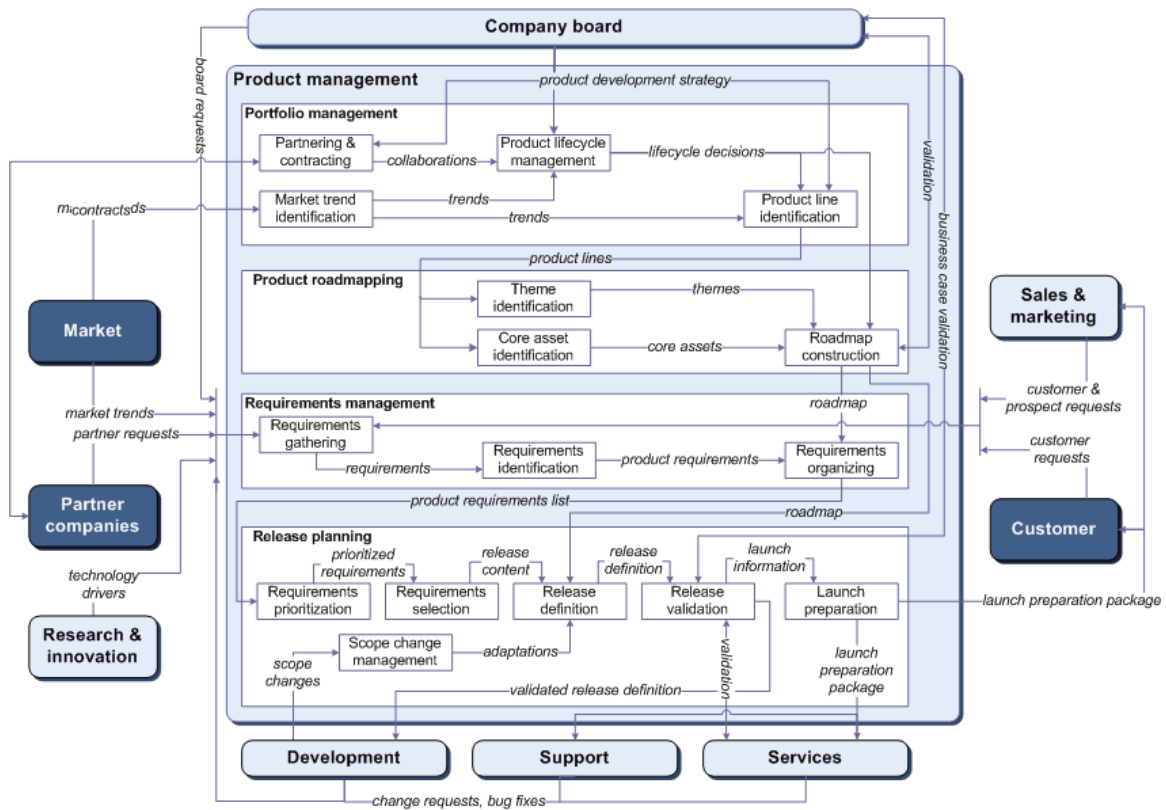


Figure 2: Frameworks of software product managements (Copyright I. van de Weerd et al.) [12]

The Vander Weerd’s product management framework is presented in 2006. It is the most relevant SPM framework for the current study [1]. This framework clearly differentiates four main product management processes i.e., product roadmapping, portfolio management, release planning and requirements management [12]. These frameworks also depict relationship with stakeholders, customers and other influences. The importance of internal stakeholders, external stakeholders, customers and markets to build proper product managements is shown in the Vander Weerd’s product management framework. Haines, S defined the scope of the product management [1]. However, Vander Weerd’s product management framework overviews product management practices using empirical study to develop processes [1].

Day by day product is becoming software-based than human-based. Different sectors such as banking, telecommunication, automobile industry, scientific research, commerce are relying on software system then direct human involvement. Again software product is spreading on broader area. Different customers or users from different geographical areas are using the same product. Continuous product evolution is necessary to compete with the global market demand and changes of customer preference [13]. Any product or software should adjust changes with the situation to fulfill the customers’ demand progressively [14].

Product management discipline in software engineering is important for product success. With a good product management plan, product can be more successful. On the

other hand a bad product management plan can make the product worse [15]. Product planning is a collection of four parts: product lifecycle management, product roadmapping, release planning and requirements management [1]. The product manager is responsible for all of the four parts directly or indirectly. He/she is the “mini CEO” of the company [15] who is mainly planned product strategy and product planning. The product manager needs to plan when product should be developed, which part should be developed and how it should be developed and when it should be launched and updated to market or to customers [1].

The product manager manages product development from the beginning of execution to bring the business value to the product [15]. He/she plans long term product development, product roadmap and release. Then evaluate roadmap and release continuously with the current and previous business perspective of customer preferences.

To plan the long term product development strategy and software product planning, product managers involve with different stakeholders both internal and external stakeholders. Those internal and external stakeholders are the customers, marketing persons, sales persons, support persons, developers, managers, company strategy and decision-makers [12]. Product managers involve with different types of stakeholders to mitigate risk and uncertainty of planning roadmap and release of products and to prioritize the release of features. Different stakeholders have different views, needs, motto and different styles of explanations. So this is very difficult for product managers to interpret all of these stakeholders’ opinions and make the proper product plan to meet the business goal. Misinterpretation of stakeholder preferences makes roadmap and release planning unsuccessful. Requirements are elicited from stakeholders that act as intermediaries to the customers who are not actual user or that requirements are not actual usage scenario of users, hence further bias information and misinformation emerge [5].

Product success depends on the customers' usage. So, if customers’ or users’ truly involved in decision-making that can facilitate software product planning such as roadmapping, release planning. Hence, the selection of requirements and features of a product can be more realistic. There are many studies focus on different areas like release planning, requirements selection, business value, requirements prioritization, product risk elimination, product roadmapping [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] . The paper [17] depicts that stakeholders and market is one of the main decision making criteria for requirement selection and release planning. In paper [18], G. Muller describes what is roadmap, why is it important and how is it can be created. Authors also explain that stakeholders are main decision maker for roadmap making. In the paper [19], authors R. Phaal, et al. depicts the first start technology roadmapping linking to business or product requirements. In another paper [20], R. Phaal, et al mentions market pull is one of the criteria to built first start technology roadmapping for future and vision. Technology roadmapping processes with people, markets trends, and users’ preferences can facilities to improve product, features. In addition historical data, future user usage data, market analysis report can be facilitating to make roadmap more appropriate [19]. The article [21] focus selection, prioritization and evaluation of requirements using trade-off analysis methods with four fold processes. The main goal is

to find out the most appropriate requirements using stakeholders' opinion. In paper [22], requirements prioritization has been done by measuring the value of user or customer preferences and cost. The paper [24] presents an analytic model to select the appropriate requirements and bundle them to release planning. It also discussed the limitation of the analytic method to make decision making of requirement selection. The authors argue that real-time and real usage requirements can evaluate the selection decision correctness. In the study [25], customers' involvements and preferences are described as the main decision making factor in a realistic release planning. The paper [27] proposes EVOLVE+ method to solve the software release problem. Human involvement is required to solve the right problem [27]. This paper [28] describes incremental planning and development of features for business driven product planning. According to the research article [29], re-organization of customers or stakeholders and identify their needs continuously is important to update release planning. So the usage behavior of the product features can be used to facilitate software product planning. The paper [30] explores the software release planning challenges in software development and one of the major category of challenges is human oriented where human involvements as for example stakeholders, customers, users have significant importance for release planning, prioritization. According to the paper [31], customer based success measurements is one of the criteria for product success measurement. Though there is no silver bullet measurement indicator which can be utilized to measure product usage and product success. But some information can be used for measuring product success with respect to customers, such as customers' satisfaction on product, number of unique customers, number of returning customers and number of new customers [31]. Most of the research studies mention about the user or customer preferences as one of the important factors. Though most of the research papers are related to release planning, requirements selection and requirements prioritization, they can also be used for product planning steps like roadmapping, product life cycle management.

In the study "Release Planning with Feature Trees: Industrial Case" [16], the feature tree concept is used to facilitate release planning. With this concept release planning can be performed in more tactical level than operational level. The author brings out related requirements considering dependency to make features and implement that together in a release. Using this concept feature tree is built where feature hierarchy is maintained. So it can be facilitated stakeholders and product managers to decide which features should be released in which release version. The study also emphasizes on customers or stakeholder's preferences' that is indicated as an important factor.

Now application or product development has changed such as cloud based, service oriented and application based product development are gaining popularity day by day. This entire product has not only had fixed customers but also lots of anonymous customers. So only depending on stakeholder opinions can invoke risks for the product evolution success and progress [1]. Again when there are lots of stakeholders, then it is not possible to get and consider all the stakeholders' opinion. Market driven product development depends on anonymous customers or users preferences and needs; and changes of demands or needs are dynamic and uncertain. So, continuous evaluation and monitoring of the status of features or product usage are important. Only limited

stakeholders' involvement cannot be enough to cope up with the changes of users' true needs. So, the real product usage information can be collected continuously to mitigate risks and also to use it for decision support to enhance product features [32]. It also can be used to persistently improve or upgrade roadmapping and release planning.

Historical data and real usage data of feature usage can be useful for software product planning. Collecting historical and real usage data of features of product usage in the form of analytics, can be used as indicators or sub indicators to facilitate inputs to software product planning by exploring about how the product is used, which features are more attractive, which feature are less attractive, how features improve the impact on usage, how the customers are satisfied, what customers want, which problems customers are often faced etc. To connect feature usage measurement with analytics can facilitate the assessment of individual feature's quality, importance, limitation and values. It is possible by summarizing, filtering, transforming and evaluating analytics with respect to the features of online products. Customers' perspectives can be used as the key feature usage measurement factor for software product planning.

To collect user preferences and feature usage information of products, it requires a mechanism or tool by which this information can be collected during the real application usage. Moreover, the tools should support the runtime mapping of features and elements that can be easily interpreted the feature usage information for software product planning.

2.2 Analytics

Analytics is the significant pattern of data that is useful to take action or to take decisions for enhancing business value. Analytics uses analysis data to gain the insights to facilitate decision making. Analytics can be used for analysis of customer preferences, competitors, processes and operations [33].

Web analytics is one kind of analytics which can be used for analysis of web application success. Web Analytics Association [34] has recently proposed a standard definition for web analytics: "Web analytics is the objective tracking, collection, measurement, reporting, and analysis of quantitative Internet data to optimize websites and web marketing initiatives" [34]. It can be said that web analytics is a meaningful pattern of quantitative data which can be used for finding answers what and why a product or application is successful or not.

The literature review results [Appendix A] discover the current relationship between software product planning and analytics. The results also discover the importance of analytics and the categories of analytics. Moreover, it reveals which kinds of analytics are more relevant for SaaS based product.

Different literatures and books cover web analytics and discussed about what is web analytics, how web analytics can be collected, why web analytics should be collected and what are the challenges to collect and implement web analytics for application success [35] [36] [37] [38] [39] [40] [41] [42] [43] [44] [45] [46] . Though most of the literature

and books emphasize general website success measurement but most of the analytics can be used for applications such as SaaS based or app.

Web analytics is the analysis of various data captured from users' interaction with websites or web applications to get insight of users or customers' online experience of that application. The data can be collected from different sources and different perspectives such as usability studies, web server performance, availability and reliability of websites. Web analytics demystified book describes and explains how web analytics can be used to evaluate website's success. In the other view, how web analytics facilitate to bring business value to the product owner [35].

Web analytics provide the real-time product usage information about customers' preferences, their real-time experience about the product, what problem they are facing, why they are facing problem, why some features are popular, why some features are not popular, why customers are not returning to websites, which parts of the product have performance issues, which parts of the product have usability issues [35] [36] [37].

There are different web analytics solutions available in markets such as Google analytics, Piwik, Yahoo! web analytics. Some research papers focus on applied experience of using web analytics tools. The books [38] demonstrate how Google analytics with web metrics can be used to optimize a web site. In the study [41] author describes the impact of Google analytics in the library website. The performance of a website is compared with respect to customer interactions before the use of web analytics tool and after the use of web analytics tool. The result shows that web analytics tools can improve the websites in a number of ways such as to make websites more usable and user-friendly for customers [41]. This book [42] describes and explains performance indicator of web site or web application, the criteria of key performance indicator. The author describes that which can be key performance indicators, which cannot consider key performance indicators, why these are important for improvement of applications. The research paper "Using Google Analytics to Evaluate the Usability of E-commerce Site" shows that web analytics such as Google analytics can be used to evaluate the usability of e-commerce sites [44].

In research paper "Improving Web Site Performance Using Commercially Available Analytical Tools", the author depicts that web analytics tools can be used to monitor and collect websites usage data to enhance the content and functionality of websites [45].

According to different web analytics books [39] [37] [36] [42] [43] and research papers [39] [41] [45] [58], it is clear that analytics can be used as the real insights of customers' online experiences, preferences in different parts of the product. Customer preferences are the main factor of the product success and failure. Software product planning is the planning to provide the product to customer in right time with right features, which is more important to customers. So the real application usage information in a form of analytics can facilitate product managers to get insights of their product status and hence, upgrade the product planning as per customers demand.

SaaS or Software as a Service is the new trend of application development that is emerging day by day [47]. SaaS based applications are eliminating the needs for desktop applications. Customers' IT infrastructure is replaced by hosted SaaS provider [47, 48]. SaaS based applications can be used in different regions of customers without installing them in physical devices, components in every place. The customers or users can use SaaS based application as economical scale such as on demand feature or service request. It is not obligatory to buy the whole product rather than only buy services or features subscription [49]. SaaS based applications can be hosted on a cloud platform. So, they are more scalable and efficient in resource managements [48]. Moreover, up-gradation and monitoring is continuous and flexible since SaaS applications are service or feature based. There is no need to replace or upgrade the whole product that is not similar with packaged software. The difference between normal websites and SaaS based websites is that SaaS are more service oriented and more attractive to business users than their consumers. The customer uses the service or renews service as per performance of the service or features. So, productivity, reliability, usability are more important than normal websites [37]. So, the monitoring of the SaaS based applications is different than normal websites.

The SaaS based application model is based on service or feature subscription. Customers can subscribe to different services or features as per demand. The product has solved the physical installation problem and the installation is centralized which facilitates monitoring, up-gradation and evaluation of features and services in a more dynamic and flexible way. Analytics can be used for SaaS based application to monitor real usage [50] and this result can be useful for software product planning decision. Upgrading and changing roadmapping, release planning and product Lifecycle management are more feasible because of the possibility of large scale monitoring of individual services and features of customer preferences and experience. So, SaaS based applications have more applicability for software product planning.

There are different taxonomies of analytics that are required to collect for measuring the product usage experiences in customer perspective. Different researchers describe the category of analytics with different indicators that can be used for measuring product usage scenarios. According to the analysis of those research studies, it can be said that analytics mainly collected in three categories: usability, performance, and reliability/availability [35][36][37][42][43]. For SaaS based applications, usability, performance and availability are the most important indicators for measuring success of the application features or services. For example, analytics can measure the user productivity, usability, availability/reliability and performance of the features or services [37]. Since, the success of SaaS based applications depends on the success of services or features, customer subscriptions i.e., maintenance of high quality services or features are highly important. That's why continuous monitoring of features or services is also important to evaluate the usage of features and services. As the SaaS application mainly provides feature-based releases, so mapping it with software product planning is more feasible.

To map the software product planning features or services in events or elements level and monitoring real-time usage of features and services to find out customer preferences and experience, an automated process is required. Automated tools can facilitate the decision making for software product planning continuously. From the results of the literature review [Appendix A] and market research on existing analytics tools, it has been concluded that there are no analytic solutions in existence that can be used to enable decision-support for software product planning. So, the challenges and risks of collecting analytics that are relevant for software product planning have not been revealed yet.

3 Overall Research Methodology

3.1 Aim and Objectives

The aim of the research is to enable software analytics and user interaction for software product planning.

- Determine the kind of analytics relevant for supporting product planning and identify an effective way to collect analytics for software product planning.
- Compare page cluttering, feature spread and erroneous page representation between feature-based analytics and page-based analytics.
- Implement and validate the software product planning concept with a prototype analytics tool.

For the thesis, the study assumes that product planning concerns about the addition, enhancement, and removal of features. This simplifies the software product planning problem, hence allows focusing on the research.

The study could achieve the same objective as ours by performing an empirical study on software product planning with the support of roadmapping, release planning and portfolio management. We are interested in collecting user representative data rather than collecting empirical evidence. So, we choose analytics to collect usage data for software product planning instead of roadmapping, release planning and portfolio management.

3.2 Expected Outcomes

The results of the study improve the inputs of software product planning by enabling analytics of user behavior for the adjustment of product features. More specifically, the study provides the following outcomes:

- Overview of current knowledge of software analytics and identification of indicators and sub-indicators that support software product planning. Indicators help product planners to make decision in product planning.
- A software-supported approach to collect analytics for software product planning. The approach includes the setup and usage of analytics. It ensures the effective way of collecting analytics for product planners.
- An open source prototype tool to collect analytics about product usage and derive indicators for software product planning. It helps product managers to recognize user representative inputs. It also helps product managers to compare the impact

of page clutter, feature spread and erroneous page presentation between page-based analytics and feature-based analytics.

3.3 Research Questions

To understand the relevant software analytics to provide decision-support for software product planning and identify an effective way to collect right analytics, the following research questions were posed:

RQ1: What is an effective way to collect analytics for software product planning?

RQ2: How do feature-based analytics compare with page-based analytics?

RQ2.1: What is the effect of page clutter on page-based analytics and feature-based analytics?

RQ2.2: What is the effect of feature spread on page-based analytics and feature-based analytics?

RQ2.3: What is the effect of erroneous page representation on page-based analytics and feature-based analytics?

Analytics summarize, filter, and transform measurements to obtain insights about what happened, how it happened, and why it happened [6].

A product manager wants to know which feature should be included during planning the next release [6]. Therefore, analytics filtering is necessary to identify the relevant features with respect to indicators and sub-indicators for software product planning. Analytics summarization discovers the insights as well as the statistics of a particular feature or the whole product. Analytics transformation helps to take pro-active decisions based on how artifacts are changing with respect to summarize statistics.

A feature (f) is a set of related requirements (R), specifications (S) and domain assumptions (W) i.e., a triplet, $f = (R, S, W)$ [51]. We indicate the domain as the SaaS website and requirements as the GUI elements or events of SaaS websites and specifications as the specifications of requirements.

An effective way [RQ1] to collect analytics means the ability to find out analytics that are relevant, feasible and have high impact on making decisions about addition, extension, and removal of features.

The web page refers to the study as a medium of representation software-as-a-service (SaaS). SaaS applications that have direct interaction with end users are considered for the study (e.g. SaaS websites) rather than SaaS service providers like Amazon. The indicators would be defined and applied for SaaS websites and also that would be visible to product managers. Web page cluttering [RQ2.1] refers to the situation where many features are present on a web page. Feature spread [RQ2.2] refers that one feature can be visible on multiple web pages i.e., one feature can be mapped to multiple elements of different web pages. Erroneous page representation [RQ2.3] refers which particular features are erroneous on a web page.

Table1 presents the mapping between research questions and their aims of the current study.

Table 1: Research Questions and their Aims

Research Question	Objective
RQ1: What is an effective way to collect analytics for software product planning?	To identify the effective way of collecting analytics for software product planning
RQ2: How do feature-based analytics compare with page-based analytics?	To validate the concept of software product planning by comparing page-based analytics and feature-based analytics
RQ2.1: What is the effect of page clutter on page-based analytics and feature-based analytics?	To compare page clutter between page-based analytics and feature-based analytics
RQ2.2: What is the effect of feature spread on page-based analytics and feature-based analytics?	To compare feature spread between page-based analytics and feature-based analytics
RQ2.3: What is the effect of erroneous page representation on page-based analytics and feature-based analytics?	To compare erroneous page representation between page-based analytics and feature-based analytics

3.4 Research Processes

The study was conducted through three different research approaches: literature review [52], market research & software development and software simulation [52] [53]; to answer the research questions. Literature review reveals the research gap and related studies on web analytics and software product planning. It prepares the ground for the empirical research method for all the stages. In Table2, we summarize the research methodologies that considered in the current study.

Table 2: Characteristics of Research Methodologies in the study

Research Design	Literature review	Market Research	Software Simulation
Research objective	Exploratory & Improving	Exploratory	Software Simulation
Primary Data	Qualitative	Qualitative	Qualitative & Quantitative
Research Environment	Literature	Google Search Engine	Between a SaaS website & a Prototype analytics tool

RQ1 is related to objective 1 & 3 and RQ2 and its sub-parts are related to objective 2.

The steps presented in Figure3 are followed in the study. The research starts with the literature review to understand related works on SaaS based software analytics and

different ways to measure software usage. The literature review will be a basis to identify related works on software analytics and define relevant indicators for software product planning. Interview with industrial experienced representative would be useful to facilitate finding relevant analytics and indicators for software product planning. But at this stage the concept is new, unexplored and not practiced by practitioners in industry. So, taking interview of industry representative is dismissed.

By performing the market research using Google search engine, different web analytics tools are compared based on the proposed method and the effective way of collecting analytics is identified (RQ1 was answered). The aim of the study is to implement analytics that are relevant for software product planning. Key customer opinion analysis or survey was not considered as research methodology because the study is aiming to know how far the known analytics can support software product planning. There are a lot of web analytics tools available to measure user interactions, but there is no software analytics solution that supports software product planning. The goal of the study is to support ease of software product planning; hence any existing software analytics solutions are not chosen. But the study would be inspired by existing solutions. When it can be possible to collect and analyze analytics of an application incrementally by using an automatic tool, it would be more effective for software product planning. Otherwise, feedback can be gathered manually through the ways e.g. performing survey and interview with customers. Then classify those collected data into analytics. But manual process is more time consuming and it requires more human resources. To implement our concept, we collect the necessary analytics in an effective way.

A software simulation was performed to measure and compare the impact of page clutter, feature spread and erroneous page presentation between page-based analytics and feature-based analytics (RQ2 was answered). The proposed method was validated by conducting a software simulation, i.e., an executable model of real world phenomena to study their behavior [54]. A software product planning supported prototype analytics tool was developed to accomplish the simulation.

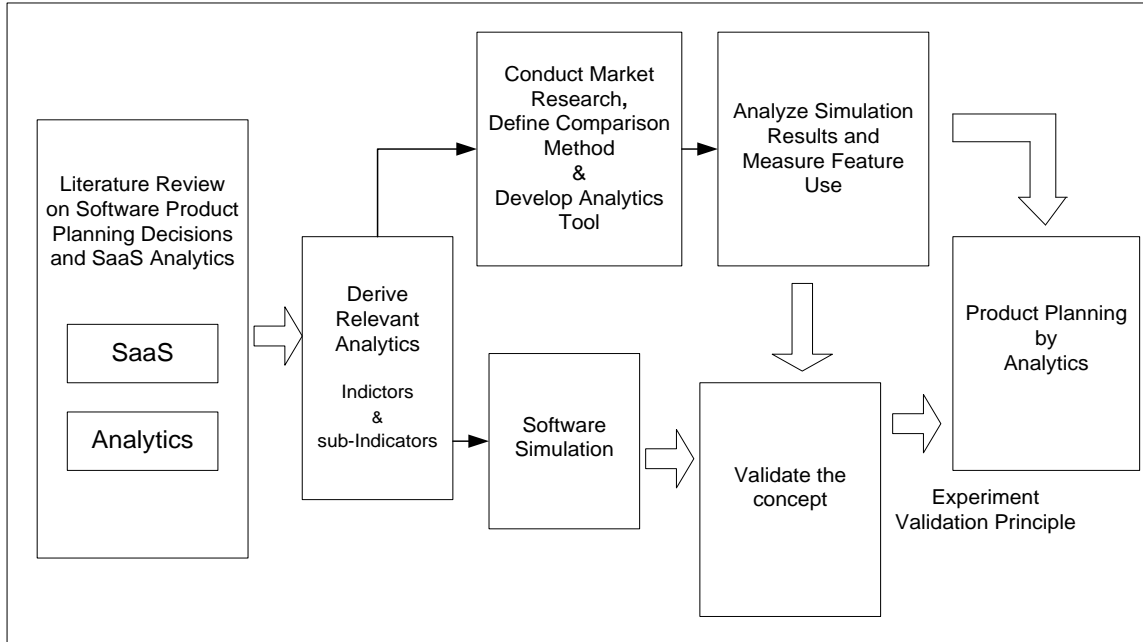


Figure 3: Overall research process

4 The Effective Way of Collecting Analytics for Software Product Planning

This chapter describes the effective way of collecting analytics for software product planning. Moreover, why the implementation of software product planning decision-supported prototype analytics tool is essential and how to measure the usage of a feature are discussed.

4.1 Research Design

Our goal of RQ1 is to find out an effective way to collect analytics that are relevant for making decisions about addition, extension, and removal of features.

We perform market research through searching “market share of web analytics tools” in Google search engine and select five web analytics tools that support the SaaS website tracking. We select five web analytics tools based on the highest market share and revenue growth [55] [56]. Those tools are Google Analytics, Adobe Analytics, IBM Digital Analytics, WebTrends and Yahoo! Web Analytics.

We define a method with specific requirements to compare different web analytics tools to check whether they have decision-support for software product planning.

4.1.1 Requirements of Analytics Tool Comparison Method

REQ1. Applicable to use for SaaS websites

REQ2. Applicable to track Analytics in GUI Element Level

REQ3. Applicable to track Features use through tentative mapping of GUI Elements

REQ4. Applicable to map Requirements with Features

REQ5. Applicable to compare Feature usage according to Indicators and Sub-indicators

REQ6. Applicable to measure Feature usage based on Page-based Analytics and Feature-based Analytics

REQ7. Applicable for Software Product Planning

4.1.2 Reasons for choosing the Requirements

Our goal of Research Question1 is to find out an effective way to collect analytics that are relevant for making decisions about addition, extension, and removal of features.

REQ1 is required to measure the feature usage of the SaaS website for product planning. REQ2, REQ3 and REQ4 are required to define the features of the SaaS website and measure the feature usage in GUI element level through tentative mapping between GUI Elements and Features. REQ4 is required to define the GUI elements as requirements and map the requirements with features by one-to-many relationship. REQ5, REQ6 and REQ7 are required to measure and compare the feature usage in terms of feature-based analytics and page-based analytics. Moreover, they are required to summarize, filter, and transform feature usage analytics for software product planning.

4.2 Method to Compare Features of different Analytics Tools

Feature wise comparison is performed between selected analytics tools features using the analytics tool comparison method. The method is derived based on the requirements of a software product planning supported analytics tool. In flowchart (Figure4), the comparison is performed according to the method to find out an effective way to collect analytics for software product planning. The method extracts features of different web analytics tool. Then it verifies whether the selected tools are compatible to track SaaS websites. The method performs further filtering to check the selected tools are able to track feature usage in GUI element level and define requirements and features; if they support SaaS website tracking. If the tools support to define and track feature usage, then the method is further ensuring whether they are able to compare feature usage between page-based analytics and feature-based analytics. We assume, if a tool can measure and compare feature usage then it is able to provide decision-support for software product planning.

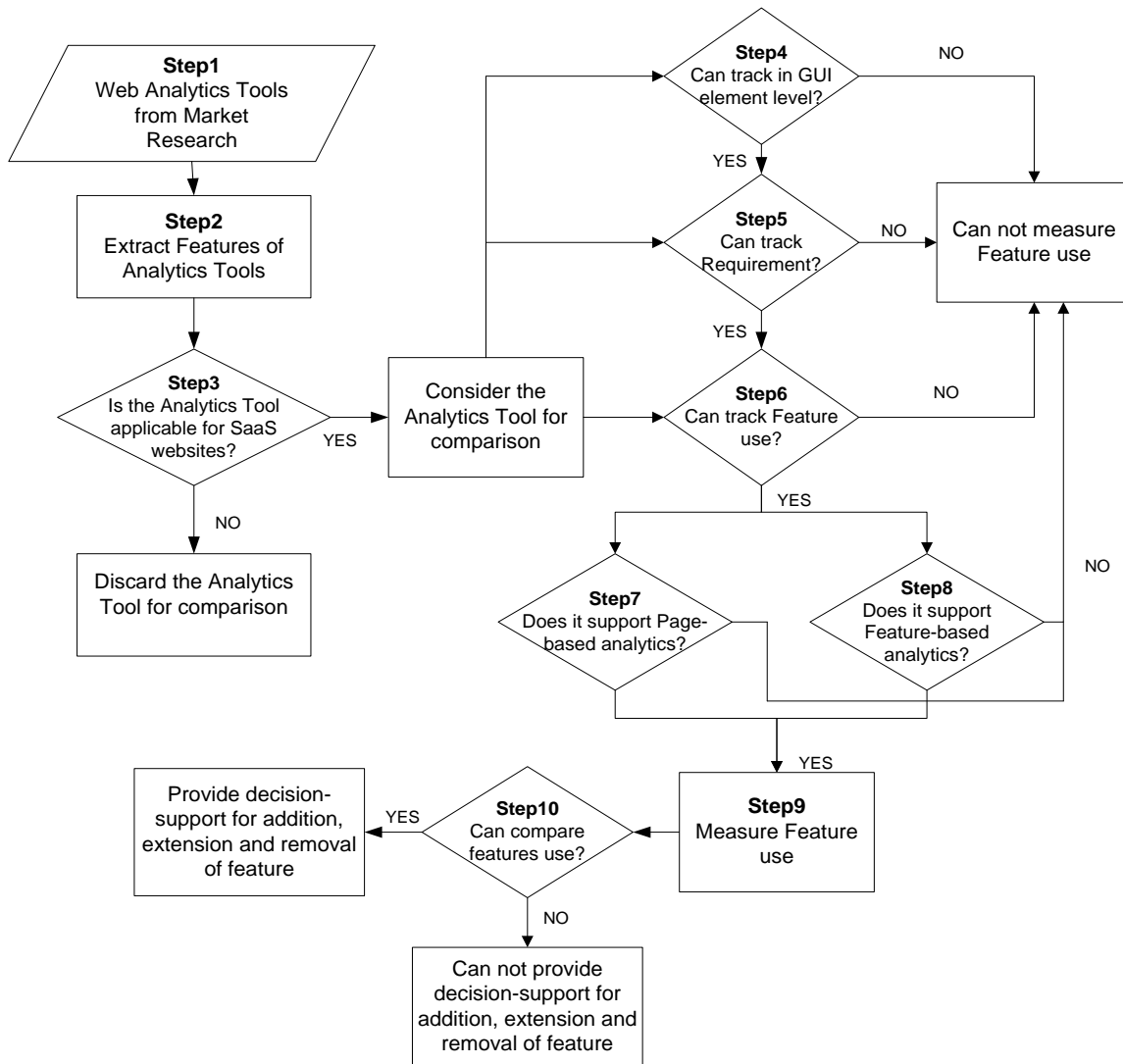


Figure 4: Compare capability of Analytics Tools to provide decision-support for Software Product Planning

4.3 Results and Analysis

4.3.1 Outcomes of feature comparison between Analytics Tools

4.3.1.1 Google Analytics

Google Analytics is an enterprise-class web analytics tool. It supports the SaaS website tracking in GUI element level. Since, Google Analytics tracks the website based on events, it supports both page-based analytics and event-based analytics [57]. Though Google Analytics is a renowned tool to track websites with different metrics i.e., visits, new visits, unique visits, returning visits, repeat visits, visit duration, bounces, referrer; there is no concept of requirements and features in Google Analytics. Since Google Analytics doesn't map features on web pages, it is not possible to measure feature usage.

As Google Analytics cannot measure feature usage, it is unable to analyze, filter, summarize and transform analytics measurement to take a decision in addition, extension and removal of features.

4.3.1.2 Adobe Analytics

Adobe Analytics is a leading solution for actionable web analytics. It provides marketers with real-time and actionable web analytics intelligence about digital strategies and marketing initiatives [58]. It supports the SaaS website tracking in GUI element level. Since, Adobe Analytics tracks the website based on events, it supports both page-based analytics and event-based analytics. Though Adobe Analytics is a renowned tool to track websites with different metrics i.e., real-time segmentation, key performance indicators (KPIs), ClickMap graphic overlays i.e., the most relevant elements on each page of a site [58]; there is no concept of requirements and features in Adobe Analytics. Since Adobe Analytics does not map features on web pages, it is not possible to measure feature usage. As Adobe Analytics can't measure feature usage, it is unable to analyze, filter, summarize and transform analytics measurement to take a decision in addition, extension and removal of features.

4.3.1.3 IBM Digital Analytics

IBM Digital Analytics is a cloud based web analytics tool that fuels the IBM Digital Marketing Optimization. IBM Digital Analytics helps enterprise to gain not only a competitive edge from state-of-art-analytics but also from comparative benchmarks and knowledge of how the best performers are achieving their successes [59]. It supports the SaaS website tracking in GUI element level. Since, IBM Digital Analytics tracks the website based on events heat map, it supports both page-based analytics and event-based analytics [60]. Though IBM Digital Analytics is a renown tool to track websites with different metrics i.e., sales heat map, KPI trends, visitor purchase funnel, bounce rate trend, cross-channel interaction optimization; there is no concept of requirements and features in IBM Digital Analytics. Since IBM Digital Analytics does not map features on web pages, it cannot measure feature usage. As IBM Digital Analytics cannot measure feature usage, it is unable to analyze, filter, summarize and transform analytics measurement to take a decision in addition, extension and removal of features.

4.3.1.4 WebTrends

Webtrends is a web analytics tool that gives a new perspective and insight of data in a visual form to see what customers are most interested in the website. Webtrends Analytics provides enterprise a unified view of customer data that allows seeing the activity in the context of all digital channels. This helps for a better understanding of what is working and what is not working [61]. Webtrends Analytics supports the SaaS website tracking in GUI element level. Since, webtrends analytics tracks the website based on events, it supports both page-based analytics and event-based analytics. Though webtrends analytics is a renown tool to track websites with different metrics i.e., webtrends streams, conversion optimization, targeted content, campaign optimization, heatmaps, real-time intelligence [62]; there is no concept of requirements and features in webtrends. As webtrends does not map features on web pages, it cannot measure feature usage. Since webtrends analytics cannot measure feature usage, it is unable to analyze,

filter, summarize and transform analytics measurement to take a decision in addition, extension and removal of features.

4.3.1.5 Yahoo! Web Analytics

Yahoo! Web Analytics is a customizable and enterprise oriented website analytics system. It supports the SaaS website tracking in GUI element level. Since, Yahoo! Web Analytics tracks the website based on events, it supports both page-based analytics and event-based analytics [63]. Though Yahoo! Web Analytics is a renowned tool to track websites with different metrics i.e., click paths, spent time, taken actions and other information about particular visits; there is no concept of requirements and features in Yahoo! Web Analytics. Since Yahoo! Web Analytics does not map features on web pages, it is not possible to measure feature usage. As this web analytics tool cannot measure feature usage, it is unable to analyze, filter, summarize and transform analytics measurement to take a decision in addition, extension and removal of features.

4.3.2 Comparison Summary

The summary of the overall discussion above can be presented in table3.

Table 3: Comparison of different analytics tools

Requirements	Google Analytics	Adobe Analytics	IBM Digital Analytics	Webtrends	Yahoo! Web Analytics
Applicable for SaaS websites	√	√	√	√	√
Able to track analytics of web pages	√	√	√	√	√
Able to track analytics in GUI element level	√	√	√	√	√
Support feature & requirement concepts	X	X	X	X	X
Support page-based analytics	√	√	√	√	√
Support element-based analytics	√	√	√	√	√
Support feature-based analytics	X	X	X	X	X
Able to compare feature usage according to indicators and sub-indicators	X	X	X	X	X
Able to measure feature usage	X	X	X	X	X
Has decision-support for software product planning	X	X	X	X	X

According to the comparison that performed on selected analytics tools (Table3), no analytics tool is observed that supports the features and requirements concepts and have decision-support for software product planning. Hence, product managers unable to utilize those web analytics tools for software product planning.

So, we propose and implement a SaaS website tracking compatible prototype web analytics tool that supports the features and requirements concepts and can measure feature usage. Hence, the tool helps to provide decision-support for software product planning through the collection of feature usage analytics and measurement of feature usage.

4.4 Proposed Analytics Tool

Prototype Analytics Tool helps to provide decision support for Software Product Planning using the measurement of feature usage. Analytics Tool is a customizable, research compatible web analytics tool. It supports the SaaS website tracking in GUI element level. Since, Analytics Tool can track the website in GUI element level (GUI elements are also defined as requirements) and GUI elements are mapped with features, it supports both page-based analytics and feature-based analytics. Analytics Tool tracks SaaS websites with different metrics i.e., indicators Usage and Health (reliability & performance) of software product planning and their sub-indicators visit count, unique visitor, new unique visitor, returning visitor, visitor location and visit time (Usage), down time, error rate (Reliability) & service response time, throughput (Performance) [Appendix B, Table17]. The Analytics tool is developed based on the concept of requirements and features. Hence, Analytics Tool can map features on web pages, and it is possible to measure feature usage and health. Moreover, it distinguishes between a click and a deliberate click based on the feature mapping. The tool only filters the clicks on a feature that is mapped by the product managers. As analytics tool can measure feature usage, it can analyze, filter, summarize and transform analytics measurement to take a decision in addition, extension and removal of features.

4.4.1 Software Requirements Specification of Analytics Tool

This section describes the software requirements specification [64] of analytics tool.

4.4.1.1 Scope

The analytics tool is able to track feature usage of the SaaS application in GUI element level. It uses three influential indicators and their sub-indicators. The key concept of the tool is developed based on the base components of software product planning such as features and requirements. The indicators of the tool are usage, reliability and performance. The sub-indicators of indicator usage are user visit count, unique visitor, new unique visitor, returning visitor, visitor location, visit time and average bounce rate. The sub-indicators of indicator reliability are down rate and error rate. The sub-indicators of indicator performance are average feature response time and throughput. The analytics generated by the tool are analyzed under specific timestamp. Then it presents the analysis result by two types of graphs e.g., line graph and pie graph.

4.4.1.2 Tool Perspective

4.4.1.2.1 System Interface

The analytics tool directly interacts with the following features of the analytics system:

Dashboard

The dashboard is the homepage of the analytics system. Product managers can surf the features on this page to manage and configure analytics and SaaS applications. Also, they can generate reports on analytics statistics [Appendix C, Figure22].

Create Indicators

It is an option of the analytics tool to create Indicators for generating statistics based on Indicator selection [Appendix C, Figure23].

Manage Indicators

Update Indicators is an option of the analytics tool to update the existing Indicators [Appendix C, Figure24].

Create Sub-indicators

It is an option of the analytics tool to create Sub-Indicators for generating statistics based on Indicator & Sub-Indicators selection [Appendix C, Figure25].

Manage Sub-indicators

Update Sub-Indicators is an option of the analytics tool to update the existing Sub-Indicators [Appendix C, Figure26].

Create Features

It is an option of the analytics tool to create features for generating statistics based on feature-based analytics [Appendix C, Figure27].

Manage Features

Manage Features is an option to modify or extend the existing features of SaaS application in analytics tool [Appendix C, Figure28].

Create Requirements

It is an option of the analytics tool to create requirements under specific features for generating statistics based on the feature-based analytics [Appendix C, Figure29].

Manage Requirements

Manage Requirements is an option to modify or extend the existing requirements of the SaaS application in analytics tool [Appendix C, Figure30].

Map Requirements with GUI elements

This option of the tool is for tentative mapping between a SaaS application feature and an Analytics Tool to track feature usage. The requirements that created in analytics

tool are mapped to the GUI elements of the SaaS application by this configuration option [Appendix C, Figure31].

Compare Features Use

The analytics of features (captured by the analytics tool) can be compared based on the selection of Indicators & Sub-indicators for specific time duration. It presents the interactive graphical presentation of data [Appendix C, Figure32].

Admin Configurations Setup

The option of Admin Configuration is for enabling and disabling the tentative feature mapping session between the SaaS application and the analytics tool [Appendix C, Figure33].

4.4.1.2.2 User Interface

Dashboard of the analytics tool would act as tailor for the product managers. It can browse from all browsers.

4.4.1.3 Stakeholder Description

The stakeholders of Analytics System are Product Managers, Developers, Visitors of SaaS websites and the Analytics System. The description and responsibilities of each stakeholders of analytics system are presented in Table4.

Table 4: Stakeholder descriptions of Analytics System

Name	Description	Responsibilities
Product Manager	The Product Manager of a SaaS Website	The responsibility of Product Manager is to use Analytics tool to track and measure feature usage to obtain decision support of software product planning
Developer	The Developer of a SaaS Website	The responsibility of the developer is to set up the configuration or map between a SaaS website and an analytics tool
Visitor/User	Visitor of a SaaS Website	The responsibility of the visitor is to use the features of SaaS websites
Analytics System	A system to track analytics of user interaction (feature usage) with SaaS websites	The responsibility of Analytics System is to track feature usage and enable decision support for Product Managers

4.4.1.4 Functions

The prototype tool facilitates decision support for software product planning. Hence, it enables comparison of feature usage analytics between two features or the whole product for a selected time span. The tool is also capable to configure requirements and features of the SaaS website using GUI elements in run time.

The prototype tool develops in such a way that the GUI elements of SaaS websites are connected with product manager's defined requirements. Requirements are connected with features. Therefore, it is possible to analyze the feature usage of the SaaS application in GUI element level. So, the product manager can aware regarding the usage and health i.e. reliability and performance of a feature and utilize analytics for software product planning.

4.4.1.5 Functional Requirements

The functional requirements of analytics tool are described below –

- I. The product manager shall be able to create features based on the features of the SaaS website.
- II. The product manager shall be able to maintain features.
- III. The product manager shall be able to create requirements based on the features and GUI elements of the SaaS website.
- IV. The product manager shall be able to maintain the requirements.
- V. The product manager shall be able to create Indicators for analyzing analytics of feature usage.
- VI. The product manager shall be able to maintain Indicators.
- VII. The product manager shall be able to create Sub-Indicators based on Indicators.
- VIII. The product manager shall be able to maintain Sub-Indicators.
- IX. The product manager shall be able to set admin status to enable mapping between an analytics tool and a SaaS website.
- X. The developer/product manager shall be able to map features between the analytics tool and the SaaS website.
- XI. The product manager shall be able to select features to generate report with interactive graphs.
- XII. The product manager shall be able to compare feature usage and health between two features

4.4.2 UML Architecture

The architecture of the analytics tool with entities and their functionalities is described in Figure5. The prototype analytics tool collects analytics of user interaction with the SaaS website. There are several web pages in a SaaS website. Each web page contains GUI elements. We indicated that GUI elements as the requirements of a SaaS web page. The features can be created based on one or more than one requirements.

Analytics tool is connected with a SaaS website by the configuration of features and requirements between an analytics tool and a SaaS website. The analytics collected from the SaaS website are categorized in several indicators and sub-indicators.

The product managers of the SaaS websites can configure the mapping the analytics tool and the SaaS website. They can create features and requirements in the analytics tool based on the SaaS website features. The product managers are also responsible for managing the requirements and features.

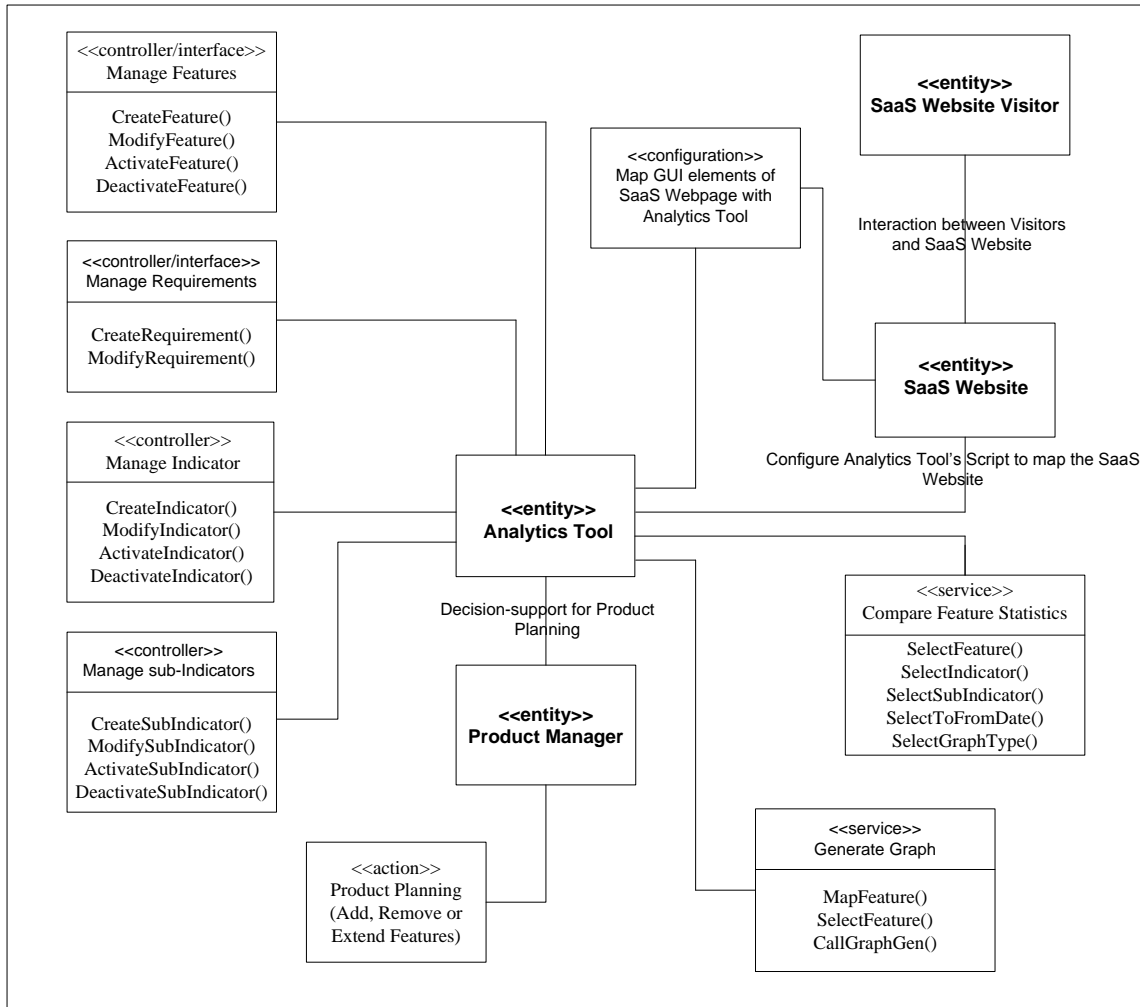


Figure 5: UML Architecture Diagram of Analytics Tool

In Figure5, the entities are the actors of the analytics system. Entity ‘visitor’ has only interactions with the SaaS website. ‘SaaS Website’ and ‘Product Manager’ entities are connected with analytics system, where the product manager configures and defines the requirements (GUI elements) and features in analytics system based on the SaaS website features and requirements. Product manager is able to manage features i.e., create, modify, activate and deactivate features; manage requirements i.e., create, modify, activate and deactivate requirements; manage indicators i.e., create, modify, activate and deactivate indicators and manage sub-indicators i.e., create, modify, activate and deactivate sub-indicators.

Product managers can generate graphs utilizing functionalities MapFeature, SelectFeature and CallGraphGen. Graph generation is also dependent on the selection of indicators and sub-indicators. They can compare analytics of feature usage utilizing SelectFeature, SelectIndicator, SelectSubIndicator, SelectToFromDate and SelectGraphType functionalities between two or more features. Based on the report of analytics, product managers can understand the importance of a feature. So, it helps them

to take decision whether a feature would be extended or removed. Therefore, the analytics tool can support product planners to perform product planning.

4.4.3 System Context Diagram

The system context diagram of analytics system is presented in Figure6. Visitor’s interactions with the SaaS website are collected by an analytics system to compare feature usage of a SaaS website.

Product manager and Developer of SaaS website are connected with Analytics system. Developer or product manager can configure the SaaS website with analytics system to enable analytics for software product planning. The product manager is also responsible for maintaining and configuring features of the SaaS website.

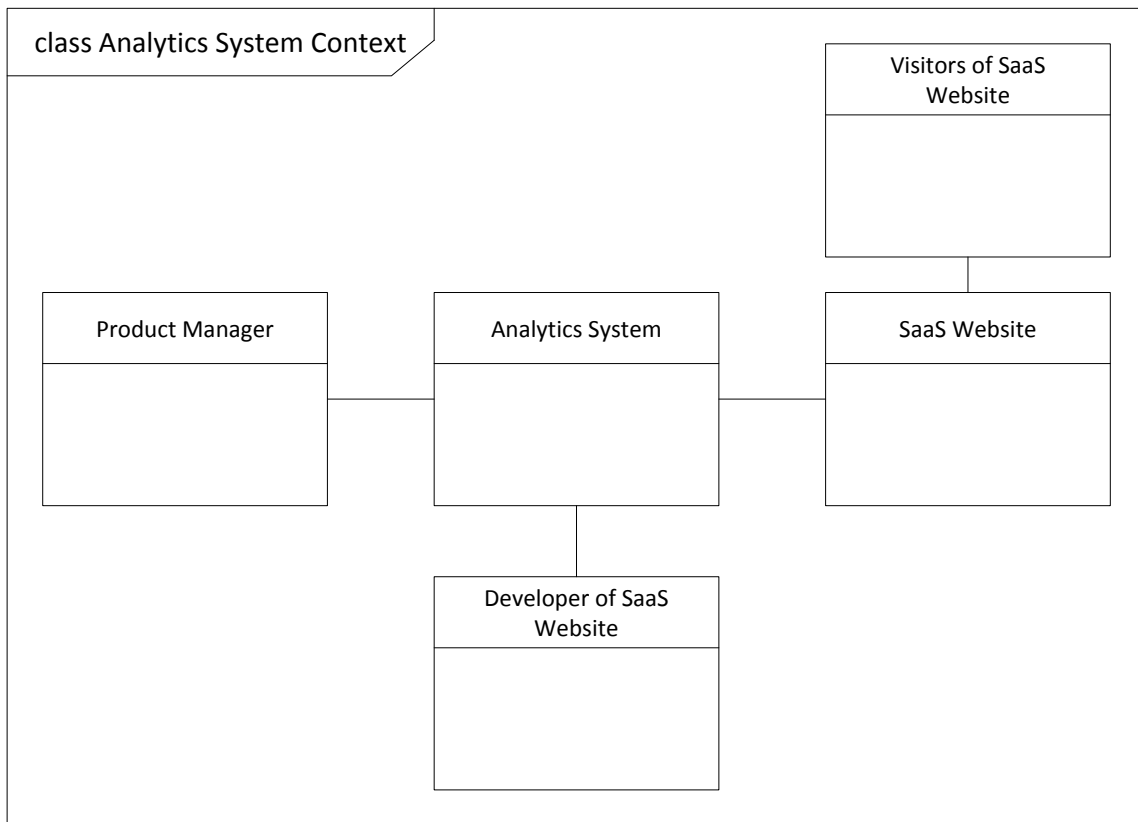


Figure 6: System context diagram of Analytics Tool

4.4.4 Use Case Diagrams

4.4.4.1 Visitor

The use case diagram of SaaS visitors is presented in Figure7. Visitors of a SaaS website are connected with features and requirements (GUI elements) of SaaS websites. They are connected by visiting the features and requirements of SaaS websites. The analytics system captures analytics of feature visited by SaaS visitors.

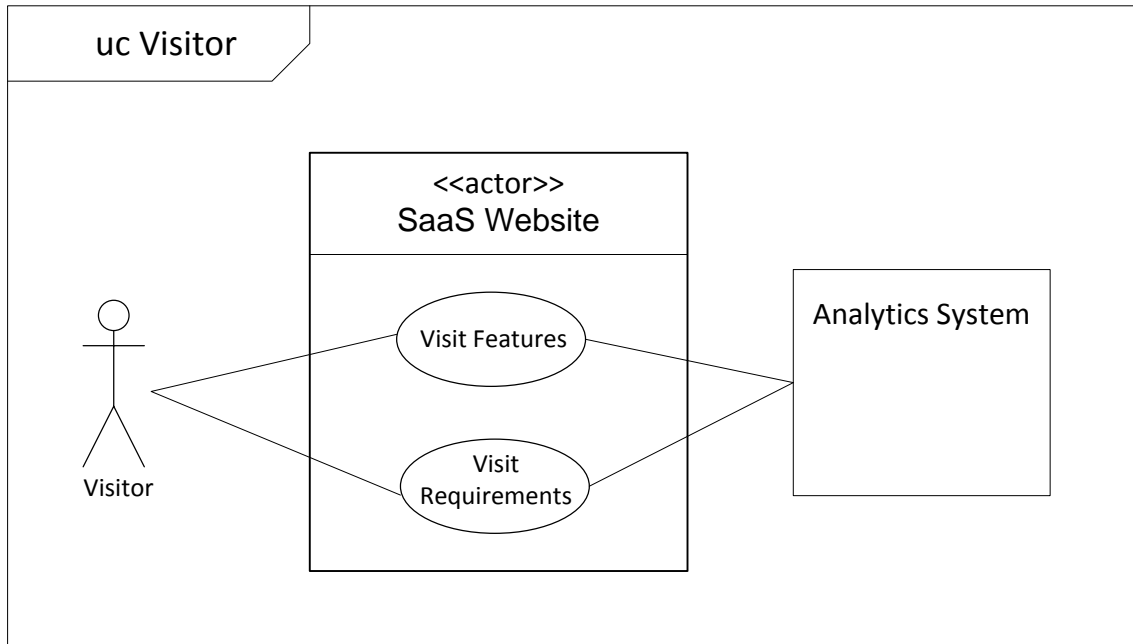


Figure 7: Use case diagram of Visitor

4.4.4.2 Product Manager

The role of product manager in analytics system is described in Figure8 by the use case diagram of Product manager. The product manager is responsible to manage features and requirements of analytics tool that are mapped with a SaaS website. Product managers can select indicators and sub-indicators, graph type and certain time range to generate graphs from analytics.

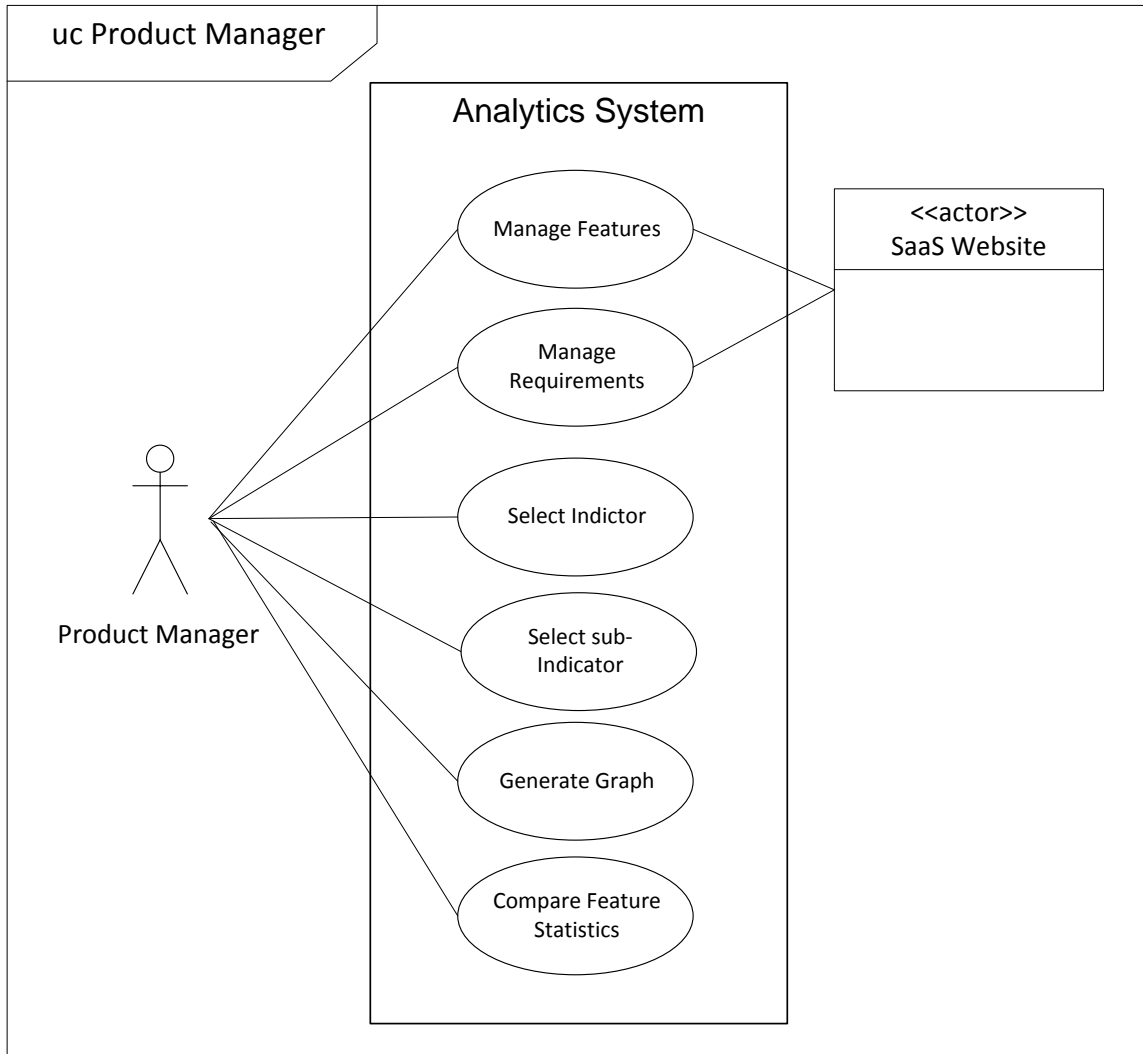


Figure 8: Use case diagram of Product Manager

4.4.4.3 Developer

The use case diagram of the role of developer in analytics system is depicted in Figure9. Developer of analytics tool is responsible for developing analytics configuration, map requirements with the SaaS website GUI elements. The developer has also the privilege of managing indicators and sub-indicators.

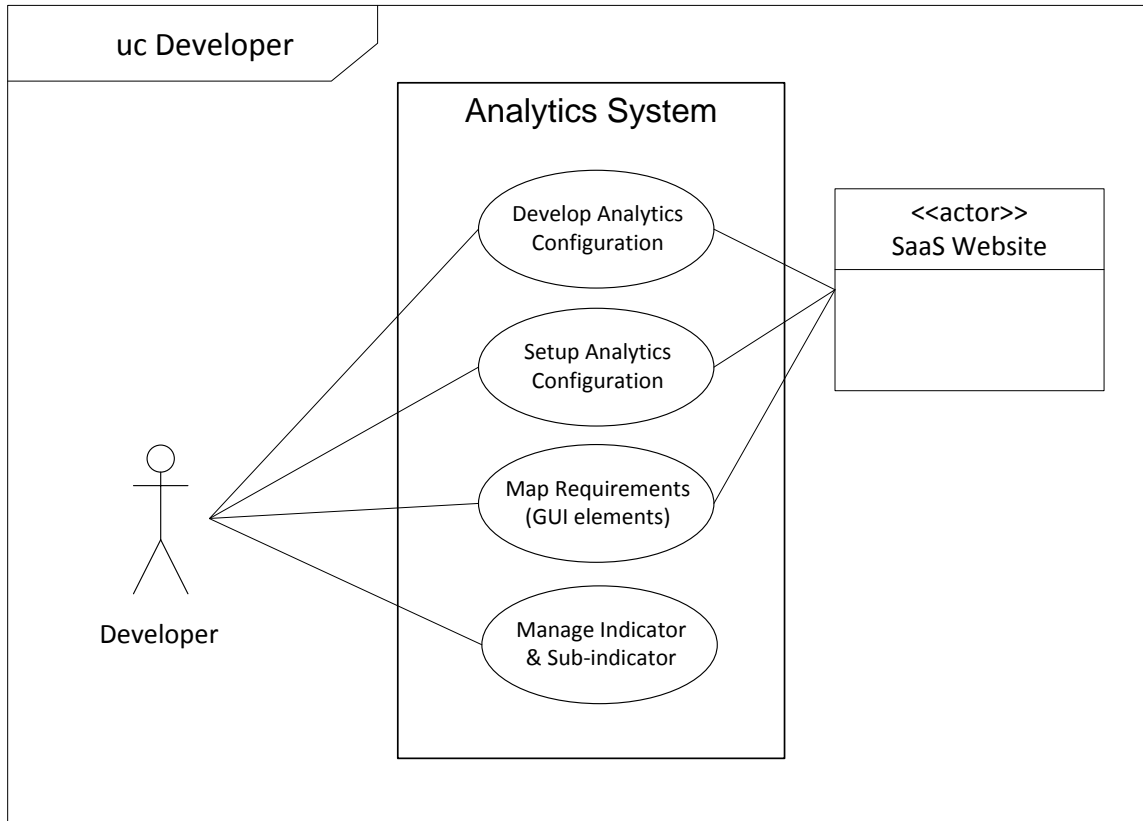


Figure 9: Use case diagram of Developer

4.4.5 Class Diagram

Figure10 depicts the class diagram of the analytics system. Classes of analytics system are requirement, feature, GUI element, track visitor, visitor, and visitor info, manage indicator, product manager, manage feature, manage requirement.

The visitor and visitor info classes are for representing visitors' information; SaaS application is represented the information about SaaS websites; product manager class is representing the product managers' collaboration with analytics tool and SaaS application. Requirement class indicates the information of requirements (GUI elements) of SaaS websites. Feature class indicates the information of features of SaaS websites. There is a one-to-one relationship between GUI elements and Requirements; one-to-many relationship between requirements and features. The track visitor class maintains the relation between visitors, SaaS websites and analytics tool. Manage feature and manage requirement classes are responsible to create, update and extend features and requirements.

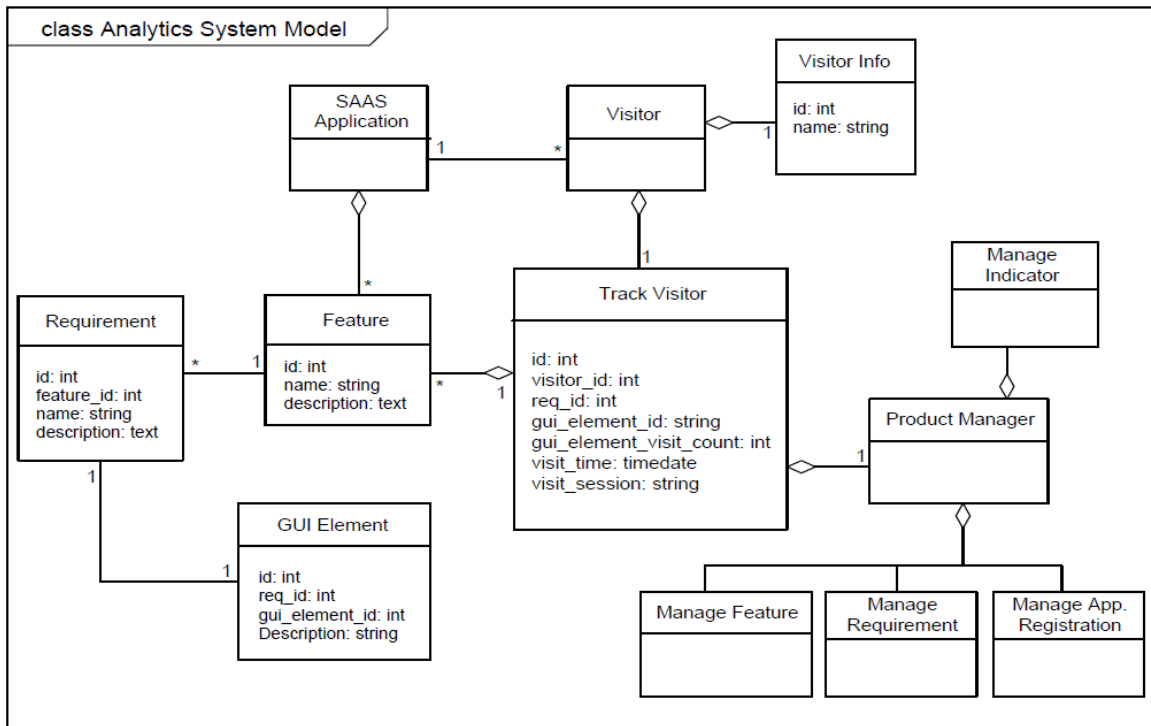


Figure 10: Class Diagram of Analytics System

4.4.6 Sequence Diagram

The sequence diagram of analytics tool that represents the interaction of visitor, product manager and SaaS website with analytics tool is described in Figure11. Visitor interacts with the SaaS website and analytics tool tracks the user interaction analytics. Product manager sends a request to analytics tool to create requirements and features. The analytics tool sends a response by message that the requirements and features are created successfully. The product manager sends requires to analytics tool to map features with SaaS application to track user interaction. Analytics tool responses that the features are mapped properly with SaaS feature. Then the product manager selects indicator and sub-indicator to generate graph based on feature usage analytics. Based on the graph product manager can compare the statistics between two features.

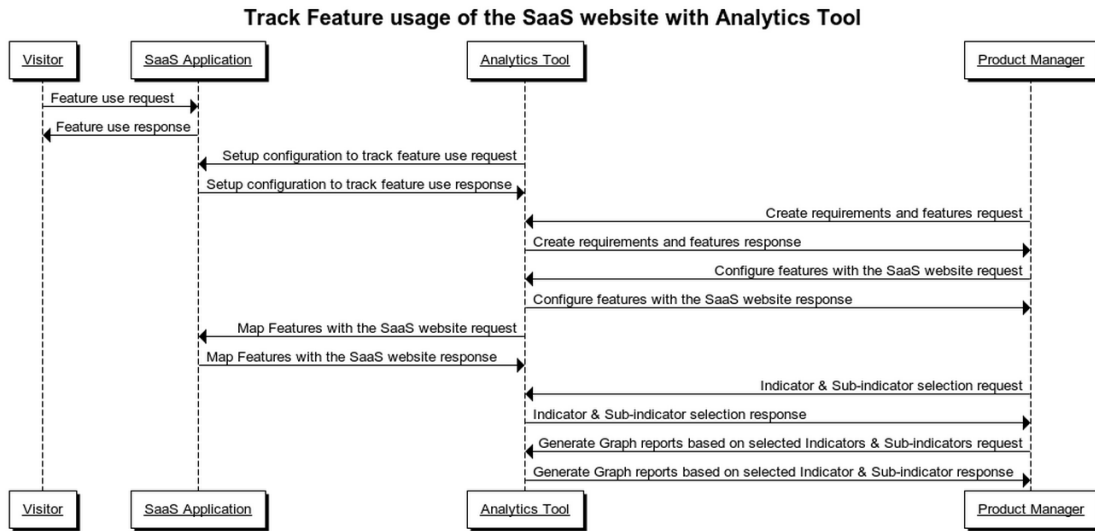


Figure 11: The sequence diagram of analytics tool, visitor, product manager and SaaS website interaction

4.4.7 Track the SaaS website by prototype Analytics Tool

In this section, we describe how to set-up configuration, track and measure the feature usage of a SaaS website by the prototype analytics tool. The SaaS website is provided by the supervisor and he performed the product manager role to define features and requirements of the SaaS website.

4.4.7.1 Script configuration of Analytics Tool

The script configuration is required to connect a SaaS website with analytics tool and configure analytics tool to capture feature usage of the SaaS website.

Front-end Script Configuration in the SaaS website:

It requires referring one Js link in the header or footer section of the webpage of the SaaS website for tracking.

E.g., <http://54.246.61.52:8080/featureTree/resources/js/analytics.js>

DB Configuration:

1. Create database named as 'analytics_tool'
2. Upload SQL Script to generate all tables of 'analytics_tool' in the database

4.4.7.2 Step-by-step guideline to track Feature usage of the SaaS website by Analytics Tool

We describe how to track feature usage analytics of a SaaS website by the prototype Analytics Tool in this section.

1. Create features in Analytics Tool based on the defined features of the SaaS website [Appendix D, Figure35]. Click on the 'Manage Feature' option on the dashboard of

Analytics Tool. Then click on ‘Add Feature’ option and enter Feature Name, Status and Feature Description. Finally, click on ‘Add Feature’ button to create features.

The features are defined by the product manager of the SaaS website [Appendix D, Figure34].

2. Create requirements of defined features in Analytics Tool based on the related events (GUI elements) of the SaaS website [Appendix D, Figure36]. Click on the ‘Manage Requirement’ option on the dashboard of Analytics Tool. Then click on ‘Add Requirement’ option. After that select Feature Name, Status from the drop down list, and enter Requirement Name & Requirement Description. Finally, click on ‘Add Requirement’ button to create the requirement.

There is a one-to-one mapping relationship between requirements and GUI elements. The requirements of features are defined by the product manager of SaaS website [Appendix D, Figure34].

3. Set admin status as ‘active’ on the Analytics Tool to enable mapping of the SaaS website GUI elements with the created requirements of the Analytics Tool [Appendix D, Figure37]. Click on the ‘Set Admin Status’ option on the dashboard of Analytics Tool. Then select ‘active’ from ‘Admin Status’ drop down list and click on ‘Update Admin Status’ button.
4. Map the GUI elements of the SaaS website with the created requirements of the Analytics Tool [Appendix D, Figure38]. Click on the GUI element of the SaaS website. A pop-up window would be appeared. Select ‘Requirement’ from the drop down list and press ‘MAP GUI Element’ button from the pop-up window to map a particular requirement with a GUI element.
5. Set admin status as ‘inactive’ on the Analytics Tool to disable mapping of the SaaS website GUI elements [Appendix D, Figure37]. Click on the ‘Set Admin Status’ option on the dashboard of Analytics Tool. Then select ‘inactive’ from ‘Admin Status’ drop down list and click on ‘Update Admin Status’ button.
6. Visit the mapped feature on the SaaS website to track the analytics of feature usage.
7. Compare the feature usage that is captured by the Analytics Tool from the user interaction analytics [Appendix D, Figure39]. Click on the ‘Statics & Graph’ option on the dashboard of Analytics Tool. Select Feature, sub-Indicators (previously created with DB script configuration), To-From date and Graph Type to generate the graph of selected features.

4.5 Discussion

The study develops a comparison method using some specific requirements that are able to facilitate an analytics tool by enabling decision-support for software product planning.

The feature comparison results between different analytics tools, according to the comparison method (Figure4 & Table3) show that no web analytics tool supports features and requirements concepts. Though they support tracking user interaction in page and GUI element level, they are not aligned with the concept of software product planning. Moreover, they do not have decision supports for software product planning. So, the

study introduces the concept of decision-support in software product planning by utilizing user interaction analytics through the implementation of a prototype analytics tool. The tool is able to capture and measure the feature usage. Hence, provide decision-support to product planners of SaaS websites in addition, extension or removal of features.

As the prototype analytic tool only supports to track feature of SaaS websites that have direct interaction with end users rather than SaaS desktop applications i.e., CRM Software, ERP Software, Email Marketing Software, Transaction Processing Software etc. The tool is also unable to track the requirements (GUI elements) that are related to iFrame, Flash and Video events of SaaS websites. Moreover, to facilitate decision support for software product planning, SaaS based analytics might not be sufficient enough to provide adequate information for software product planning, while business analytics can be supportive.

The implications of the prototype analytics tool for product managers are -

- Product managers would be able to track the requirements and features in the GUI element level of the product. So, it would be possible for tracking of a feature at the unit level of a product.
- Product managers would be able to perform feature measurement using relevant indicators and sub-indicators [65] of analytics.
- Product managers would be able to compare features use between different features and perceive the importance of the features to users. Hence, product managers would be able to utilize the feature usage measurement results to take decision about addition, extension or removal of features during product planning.
- Product managers would be able to detect page clutter, erroneous page presentation problems of product features and take decision regarding enhance or removal of that features.
- Product managers would be able to measure feature usage for feature spreads in their product and understand the usage of deferent elements of a features in several pages of product.

The implications of the prototype analytics tool for analytics tool constructors are –

- Analytics tool constructors would be able to introduce the features and requirements concepts to develop their solutions and make it helpful for product managers or product planners to take advantages of decision-support in software product planning.
- Analytics tool constructors would be able to make use of the concept and hence, implement analytics solutions compatible with software product planning.

The implications of the prototype analytics tool for researchers are –

- Researchers would be able to utilize the open source analytics tool to research the different cases of real life industrial scenarios that product managers often face during product planning.
- Researchers would be able to use the open source analytics tool to perform experiment on other influential problems of SaaS web applications rather than page clutter, erroneous page presentation or feature spread and enhance the

features of the analytics tool to make critical or advanced level decision-support for product evolution. That would establish a bridge between the combination of analytics and the business strategy.

Wei Fang utilized Google Analytics to track the visitors' behavior and motivation behind their information-seeking to improve a library website, Rutgers-Newark Law Library (RNLL) [41]. He used different features of Google Analytics e.g., visitor count, visitor's location, visitor link referral, page visit count, visitor session; to improve the content of the library website. The proposed prototype analytics tool in the study is able to track the user behavior and measure the feature usage of SaaS websites. The events of SaaS websites are mapped as requirements on the prototype analytics tool. One or more requirements are connected together to form features on the analytics tool. By this way the tool is mapping the features of SaaS websites. The measurement of feature usage is performed based on the categories of analytics i.e., indicators and sub-indicators, that are referred as relevant for measuring software usage by the outcome of the research [65]. Moreover, the proposed analytics tool is implemented based on the concept of software product planning and can distinguish the analytics in both page and feature level i.e. page-based analytics and feature-based analytics.

4.5.1 Threats to Validity

4.5.1.1 Conclusion Validity

Conclusion validity relates the treatment and the outcome of the simulation [53]. The goal of the prototype tool is to enable decision support for software product planning. There is a possibility to make wrong data analysis by tool and hence, make a wrong suggestion for an addition, extension or removal of features. We are validating the results of analytics tool with the conceptual calculation of feature usage (in RQ2). Moreover, the calculation inside the analytics tool is performing in an automated way by using different analytics functionality i.e., based (visit count, error rate, page load time etc.) and derived (accuracy, precision) measurements.

This wrong decision-support can be interpreted because of the lack of true patterns e.g., continuous or discontinuous feature visits or usage in the data. So, to make a complete decision support regarding software product planning based on the analysis of the tool may not be possible.

4.5.1.2 Internal Validity

The results generated by the prototype tool may not reflect the real life scenario. The suggestions of the tool regarding the status of features may not accept as appropriate to product manager for features maintenance. The growth of analytics and tool or analytics solutions are asymmetric. Hence, the relationship between them may not symmetric. The results of analytic tool may change based on indicators and sub-indicators. The tool generated results may not help product planners to take decision on features management. Because there are other influential factors e.g., key stakeholders choice, competitor analysis, technical development difficulties to maintain the features rather than considering only in the perspective of the sub-indicator factors of visitors.

4.5.1.3 Construct Validity

The results of the simulation are dependent on indicators and sub-indicators parameters. So, the decision support for software product planning can differ based on the analytics parameters. But in real life software product planning, the changes of one or two parameters may not affect the product planning decisions. SaaS based analytics may not be sufficient enough to provide adequate information for software product planning, while business analytics can act as supportive factor.

4.5.1.4 External Validity

Prototype tool generated results may not generalize enough to use in every industrial practice. There are some limitations which limiting the tool to simulate data and propose a suggestion regarding software product planning in controlled and defined environment only. As the proposed analytics tool is a prototype version, it is only applicable for tracking the user interactions of SaaS websites. The analytics tool is not applicable to track the user interactions for other types of SaaS applications.

5 Compare Page-based Analytics and Feature-based Analytics

In previous chapter, the effective way of collecting analytics for software product planning and how to measure feature usage using prototype analytics tool are discussed. This chapter presents the research design and results of the software simulation that was performed using the prototype tool to compare page-based analytics and feature-based analytics. Page-based analytics measures the in general usage of all the features on the web page rather than a particular feature. Contrarily, feature-based analytics measures the usage of a particular feature on the web page. The results of the simulation would be helpful for the product managers to measure the usage and health i.e., reliability and performance of a feature. So, the results of the study would facilitate the decision support of software product planning regarding the usage (i.e., simulation results obtained from page clutter and feature spread) and health (i.e., simulation results obtained from erroneous page presentation) of features.

5.1 Research Design

The goal of the simulation is to compare page-based analytics and feature-based analytics in terms of page clutter, erroneous page presentation and feature spread. The accuracy and precision are calculated to measure the feature usage in page-based analytics and feature-based analytics.

Web page is indicated as a medium of representing software-as-a-service (SaaS).

The independent variables are the page clutter, feature spread and erroneous page representation. Web page clutter refers to the situation where many features are present on a web page. Feature spread refers that one feature can be visible on multiple web pages i.e., one feature can be mapped to multiple elements of different web pages. Erroneous page representation refers which particular feature or features are erroneous on the web page.

One or more GUI elements (i.e., requirements) create a feature and a feature demands in more than one pages. So, Page Clutter (i.e., one or more features belongs to a web page) and Feature Spread (i.e., a feature belongs to one or more web pages) are selected as independent variables, to compare the feature usage when there are more features in page-based analytics and feature-based analytics. The erroneous page representation is also chosen as an independent variable to measure the feature health with respect to page-based analytics and feature-based analytics.

The dependent variables are the accuracy and precision. Accuracy indicates the true results (both true positives and true negatives [66] [67]) of feature usage, while precision indicates the repeatability and reproducibility of the feature usage. The accuracy and precision can be measured by the following way [66] [67]-

$$Accuracy = \frac{\text{number of true positives} + \text{number of true negatives}}{\text{number of true positives} + \text{false positives} + \text{false negatives} + \text{true negatives}}$$

$$Precision = \frac{\text{number of true positives}}{\text{number of true positives} + \text{false positives}}$$

The meaning of ‘true positive’ is correctly identified, ‘true negative’ is correctly rejected, ‘false positive’ is incorrectly identified and ‘false negative’ is incorrectly rejected.

Page-based analytics indicates the in general features usage of a web page, while feature-based analytics indicates a particular feature usage of a web page.

There are other kinds of analytics e.g., perspective analytics, predictive analytics, descriptive analytics, business analytics, big-data analytics [68] [69]. As those types of analytics do not have the ability to measure feature usage, they are not considered for analytics comparison in simulation. Since the feature-based analytics measures the usage of a particular feature in GUI element level (i.e., one or more GUI elements or requirements create a feature) and page-based analytics also measures the in general usage of features in GUI element level (i.e., there are one or more features on a web page), the comparison of element-based and event-based (i.e., GUI element level) analytics are not taken in action during simulation.

5.1.1 Active measurements on simulation platform

The software product planning supported analytics tool is developed based on the concept of tracking feature usage. The tool can track feature usage of a SaaS website in GUI element level.

We consider four scenarios for simulation. Scenario1 and scenario2 are designed to compare the web page clutter with respect to page-based analytics and feature-based analytics. Feature one is used out of four features on the web page in first scenario and feature one and two both are used in second scenario. Scenario3 is designed to compare

the feature spread with respect to page-based analytics and feature-based analytics. Scenario1, scenario2 and scenario3 simulate the measurement of the usage of features. Scenario4 is designed to compare the erroneous page presentation with respect to page-based analytics and feature-based analytics. Scenario4 simulates the measurement of the health of features.

Scenario1:

The SaaS website with four features and one web page, the web page contains feature one if it contains any feature. Feature one is used.

Scenario2:

The SaaS website with four features and one page, the page contains feature one and feature two if it contains any features. Feature one and two are used.

Scenario3:

The SaaS website with four web pages and one feature, the feature spreads on four web pages. Feature one has four sub elements (i.e., requirements) and they are mapped in four web pages like feature one's element one (F1.E1) is mapped on web page one (P1), feature one's element two (F1.E2) is mapped on web page two (P2), feature one's element three (F1.E3) is mapped on web page three (P3) and feature one's element four (F1.E4) is mapped on webpage four (P4). Feature one Element one (F1.E1) and Feature one Element two (F1.E2) are used on web page1 (P1) and web page2 (P2).

Scenario4:

The SaaS website with four features and one web page, the page contains erroneous feature one if it contains any erroneous feature.

This section discusses the results obtained from the measurements on the analytics tool during simulation. These simulations between a SaaS website and an analytics tool are performed in order to observe the impact of page cluttering, feature spread and erroneous page representation in terms of accuracy and precision measurement of feature usage with respect to page-based analytics and feature-based analytics. The simulation results are analyzed in the following subsections.

5.1.2 Simulation setup and methodology

The simulation is performed between a SaaS website and a software product planning supported prototype tool (analytics tool). We simulate feature usage based on pre-defined scenarios, apply those scenarios on the SaaS website and observe the feature usage based on the perspective of the page-based analytics and feature-based analytics. Finally, the real results of simulation are compared with the expected results based on predefined scenarios.

The SaaS website anforderungen.ch (a SaaS website for software development plan and commission) is considered for the simulation. Feature usage profile is defined as a single click on a web page or a particular feature. The accuracy and precision [66] [67] [70] of feature usage are measured in simulation.

Simulation was performed at the campus of Blekinge Institute of Technology. As represented in Figure12, this simulation contains a SaaS website, a software product planning supported analytics tool and predefined scenarios. The SaaS website is linked between the user interaction and the analytics tool. Our measurement point is the Analytics Tool. The SaaS website features are mapped and configured with a prototype tool to collect feature usage analytics.

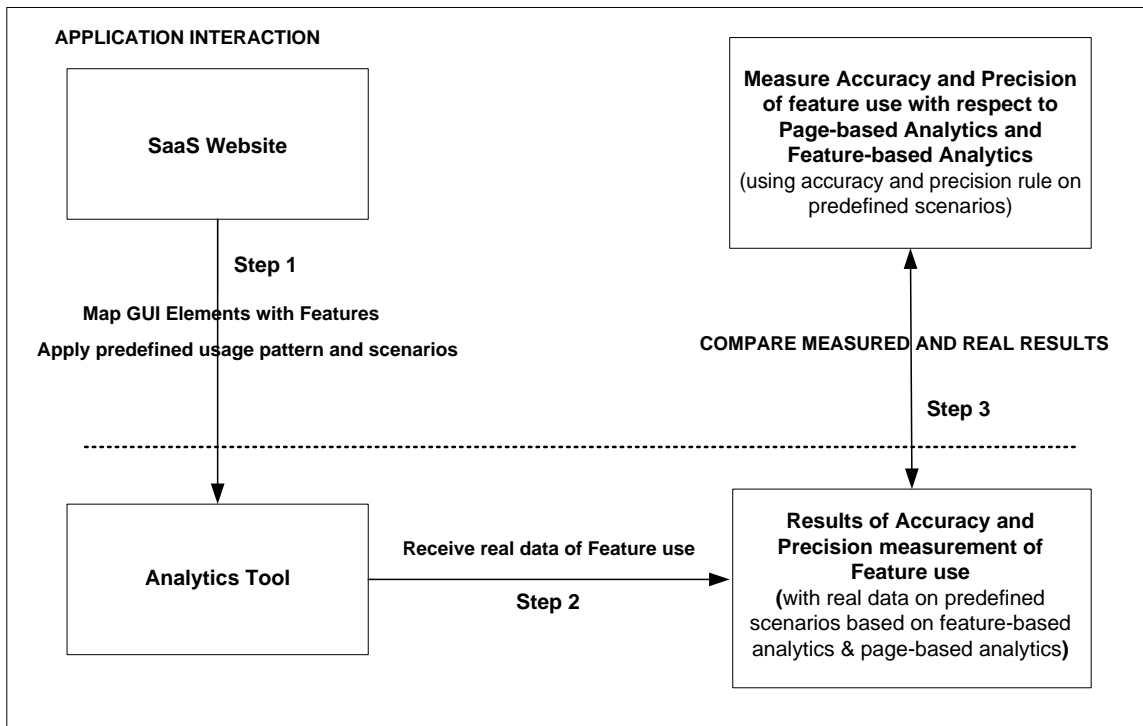


Figure 12: Simulation Setup of Research Question2

A link of 10 Mbps is used between the server (a SaaS website) and the client (the Feature Visitor/User). Simulation was performed by clicking on a specific feature on the webpage that contains maximum of four features. The user on the client computer opens the SaaS webpage and then visits the feature. While using the feature, visit count and erroneous feature were captured by the analytics tool. A given user performs single click feature usage. The user was instructed regarding the mapped features and visit types (e.g., single click or multi-click on a feature) before simulation. The accuracy and precision of feature usage are calculated based on the page-based analytics and the feature-based analytics. Hence concentrate on measuring the impact of page clutter, feature spread and erroneous page representation in terms of the results of accuracy and precision respectively.

5.2 Results and Analysis

5.2.1 Impact of page clutter on page-based analytics and feature-based analytics

In this section, we present the results obtained by end-to-end measurements that show the impact of page clutter in terms of accuracy and precision on the page-based analytics and feature-based analytics.

5.2.1.1 Scenario1

As represented in Table5, Features are created based on a SaaS website. P1 indicates as a web page1 of the SaaS website. Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4) indicate as different features of web page P1. We consider the website with one page and four features, the page contains feature one if it contains any feature. Feature one is used.

Table 5: Page clutter for page-based analytics and feature-based analytics

Page Design (P1)				Page Clutter	True Feature Usage				Page-based Measurement		Feature-based Measurement	
F1	F2	F3	F4	Features per Page	F1	F2	F3	F4	Accuracy	Precision	Accuracy	Precision
0	0	0	0	0	1	0	0	0	0.75	0	1	1
1	0	0	0	1	1	0	0	0	1	1	1	1
1	1	0	0	2	1	0	0	0	0.75	0.5	1	1
1	1	1	0	3	1	0	0	0	0.5	0.33	1	1
1	1	1	1	4	1	0	0	0	0.25	0.25	1	1

To understand the accuracy and precision of feature usage is important to product managers for measuring feature usage.

Figure13 shows the results between accuracy of feature usage and page clutter i.e., features per web page. We measure the accuracy of a feature usage between feature-based analytics and page-based analytics. Figure14 shows the plots among calculated precisions of feature usage and page clutter. The first figure (Figure13) indicates the accuracy of feature and the second figure (Figure14) indicates the precision i.e. consistency of feature usage. While the feature one (F1) is used by the user, both accuracy and precision are 1 in feature-base analytics, even there are four features on the web page (F1, F2, F3, F4). On the contrary, as the number of features grows the accuracy and precision decrease. It indicates the page clutter in page based analytics. There is a significant degradation of accuracy and precision in the page-based analytics for the page clutter between numbers of feature per page 2 to 4.

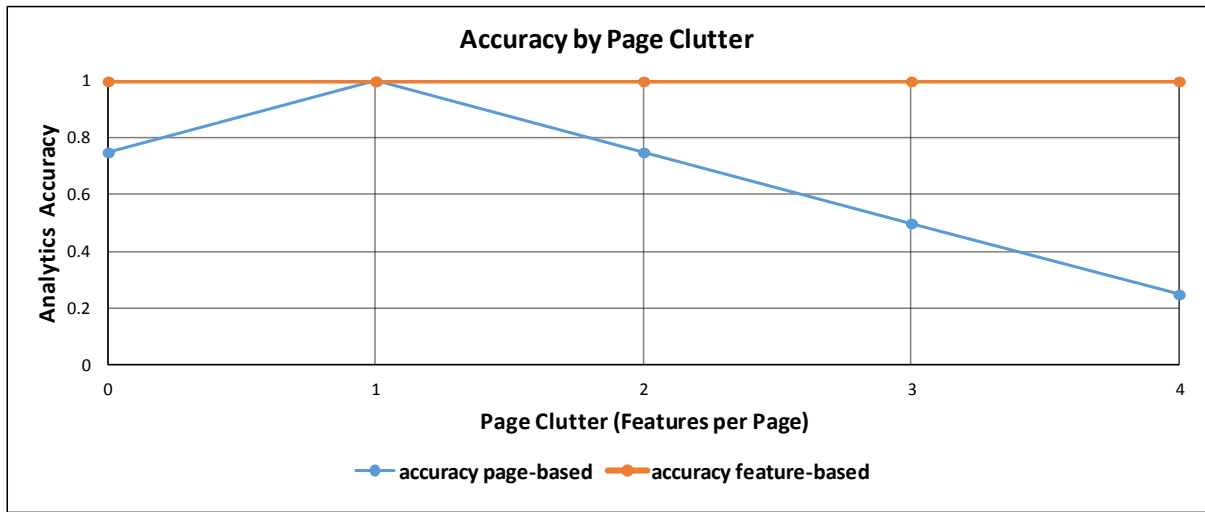


Figure 13: Accuracy by Page clutter measurement for page-based analytics and feature-based analytics

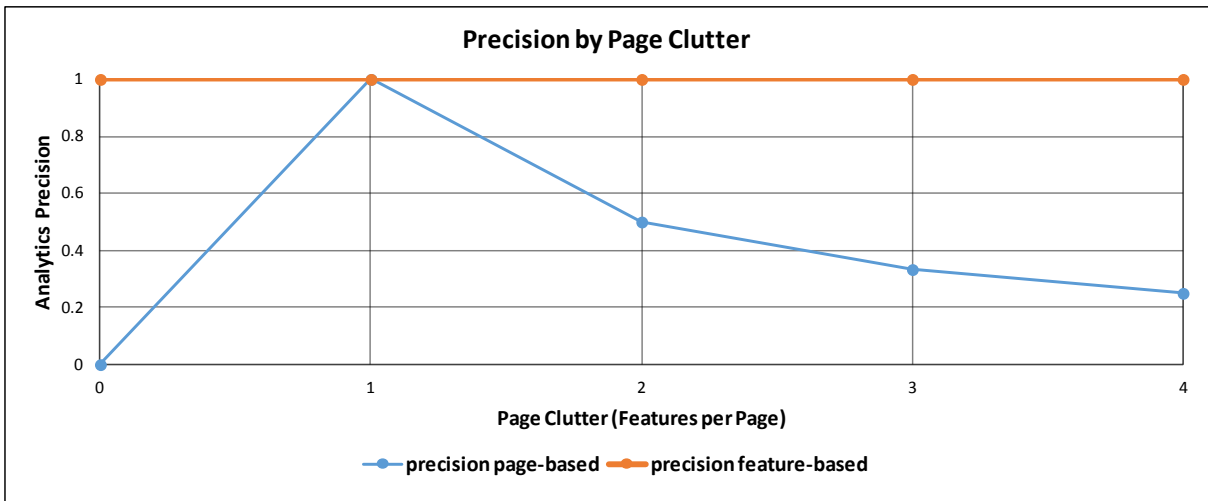


Figure 14: Precision by Page clutter measurement for page-based analytics and feature-based analytics

In Table6, we measure the real feature usage based on the feature usage captured by our prototype analytics tool. The analytics of feature usage are generated by the interaction between a real user and a SaaS website. Features are created based on a SaaS website. P1 denotes as web page1 of the SaaS website. Feture1 (F1), Feture2 (F2), Feture3 (F3) and Feture4 (F4) represent as different features of web page1 (P1). We consider the website with four features and one page, the page contains feature one if it contains any feature. Feature one is used (scenario1).

Table 6: Page clutter on real feature usage for page-based analytics and feature-based analytics (Appendix E, Figure40 & Figure41)

Page-based Analytics		Feature-based Analytics	
Web page/Feature Name	Visit Count	Web page/Feature Name	Visit Count
Webpage1 (P1)	4	Webpage1 (P1)	4
Feature1 (F1)	4	Feature1 (F1)	4
Feature2 (F2)	4	Feature2 (F2)	0
Feature3 (F3)	4	Feature3 (F3)	0
Feature4 (F4)	4	Feature4 (F4)	0

Page-based analytics (Appendix E, Figure40) only counts the page visits rather than individual features, so if there is an increase feature in that web page P1 then the accuracy and precision measurement of feature usage decreases. Here visitor visits the web page1 (P1) 4 times. Though only feature one (F1) is truly used, it is showing the in general usage of all features (i.e., F1, F2, F3 and F4 are visited 4 times) in page-based analytics. So the accuracy and precision measurement of feature usage decreases to 0.25, 0.25 respectively (Figure13, Figure14). On the other hand, feature-based analytics (Appendix E, Figure41) counts features visit individually. The visit count of feature one is 4. So, from the analysis result (Figure13, Figure14), we see that in web page1 (P1) the accuracy and precision measurement of feature usage remain stable and both are 1 and 1 respectively.

5.2.1.2 Scenario2

In simulation of scenario2, we consider the SaaS website of four features and one web page, the page contains feature one and feature two if it contains any features. Feature one and two are used (Table7).

Table 7: Page clutter for page-based analytics and feature-based analytics

Page Design (P1)				Page Clutter	True Feature Usage				Page-based Measurement		Feature-based Measurement	
F1	F2	F3	F4	Features per Page	F1	F2	F3	F4	Accuracy	Precision	Accuracy	Precision
0	0	0	0	0	1	1	0	0	0.5	0	1	1
1	0	0	0	1	1	1	0	0	0.75	0.5	1	1
1	1	0	0	2	1	1	0	0	1	1	1	1
1	1	1	0	3	1	1	0	0	0.75	0.67	1	1
1	1	1	1	4	1	1	0	0	0.5	0.5	1	1

Figure15 and Figure16 also show the same result, while the website contains four features and one page. The page contains feature one (F1) and feature two (F2) if it contains any features. Also, feature one and two are used. Feature-based analytics is accurate and precise to capture true feature usage of F1 and F2. But page-based analytics is unable to capture the true use of feature accurately and precisely as feature-based

analytics. The overall trend is that the accuracy and precision decrease with the increase of page clutter in page-based analytics.

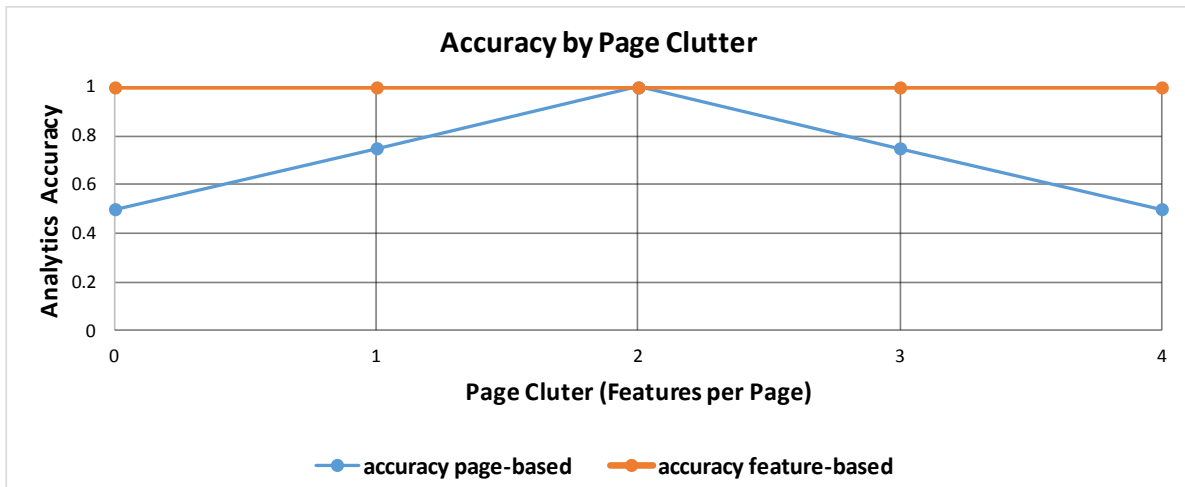


Figure 15: Accuracy by Page clutter measurement for page-based analytics and feature-based analytics

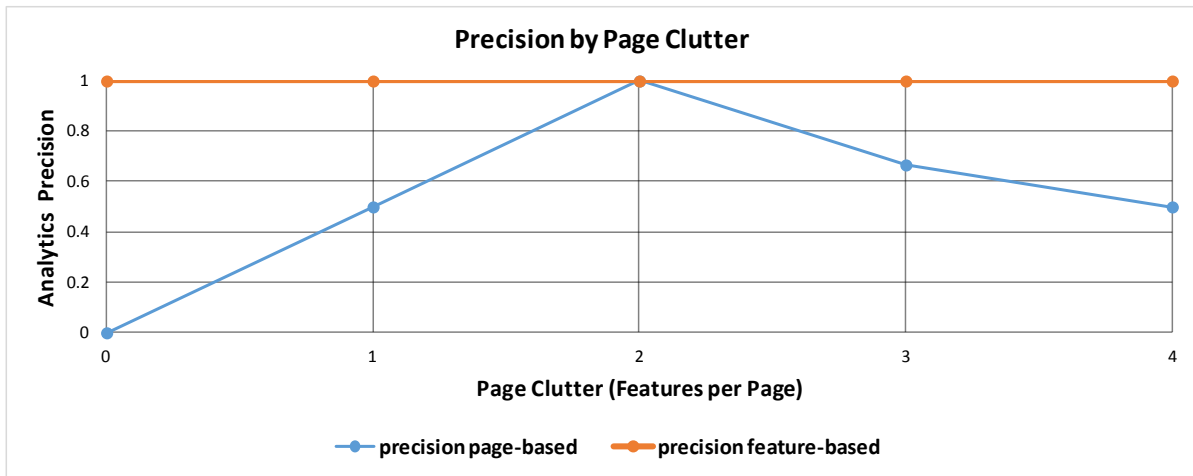


Figure 16: Precision by Page clutter measurement for page-based analytics and feature-based analytics

In Table8, we measure the real feature usage based on the feature usage captured by our prototype analytics tool. The analytics of feature usage are generated by the interaction between a real user and a SaaS website. Features are created based on the SaaS website. P1 indicates as web page1 of the SaaS website. Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4) represent different features of web page1 (P1). We consider the SaaS website with four features and one page, the page contains feature one and feature two if it contains any features. Feature one and two are used (scenario2).

Table 8: Page clutter on real feature usage for page-based analytics and feature-based analytics (Appendix E, Figure42 & Figure43)

Page-based Analytics		Feature-based Analytics	
Web page/Feature Name	Visit Count	Web page/Feature Name	Visit Count
Webpage1 (P1)	8	Webpage1 (P1)	8
Feature1 (F1)	8	Feature1 (F1)	4
Feature2 (F2)	8	Feature2 (F2)	4
Feature3 (F3)	8	Feature3 (F3)	0
Feature4 (F4)	8	Feature4 (F4)	0

In page-based analytics (Appendix E, Figure42) web page1 (P1) has 4 features. Here in web page1 (P1), visitor visits the page 8 times but use only two features i.e., Feature1 (F1) and Feature2 (F2)). But in page-based analytics it only shows the in general usage of features (web page and features are visited 8 times) and no more information about a particular feature usage. So, accuracy and precision measurement of feature usage are changed and increased to 0.5 and 0.5 respectively (Figure15, Figure16). On the other hand, feature-based analytics (Appendix E, Figure43) count features visits individually. The visit count of Feature1 (F1) is 4 and Feature2 (F2) is 4. In feature-based analytics it is possible to measure each feature usage individually. So from the result we see that in web page1 (P1) the accuracy and precision measurement of feature usage remain stable at 1, 1 respectively (Figure15, Figure16).

Finally, the results of simulation1 and simulation2 represent that page clutter increases with the increase of number of features per page in page-based analytics, which is quite understandable as accuracy and precision decrease due to the increase of features per page. So, Page cluttering exaggerates feature usage measurement with page-based analytics, but not with feature-based analytics.

5.2.2 Impact of feature spread on page-based analytics and feature-based analytics

In this section, we present the impact of feature usage measurement for feature spread. The measurement is calculated in terms of accuracy and precision on the page-based analytics and feature-based analytics.

5.2.2.1 Scenario3

As represented in Table9, the web pages and features are created based on a SaaS website. F1 indicates as feature one of the SaaS website. Web page1 (P1), web page2 (P2), web page3 (P3) and web page (P4) are different web pages of the SaaS website. We consider the SaaS website with four web pages and one feature, the feature is spread in four pages. Feature one is constructed by four elements i.e., Feature1 Element1 F1.E1, Feature1 Element2 F1.E2, Feature1 Element3 F1.E3 and Feature1 Element4 F1.E4. Four elements of feature one are mapped to four web pages. Feature1 Element1 (F1.E1) and Feature1 Element2 are truly used in web page1 (P1) and web page2 (P2).

Table 9: Feature spread measurement with respect to page-based analytics and feature-based analytics

Scenarios of 4 Pages Design (Total of F1 Features spread in the application)					True Use				Page-based Measurements		Feature-based Measurement	
P1	P2	P3	P4	Pages per Feature	F1E1(Page1)	F1E2(Page2)	F1E3(Page3)	F1E4(Page4)	Accuracy	Precision	Accuracy	Precision
0	0	0	0	0	1	1	0	0	0.5	0	1	1
1	0	0	0	1	1	1	0	0	0.75	0.5	1	1
1	1	0	0	2	1	1	0	0	1	1	1	1
1	1	1	0	3	1	1	0	0	0.75	0.67	1	1
1	1	1	1	4	1	1	0	0	0.5	0.5	1	1

Figure17 shows the results between accuracy of feature usage in the case of feature spread. We measure the accuracy of the feature usage in terms of feature-based analytics and page-based analytics. Figure18 shows the plots between calculated precision of feature usage with respect to feature spread. The first figure (Figure17) indicates the accuracy or true use of a feature and the second figure (Figure18) indicates the precision of the feature usage. While the feature one's element one (F1.E1) and element two (F1.E2) are used on web page one (P1) and web page two (P2), both accuracy and precision remain stable at 1 in feature-base analytics, even the feature one (F1.E1, F1.E2) is spread in four web pages (P1, P2, P3, P4). On the contrary, as the number of web pages grows, the accuracy and precision decrease that indicates the feature spread alter feature usage measurement in page-based analytics. There is a significant degradation of accuracy and precision in the page-based analytics while the number of web pages is increased to 3 or 4 (i.e., web pages per feature).

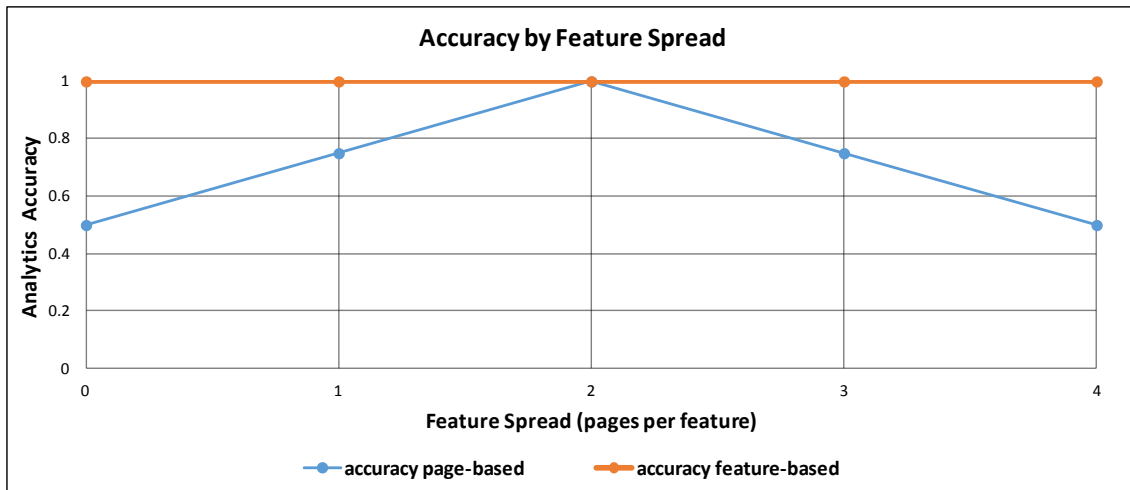


Figure 17: Accuracy measurement for page-based analytics and feature-based analytics

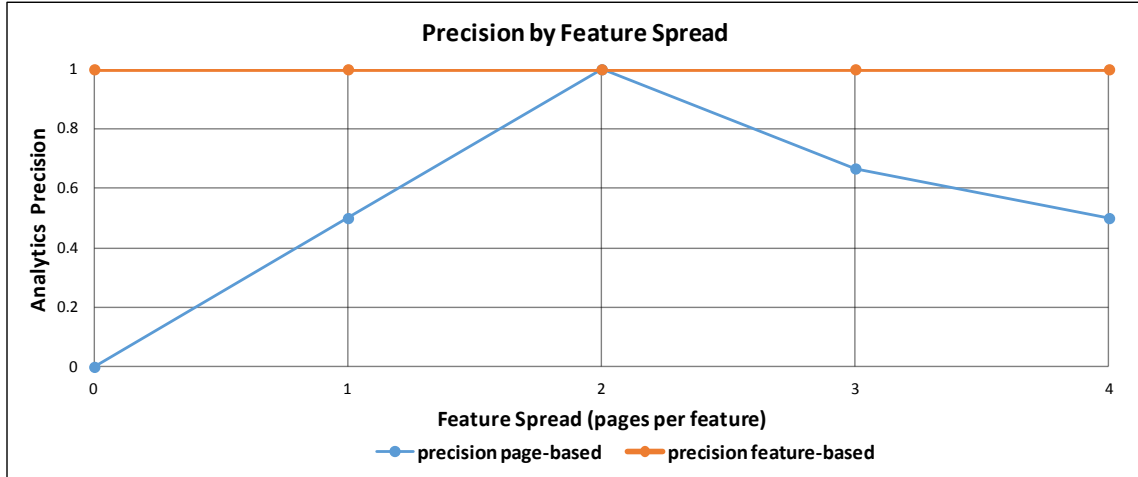


Figure 18: Precision measurement for page-based analytics and feature-based analytics

We measure the real feature usage captured by our prototype analytics tool (Table10). The analytics of feature usage are generated by the interaction between a given user and the SaaS website. Web pages and Features are created based on the SaaS website. F1 indicates as feature one of the SaaS website. Feature one is spread on different web pages P1, P2, P3 and P4. We consider the SaaS website with four pages and one feature, the feature is spread in four pages. Feature one is divided into four elements and mapped with four pages. Element one of Feature one (F1.E1) is mapped with web page1 (P1), Element two of Feature one (F1.E2) is mapped with web page2 (P2), Element three of Feature one (F1.E3) is mapped with web page3 (P3), Element four of Feature one (F1.E4) is mapped on web page4 (P4). Feature one's element one (F1.E1) and element two (F1.E2) are truly used in web page1 (P1) and web page2 (P2) (Scenario3).

Table 10: Feature Spread on real feature usage for page-based analytics and feature-based analytics (Appendix E, Figure44 & Figure45)

Page-based Analytics		Feature-based Analytics	
Web page/Feature Name	Visit Count	Web page/Feature Name	Visit Count
Webpage1 (P1)	1	Webpage1 (P1)	1
Webpage2 (P2)	1	Webpage2 (P2)	1
Webpage3 (P3)	1	Webpage3 (P3)	1
Webpage4 (P4)	1	Webpage4 (P4)	1
Webpage1 Feature1 (F1.E1)	1	Webpage1 Feature1 (F1.E1)	1
Webpage2 Feature1 (F1.E2)	1	Webpage2 Feature1 (F1.E2)	1
Webpage3 Feature1 (F1.E3)	1	Webpage3 Feature1 (F1.E3)	0
Webpage4 Feature1 (F1.E4)	1	Webpage4 Feature1 (F1.E4)	0

Page-based analytics (Appendix E, Figure44) only count the in general feature usage rather than the individual feature. So, if there is a feature spread in different web pages then the accuracy and precision measurement of feature spread decreases. Here, visitor visits the feature one element one on web page1 once and also feature one element two

on web page2 once. But there is the in general visit count is captured in page-based analytics and it shows that all the feature elements are used based on the visit of web pages. The accuracy and precision measurement of feature spread decreases to 0.25, 0.33 respectively (Figure17, Figure18) when the feature is spread in three web pages. On the other hand, feature-based analytics (Appendix E, Figure45) captures analytics based on the particular feature usage. It collects analytics separately for all elements of the feature that are mapped with different web pages. In feature-based analytics, visit count of feature one element one and feature one element two both are captured as 1 by the analytics tool. So, it is possible to measure the usage of different elements of the same feature that spread in different web pages. So, the result presents that even feature one is spread in four web pages, the accuracy and precision measurement of feature spread remain stable at 1, 1 respectively (Figure17, Figure18).

The result from Simulation3 shows that while feature spread is increased, accuracy and precision are decreased in page-based analytics. On the other hand, in feature-based analytics accuracy and precision are remain stable even the number of web pages are increased with feature spread.

So, Feature spread does not alter feature usage measurement with feature-based analytics compare to page-based analytics.

5.2.3 Impact of erroneous page representation on page-based analytics and feature-based analytics

This section discusses the impact of erroneous features on the SaaS web page based on the occurrence of HTTP error codes [46] [71] during feature usage (e.g. 404, 408, 500 etc.). We present the results about the accuracy and precision of erroneous page presentation in terms of feature-based analytics and page-based analytics.

5.2.3.1 Scenario4

As represented in Table11, features are created based on the SaaS website. P1 indicates as the web page of the SaaS website. Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4) indicate as different features of web page1 (P1). We consider the SaaS website with four features and one web page. The page contains erroneous feature one if it contains any erroneous feature.

Table 11: Measure Accuracy and Precision of Erroneous Page in terms of Feature-based and Page-based analytics

Page Design (P1)				Erroneous Page Features per Page	True Feature Usage				Page-based Measurement		Feature-based Measurement	
F1	F2	F3	F4		F1	F2	F3	F4	Accuracy	Precision	Accuracy	Precision
0	0	0	0	0	1	0	0	0	0.75	0	1	1
1	0	0	0	1	1	0	0	0	1	1	1	1
1	1	0	0	2	1	0	0	0	0.75	0.5	1	1
1	1	1	0	3	1	0	0	0	0.5	0.33	1	1
1	1	1	1	4	1	0	0	0	0.25	0.25	1	1

To understand the accuracy and precision of the occurrence of an erroneous feature on the web page is important to product manager. Product manager can understand the consistency of using the web page when there is an erroneous feature on the web page by the precision graph and further can discover whether the erroneous feature is truly accessed by the accuracy graph.

Figure19 shows the results between accuracy of feature usage and erroneous page presentation when the feature one is erroneous. We measure the accuracy of erroneous feature for feature-based analytics and page-based analytics. Figure20 shows the scenarios between measured precision of feature usage and erroneous page presentation. The first figure (Figure19) indicates the accuracy i.e., usage of the erroneous feature and the second figure (Figure20) indicates the precision i.e., consistency or repeatability of using the erroneous feature. While the feature one (F1) is erroneous, both accuracy and precision are 1 in feature-base analytics, even there are four features on the web page (F1, F2, F3 and F4). Contrarily, as the number of features grows the accuracy and precision decrease. It indicates the failure of capturing an erroneous feature in page-based analytics.

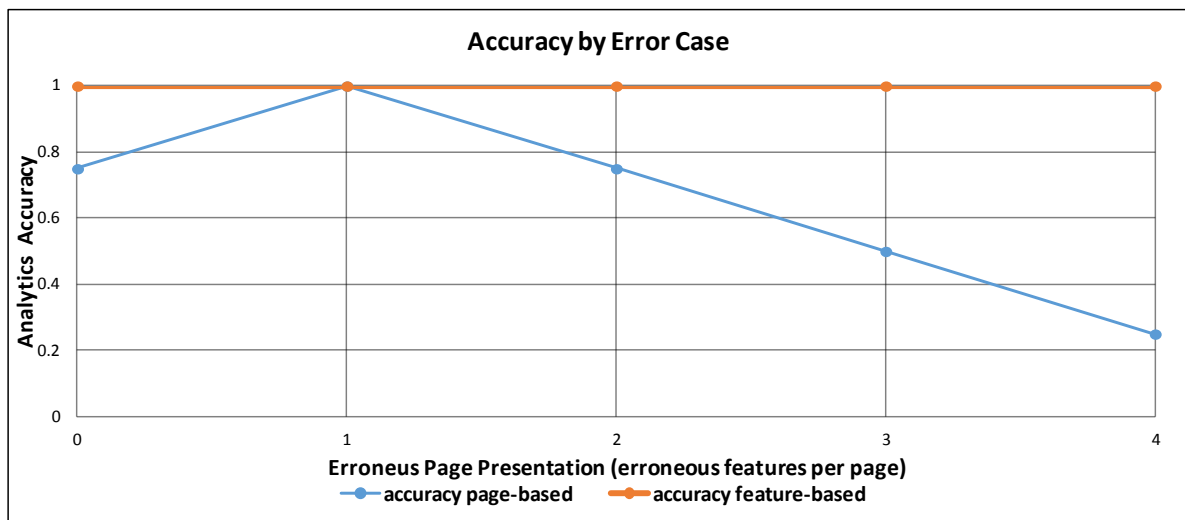


Figure 19: Accuracy of Error count measurement for page-based analytics and feature-based analytics

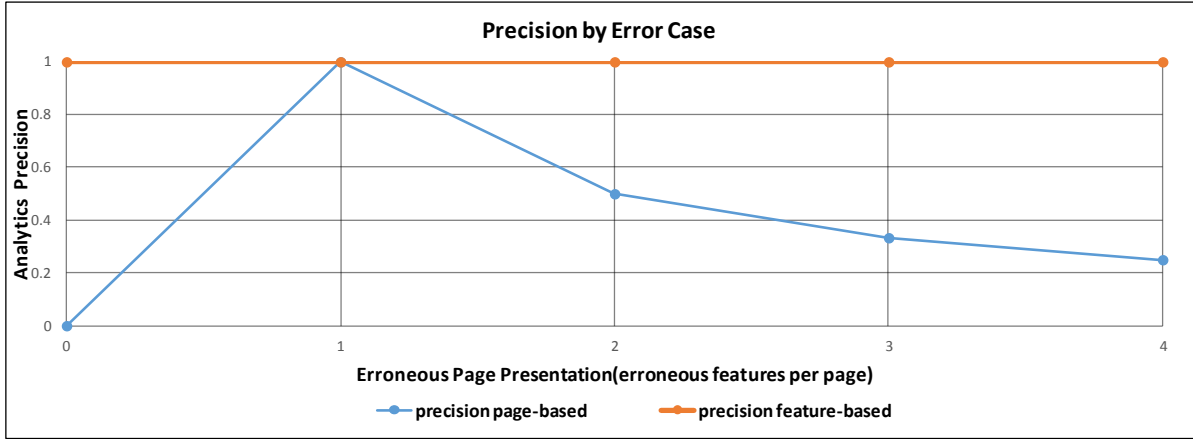


Figure 20: Precision of Error count measurement for page-based analytics and feature-based analytics

In Table12, we measure the real erroneous feature usage based on the feature usage captured by our prototype analytics tool. The analytics of erroneous feature usage are generated by the interaction between a user and the SaaS website. Features are created based on the SaaS website. P1 indicates as a web page1 of the SaaS website. F1, F2, F3 and F4 indicate as different features of the web page1 (P1). We consider the website with four features and one web page, the page contains erroneous feature one if it contains any erroneous feature (scenario4).

Table 12: Erroneous page presentation on real feature usage for page-based analytics and feature-based analytics (Appendix E, Figure46 & Figure47)

Page-based Analytics		Feature-based Analytics	
Web page/Feature Name	Error Count	Web page/Feature Name	Error Count
Webpage1 (P1)	4	Webpage1 (P1)	4
Feature1 (F1)	4	Feature1 (F1)	4
Feature2 (F2)	4	Feature2 (F2)	0
Feature3 (F3)	4	Feature3 (F3)	0
Feature4 (F4)	4	Feature4 (F4)	0

In page-based analytics (Appendix E, Figure46) visitor visits web page1 (P1) 4 times in the erroneous page but only feature one is erroneous. Page-based analytics cannot capture analytics of erroneous feature one separately as it captures the error occurrence of all features in general. So the accuracy and precision of the erroneous feature usage are decreased to 0.25, 0.25 respectively (Figure17, Figure18). Even the user visits the web page (P1) 4 times; it's not understandable from page-based analytics which particular erroneous feature is used by the user. On the other hand, feature-based analytics (Appendix E, Figure47) count the usage of erroneous features individually. The erroneous feature's (Feature1 (F1)) error count is 4 according to the analytics tool. So, the simulation result shows, the accuracy and precision of erroneous feature usage on web

page1 (P1) remain stable at 1, 1 respectively (Figure17, Figure18). In feature-based analytics, it is possible to measure which particular erroneous feature is used by the user.

So, Page presentation errors exaggerate feature usage measurement with page-based analytics, but not with feature-based analytics.

5.3 Discussion

The simulation is conducted by prototype analytics tool to compare feature usage with respect to page-based analytics and feature-based analytics. Impact of page clutter, feature spread and erroneous page representation through the measurement of feature usage has been analyzed. The result depicts how page-based analytics and feature-based analytics differ in accuracy and precision perspective of feature usage measurement. From the analysis and result of the simulation it has been revealed that feature-based analytics is better than page-based analytics with respect to measurement of feature usage. Current page-based analytics concept has no direct relationship with software engineering perspective such as software product planning. The feature tree concept was introduced by Samuel A. Fricker what describes the product as a feature tree [16]. Product manager can measure the usage of individual features of a product through a feature-based analytics tool.

In RQ2, the paged-based analytics and feature-based analytics solutions are compared with respect to page cluttering, feature spread and erroneous page representation by calculating precision and accuracy of feature usage measurement. First the precision and accuracy formula is used theoretically with the concept of both page-based and feature-based analytics. Then the measurement of feature usage has been done using real data (simulation results) on predefined scenarios. From the results and analysis of simulation, it has been shown that page clutter, feature spread and erroneous page representation have impact on the measurement of feature usage with respect to page-based analytics. Page cluttering, feature spread and erroneous page presentation exaggerate feature usage measurements with page-based analytics. Moreover, Page-based analytics alter feature usage measurement.

On the other hand, in feature-based analytics there is no impact of page clutter, feature spread and erroneous page representation on the measurement of feature usage. Also, Feature-based analytics does not alter feature usage measurement. As for example, in scenario1 and scenario2 (Page Clutter), there are four features in a web page. When the feature increases per web page from 0 to 4, the precision and accuracy of feature usage are remain stable. The simulation result with the real data (collected from prototype tool) presents the same result that the accuracy and precision of feature usage measurement remain stable with the increase of number of features on the web page. For other two scenarios such as feature spread and erroneous page representation, there is no impact of the feature usage measurement on feature-based analytics.

ISO describes a process for defining measures that is appropriate to the Information needs of a particular project [72]. The standard ISO/IEC 15939:2002 can be used for

software measurement. In the ISO/IEC 15939:2002, different steps described in the measurement process are shown in figure 21.

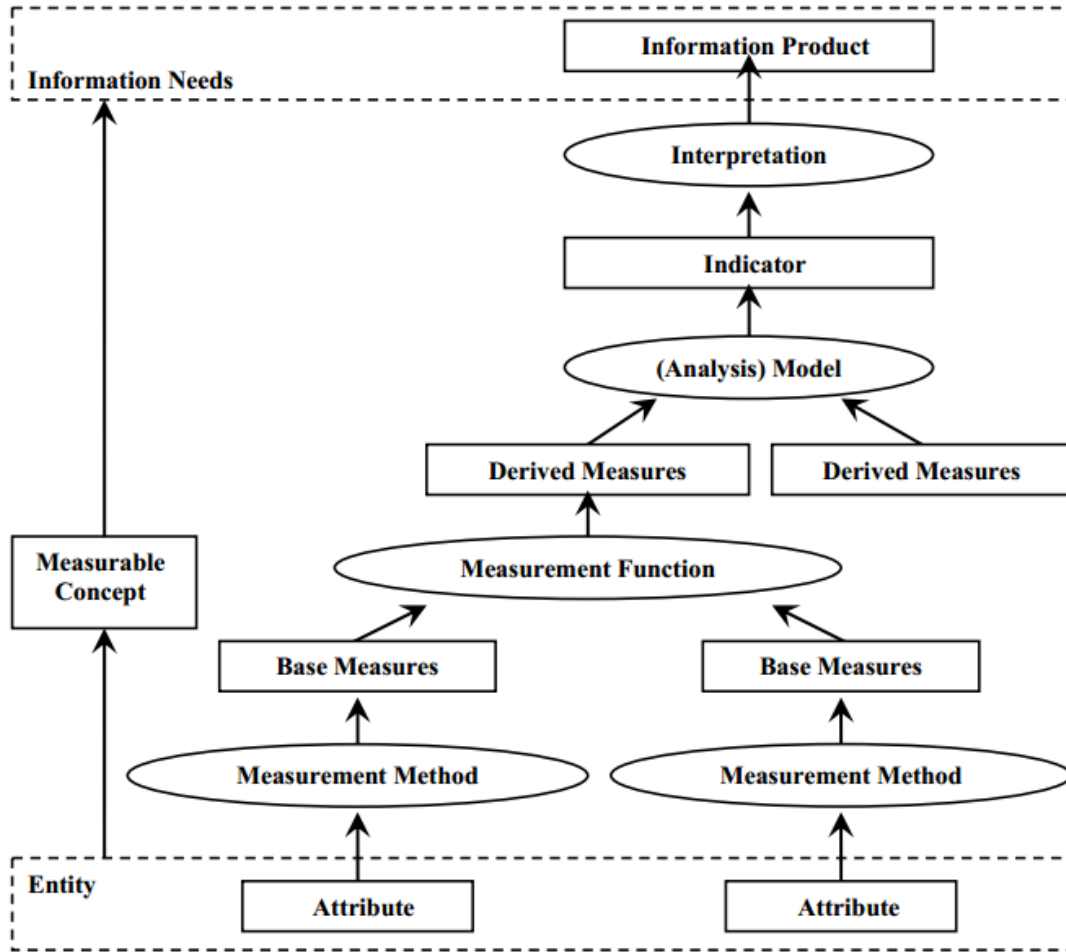


Figure 21: The measurement information model ISO/IEC 15939:2002, adapted from [72]

A measurement information model ISO/IEC 15939:2002 (Figure21) can be used to present a framework for the software measurement system. For accuracy and precision measurement of feature usage, simulation uses ISO/IEC 15939:2002 measurement information model. The different steps of the model are interpreted for the simulation. The measurement tables describe feature usage measurement system. Here three information need (i.e., information need for page clutter, feature spread and erroneous page representation) are utilized to validate feature usage measurement of the simulation. Feature usage measurement in case of page clutter, feature spread and erroneous page representation are presented in Table 13, Table 14 and Table15.

Table 13: Feature usage measurement system for Page Clutter

Concept	Definition
Information Need	What is the impact of page cluttering to measure feature usage in page-based analytics and feature-based analytics
Measurable Concept	Deviation of measurement of feature usage
Entity	Deviation of measurement of feature usage
Attributes	The report of feature usage The report of true feature usage The report of false feature usage
Measurement Method	Number of feature usage Number of true feature usage Number of false feature usage
Base Measures	True feature usage, False feature usage
Measurement Function	Accuracy and precision law
Derived Measure	Accuracy and precision of feature usage measurement.
Indicator	Different values of accuracy and precision of feature usage measurement
Interpretation	Impact of page clutter on feature usage measurement.

Table 14: Feature usage measurement system for Feature Spread

Concept	Definition
Information Need	What is the impact of feature spread to measure feature usage in page-based analytics and feature-based analytics
Measurable Concept	Deviation of measurement of feature usage
Entity	Deviation of measurement of feature usage
Attributes	The report of feature usage The report of true feature usage The report of false feature usage
Measurement Method	Number of feature usage Number of true feature usage Number of false feature usage
Base Measures	True feature usage, False feature usage
Measurement Function	Accuracy and precision law
Derived Measure	Accuracy and precision value of feature usage

	measurement.
Indicator	Different values of accuracy and precision of feature usage measurement
Interpretation	Impact of page cluttering of feature usage measurement.

Table 15: Feature usage measurement system for Erroneous Page Representation

Concept	Definition
Information Need	What is the impact of feature spread to measure the occurrence of errors during feature usage in page-based analytics and feature-based analytics
Measurable Concept	Deviation of measurement of error occurrence during feature usage
Entity	Deviation of measurement of error occurrence during feature usage
Attributes	The report of error occurrence at the time of feature usage The report of true error occurrence at the time of feature usage The report of false error occurrence at the time of feature usage
Measurement Method	Number of error occurrences at the time of feature usage Number of true error occurrences at the time of feature usage Number of false error occurrences at the time of feature usage
Base Measures	True error occurrence at the time of feature usage, False error occurrence at the time of feature usage
Measurement Function	Accuracy and precision law
Derived Measure	Accuracy and precision of error occurrence measurement of feature usage.
Indicator	Different values of accuracy and precision of error occurrence measurement of feature usage.
Interpretation	Impact of erroneous page representation on feature usage measurement.

Accuracy and precision steps of feature usage measurement can be achieved using Table13, Table14 and Table15. According to the entire three tables, the measurement process answers the questions to the product manager related to the actual feature usage measurement with respect to paged-based analytics and featured-based analytic. As for example, if the page clutter is higher than accuracy and precision of feature usage measurement, it implies to the product manager which features are not exactly working as per customers' demand.

The result of simulation can be meaningful for the product managers, tool constructors and researchers.

The implications of the simulation results for product managers are –

- Product manager would be able to measure product features usage accurately and precisely using feather-based analytics. So the result can be used to take decision about future release and roadmpapping. The result can be used to also decision about the addition, extension or removal of features or services.
- Product manager would be able to detect individual features problem explicitly through implementing feature-based analytics.
- Feature-based tools can monitored features and services accurately so product manager can change from traditional software product planning system such as only stake holder opinion based to true feature or product usage based or analytics based software product planning.

The implications of the simulation results for analytics tool constructors are –

- Analytics tool constructors would be able to utilize the feature-based concept and hence, implement analytics solutions compatible with software product planning.
- Tool constructor should built analytics system which can be used to mapping product feature with web site element to track feature true usage statistics.

The implication of the simulation results for researchers is –

- Researchers would be able to use analytics to build new software product planning models that are related with software product planning.

Different studies have been carried out on how web analytics tools and page-based analytics can influence the success of web applications [36] [37] [38] [41] [43]. An experimental study has been performed to observe how the quality of service impacts on the usability or quality of experience [73]. Other studies evaluated the usability improvement of web applications before and after using analytics tools such as Google analytics. But no analytical experiment has been done on the limitation of webpage-based analytics from software engineering perspective. In this simulation the comparison between page-based analytics and feature-based analytics have been performed to find out the solution of feature usage measurement problems and also compare the conceptual results with the results collected from prototype tool (real data).

5.4 Threats to Validity

5.4.1 Conclusion Validity

The goal of the simulation is to compare the feature usage measurement accuracy and precision with the concept and from real data with respect to page-based analytics and feature-based analytics to enable decision support for software product planning. The result of the simulation i.e., page clutter and erroneous page presentation exaggerate feature usage measurements with page-based analytics, but not with feature-based analytics; may not be sufficient for every SaaS web applications to conclude as the same results. It may differ by supplementary variables e.g., business strategy.

5.4.2 Internal Validity

The results generated by the simulation may not be conclusive and reflect the real life scenario. The suggested results, feature-based analytics is better than page-based analytics, cannot act as a recommendation without applying the scenarios in real life situation. So, to mitigate this threat page-based analytics and feature-based analytics tool can be used in different situation and validated the results.

5.4.3 Construct Validity

The results of the simulation are dependent on indicators and sub-indicators variable and different scenarios. The decision support for software product planning varies based on the variables as well. But in real life, the results of four scenarios may not be enough for software product planning decision-support.

5.4.4 External Validity

The results that are obtained from the prototype analytics tool may not generalize enough to use it in every industrial scenario. Additionally, all possible scenarios are not considered to compare the page-based analytics with the feature-based analytics. So, it is limiting the resulted comparison and cannot propose a general solution regarding software product planning. The reason behind the limitation is the simulation has been performed in controlled and defined environment and on defined scenarios only.

6 Summary and Conclusions

6.1 RQ1: What is an effective way to collect analytics for software product planning?

We perform market research through searching “market share of web analytics tools” in Google search engine and select five web analytics tools that support the SaaS website tracking. We select five web analytics tools based on the highest market share and revenue growth. Then we define a method with some specific requirements to compare different web analytics tools whether they have decision-support for software product planning. Feature wise comparison is performed between selected analytics tool’s features according to the analytics tool comparison method. The method is derived based on the requirements of a software product planning supported analytics tool. According to the comparison results that performed between the selected analytics tools, no web analytics tool is found that supports the features and requirements concepts and has decision-support for software product planning. Hence, product managers are unable to use those web analytics tools for software product planning. So, the study proposes and implements a SaaS website tracking compatible prototype web analytics tool. It supports the features and requirements concepts and has decision-support for software product planning. The prototype analytics tool is a customizable and research oriented web analytics tool. It supports the SaaS website tracking and event tracking in GUI element level as well. Since the proposed analytics tool can track the websites based on events and events are mapped with features, it supports both page-based analytics and feature-

based analytics. Hence, the tool helps to provide decision-support for software product planning through the analysis of measurement of feature usage.

6.2 RQ2: How do feature-based analytics compare with page-based analytics?

Software simulation was performed to compare feature usage between page-based analytics and feature-based analytics in terms of page clutter, erroneous page presentation and feature spread. The accuracy and precision are calculated to measure the feature usage. The accuracy indicates the constancy of feature usage and the precision indicates the repeatability or reproducibility of feature usage during feature usage measurement. The study performed the simulation between a SaaS website and a software product planning supported prototype analytics tool. In the simulation, feature usage is simulated based on pre-defined scenarios. Then apply those scenarios on a SaaS website and observe the feature usage based on the perspective of the page-based analytics and the feature-based analytics. Finally, it compares real results of the simulation with the expected results based on the predefined scenarios.

6.2.1 RQ2.1: What is the impact of page cluttering on page-based analytics and feature-based analytics?

Page-based analytics measure the usage of features in general rather than an individual feature. So, if the number of features increases on the web page then the accuracy and precision measurement of feature usage decrease. On the other hand, feature-based analytics count features visit individually. So, the analysis results show that the accuracy and precision measurement of feature usage remain stable with the increase of features per web page. The simulation results show that page clutter increases with the number of features per page in page-based analytics, which is quite understandable as accuracy and precision decrease due to the increase of features per page. So, Page cluttering exaggerates feature usage measurements with page-based analytics, but not with feature-based analytics.

6.2.2 RQ2.2: What is the impact of feature spread on page-based analytics and feature-based analytics?

The accuracy and precision of feature spread for feature-based analytics and page-based analytics are measured and the simulation results show that both accuracy and precision are stable in feature-base analytics, even there are several pages contain different elements of a feature. On the contrary, as the number of web pages grows, the accuracy and precision decrease that indicates the feature spread in page based analytics alter the measurements of feature usage. So, Feature spread does not alter feature usage measurement with feature-based analytics compared with page-based analytics.

6.2.3 RQ2.3: What is the impact of erroneous page representation on page-based analytics and feature-based analytics?

The accuracy and precision of erroneous feature for feature-based analytics and page-based analytics are measured and the simulation results show that both accuracy and

precision are remain stable in feature-base analytics, even there are several features on the web page. Contrarily, as the number of features grows, the accuracy and precision decrease what indicates the failure of capturing the specific usage of an erroneous feature in page-based analytics. So, Page presentation errors exaggerate feature usage measurement with page-based analytics, but not with feature-based analytics.

6.3 Lesson Learned

The main lesson learned about the usage of analytics in software product planning is to collect right analytics always depends on the right environment in analytics-based approach. This is also true to facilitate decision-support for software product planning. SaaS based analytics may not be sufficient enough to provide adequate information, while business analytics can be a supportive factor. Moreover, page cluster and erroneous page presentation exaggerate feature usage measurements with page-based analytics, but not with feature-based analytics. In addition, feature spread does not alter feature usage measurements with feature-based analytics compared with page-based analytics.

6.4 Future Work

This study has further future research opportunities in software engineering perspective. The following future works can be performed using and enhancing our thesis outcomes.

The study can be enhanced in future by searching and analyzing markets and relevant research outcomes with broader literature searches such as a systematic literature review to find out more concrete and all possible kinds of analytics and software product planning decision making criteria.

Another enhancement of the study can be to utilize intelligence for enabling automated decision supports to software product planning. Furthermore, the tool would be able to track all types of SaaS applications including web and desktop rather than only track SaaS websites.

The study can be enhanced further to validate the analytics tool by performing case studies under the industrial environment. The real life problems of page clutter, erroneous page presentation and feature spread can be figured out utilizing the analytics tool by tailoring the company needs. Additionally, experiments can be performed using other aspects rather than page clutter, feature spread and erroneous page presentation.

6.5 Conclusions

In this study the relevant analytics for measuring software usage is discussed. Then an effective way is defined to collect the user interaction analytics and utilize them as inputs to software product planning. The study justifies the measurement of feature usage by utilizing the concept of accuracy i.e., stability of feature usage and precision i.e., repeatability or reproducibility of feature usage. The concept is validated by simulating a software simulation to understand the impact of page clutter, feature spread and erroneous page presentation with respect to page-based analytics and feature-based

analytics. The study discusses the relevant analytics for measuring software usage. In addition, an effective way to connect that analytics to enable decision-support for software product planning is presented. This study would act as a pioneer for researchers to understand how analytics can be utilized to measure the usage of features in software product planning. Moreover, the study would enable researchers to investigate further on the analytics for software product planning. Furthermore, product managers or product planners can utilize the simulation results for understanding the usage measurement of features. Hence, take decision in addition, extension or removal of features.

7 References

- [1]. S. Fricker, “Software Product Management”, *Software for People - Fundamentals, Trends and Best Practices*, Alexander M., Achim B., Ludwig N. (eds.), Springer Verlag, Berlin, Germany, ISBN/EAN: 978-3-642-31370-72005, 2012.
- [2]. H.J. Kung and C. Hsu, “Software maintenance lifecycle model”, In *Proceeding International Conference on Software Maintenance*; IEEE Computer Society Press: Los Alamitos CA; 1998, pp. 113–117.
- [3]. J. Zhang, et al., “A Framework of User-Driven Data Analytics in the Cloud for Course Management”, in *Proceedings of the 18th International Conference on Computers in Education*, S. L. Wong et al., Eds. Putrajaya, Malaysia: Asia - Pacific Society for Computers in Education, 2010, pp. 698-702.
- [4]. M. J. Carrington, et al., "Why Ethical Consumers Don't Walk their Talk: Towards a Framework for Understanding the Gap between the Ethical Purchase Intentions and Actual Buying Behaviour of Ethically Minded Consumers", *Journal of Business Ethics* vol.97, (1), pp.139-158, 2010.
- [5]. P. Berander and A. Andrews, “Requirements Prioritization”, *Engineering and Managing Software Requirements*, A. Aurum and C. Wohlin (eds.), Springer Verlag, Berlin, Germany, 2005.
- [6]. R. P. L. Buse and T. Zimmermann, "Information needs for software development analytics", MSR-TR-2011-8, Microsoft Research, 2011.
- [7]. R. Kohavi, et al., "Controlled experiments on the web: survey and practical guide", *Data Mining and Knowledge Discovery* vol. 18,(1), pp.140-181, 2009.
- [8]. J. Kim and Y. Park., “Identifying a new service opportunity from potential needs: User-centric service map”, *IEEE International Conference on Industrial Engineering and Engineering Management (IEEM 2010)*, Macao, China, 2010.
- [9]. M. Meiss, et al., “What’s in a session: tracking individual behavior on the Web”, In *Proc. 20th ACM Conf. on Hypertext and Hypermedia (HT)*, 2009.
- [10]. M. Kutare, et al., "Monalytics: online monitoring and analytics for managing large scale data centers", *7th International Conference on Autonomic Computing*, Washington, DC, USA, 2010.
- [11]. A. Phippen, L. Sheppard and S. Furnell, "A practical evaluation of Web analytics", *Internet Research: Electronic Networking Applications and Policy* vol.14,(4), 284-293, 2004.

- [12]. I. van de Weerd, et al., "Towards a reference framework for software product management", in *Requirements Engineering, 14th IEEE International Conference*, 2006, pp. 319–322.
- [13] M. Porter, *Competitive advantage: Creating and sustaining superior performance*. New York: Free Press, 1998.
- [14]. M. M. Lehman, "Programs, life cycles, and laws of software evolution," In *Proceedings of the IEEE*, vol. 68,(9),1980,pp.1060–1076.
- [15]. C. Ebert, "The impacts of software product management," *Journal of Systems and Software*, vol. 80,(6), pp. 850–861, 2007.
- [16]. S. Fricker and S. Schumacher, "Release Planning with Feature Trees: Industrial Case," in *Requirements Engineering: Foundation for Software Quality*, vol. 7195, B.Regnell and D. Damian, Eds. Springer Berlin / Heidelberg, pp. 288–305, 2012.
- [17]. S. Barney, A. Aurum, and C. Wohlin, "A product management challenge: Creating software product value through requirements selection," *Journal of Systems Architecture*, vol. 54, (6), pp.576–593, 2008.
- [18]. G. Muller, "The role of roadmapping in the strategy process", www.gaudisite.nl,2005.
- [19]. R. Phaal, C. J. P. Farrukh, and D. R. Probert, "Fast-start technology roadmapping," in *Proceedings of the 9th International Conference on Management of Technology (IAMOT 2000)*, 2000, pp. 21–25.
- [20]. R. Phaal, C. J. P. Farrukh, and D. R. Probert, "Technology roadmapping - A planning framework for evolution and revolution", *Technological forecasting and social change*, vol. 71, (1-2), pp. 5–26, 2004
- [21]. T. Gorschek, et al., "A lightweight innovation process for software-intensive product development," *IEEE software*, vol. 27, (1), pp. 37–45, 2010.
- [22]. J. Karlsson and K. Ryan, "A cost-value approach for prioritizing requirements," *Software, IEEE*, vol. 14, (5), pp. 67–74, 1997.
- [23]. G. Ruhe, A. Eberlein, and D. Pfahl, "Trade-off analysis for requirements selection," *International Journal of Software Engineering and Knowledge Engineering*, vol. 13, (04), pp. 345–366, 2003.
- [24]. B. Regnell, L. Karlsson, and M. Host, "An analytical model for requirements selection quality evaluation in product software development", In *Proceedings 11th IEEE International Requirements Engineering Conference*, 2003, pp. 254–263.

- [25]. O. Saliu and G. Ruhe, "Supporting software release planning decisions for evolving systems," in *Software Engineering Workshop*, 29th Annual IEEE/NASA, 2005, pp. 14–26.
- [26]. A. Al-Emran and D. Pfahl, "Operational planning, re-planning and risk analysis for software releases," *Product-Focused Software Process Improvement*, vol. 4589, pp. 315–329, 2007.
- [27]. A. Ngo-The and G. Ruhe, "A systematic approach for solving the wicked problem of software release planning," *Soft Computing-A Fusion of Foundations, Methodologies and Applications*, vol. 12, (1), pp. 95–108, 2008.
- [28]. B. A. Nejme and I. Thomas, "Business-driven product planning using feature vectors and increments," *Software, IEEE*, vol. 19, (6), pp. 34–42, 2002.
- [29]. G. Ruhe and M. O. Saliu, "The art and science of software release planning," *Software, IEEE*, vol. 22, (6), pp. 47–53, 2005.
- [30]. A. S. Danesh and R. Ahmad, "Software release planning challenges in software development: An empirical study," *African Journal of Business Management*, vol. 6, (3), pp. 956–970, 2012.
- [31]. A. Griffin, and A. L. Page. 1996. "PDMA Success Measurement Project: Recommended Measures for Product Development Success and Failure," *Journal of Product Innovation Management*, vol.13, pp. 478–496, 1996.
- [32]. K. Kahn *Product planning essentials*. Thousand Oaks, Calif.: Sage Publications, 2001
- [33]. K. P. Shung and M. C. Junyu, "Application of Analytics in Business Strategy," *Business Intelligence Journal*, vol. 5, (1), 2012.
- [34]. Web Analytics Association. (October, 2006). The Web Analytics Association. From <http://www.webanalyticsassociation.org/>
- [35]. E. T. Peterson, *Web analytics demystified: a marketer's guide to understanding how your web site affects your business*. Celilo Group Media, 2004.
- [36]. A. Kaushik, *Web Analytics: An Hour A Day (W/Cd)*. Wiley-India, 2007.
- [37]. A. Croll and S. Power, *Complete web monitoring*. O'Reilly Media, 2009.
- [38]. R. Bose, "Advanced analytics: opportunities and challenges," *Industrial Management & Data Systems*, vol. 109, (2), pp. 155–172, 2009.
- [39]. B. Clifton, *Advanced web metrics with Google Analytics*. Sybex, 2012.

- [40]. J. Burby and S. Atchison, *Actionable Web Analytics: Using Data to Make Smart Business Decisions*, Wiley, Chichester, 2007.
- [41]. W. Fang. (2007), "Using Google Analytics for Improving Library Website Content and Design: A Case Study" Available at: <http://works.bepress.com/wfang/1>.
- [42]. E. Peterson. (2006), *The Big Book of Key Performance Indicators*, Last Retrieved May 27, 2013, form <http://webanalyticshub.com/PDFS/The%20Big%20Book%20of%20Key%20Performance%20Indicators%20by%20Eric%20Peterson.pdf>
- [43]. A. Kaushik, The Author of two bestselling books: *Web Analytics 2.0*, *Web Analytics: An Hour A Day* [Online] Available: <http://www.kaushik.net/avinash/>.
- [44]. L. Hasan, A. Morris, and S. Proberts, (2009). "Using Google Analytics to Evaluate the Usability of E-Commerce Sites" *Human Centered Design*, pp.697—706, [doi>10.1007/978-3-642-02806-9_81]
- [45]. J.A. Ogle., "Improving Web Site Performance Using Commercially Available Analytical Tools". In Symposium: *AJS Carl . Brighton Workshop on Health Informatics*. Springer, pp. 2604–2611, 2010.
- [46]. L. Ma, J. Tian, "Web error classification and analysis for reliability improvement", *Journal of Systems and Software*, Volume 80 (6), pp. 795-804, June 2007 ISSN 0164-1212, [doi> <http://dx.doi.org/10.1016/j.jss.2006.10.017>]
- [47]. W. Dai "The Impact of Emerging Technologies on small and medium Enterprises (SMEs)", *Journal of business Systems, Governance and Ethics*, Vol 4, (4), pp. 53—60, 2009.
- [48]. P. Mell and T. Grance, "The NIST definition of cloud computing (draft)," *NIST special publication*, vol. 800, pp. 145, 2011.
- [49]. V. Choudhary, "Software as a service: Implications for investment in software development," in *System Sciences, 2007. HICSS 2007. 40th Annual Hawaii International Conference on, 2007*.
- [50]. M. Godse and S. Mulik, "An approach for selecting software-as-a-service (SaaS) product," in *Cloud Computing, 2009. CLOUD'09. IEEE International Conference on*, pp.155–158, 2009.
- [51]. A. Classen, P. Heymans, and P. Schobbens., "What's in a Feature: A Requirements Engineering Perspective.", In *Proceedings of the International Conference on Fundamental Approaches to Software Engineering (FASE)*, volume 4961 of Lecture Notes in Computer Science, pages 16–30, Springer-Verlag, 2008.

- [52]. J. W. Creswell, *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage Publications, Inc, 2009.
- [53]. C. Wohlin, et al., *Experimentation in Software Engineering: An Introduction*. 2000.
- [54]. S. Berner and R. Weber, "Observations and lessons learned from automated testing," *Proceedings of the 27th international*, 2005.
- [55]. S. Hamel, Director of Strategic Services, Cardinal Path, WEB ANALYTICS VENDORS MARKET SHARE: GOOGLE ANALYTICS AHEAD OF THE GAME, Oct, 2011. [Online] Available: <http://www.cardinalpath.com/web-analytics-vendors-market-share> [Accessed: 15-Jun-2013].
- [56]. J. F. Belisle, The Battle of Web Analytics Solutions in 2013, Jan, 2013. [Online] Available: <http://jfbelisle.com/2013/01/battle-web-analytics-solutions-2013> [Accessed: 15-Jun-2013].
- [57]. M. E. Tyler and J. L. Ledford. *Google Analytics*. Somerset, NJ: Wiley, 2006.
- [58]. "Adobe Analytics, Marketing reports and analytics - See your business the way your data does" [Online]. Available: <http://www.adobe.com/solutions/digital-analytics/marketing-reports-analytics.html> [Accessed: 15-Jun-2013]
- [59]. "IBM Digital Analytics - See what smarter software can do for you" [Online]. Available: <http://www-03.ibm.com/software/products/us/en/digital-analytics> [Accessed: 15-Jun-2013].
- [60]. IBM Digital Analytics, "Analytics to power digital marketing optimization and execution", Enterprise Marketing Management, Nov, 2012 [Online]. Available: <http://public.dhe.ibm.com/common/ssi/ecm/en/zd03044usen/ZD03044USEN.PDF> [Accessed: 15-Jun-2013]
- [61]. "Webtrends Analytics: Re-imagining digital marketing - an Experts Deliver Outcomes, Not Just Software" [Online]. Available: <http://webtrends.com/solutions/digital-measurement/website-measurement> [Accessed: 15-Jun-2013]
- [62]. Webtrends Analytics, Whitepaper on WEBTRENDS ANALYTICS ADVANTAGES, "Advancing Your Digital Marketing Strategy with Webtrends Analytics", [Online] Available: <http://webtrends.com/files/whitepaper/Whitepaper-AdvancingYourDigitalMarketingStrategywithWebtrendsAnalytics-Webtrends.pdf>
- [63]. "Yahoo! Web Analytics - a Highly Customizable, Enterprise-level Website Analytics System" [Online]. Available: <http://web.analytics.yahoo.com> [Accessed: 02-Feb-2013].

- [64]. IEEE Std. 830-1993: IEEE Recommended Practice for Software Requirements Specifications, Url - <http://www.math.uaa.alaska.edu/~afkjm/cs401/IEEE830.pdf>
- [65]. F. Fotrousi, K. Izadyan and S. Fricker (2013), "Analytics for Product Planning: In-depth Interview Study with SaaS Product Managers", accepted at IEEE Cloud 2013.
- [66]. Wikipedia, "Accuracy and Precision", [Online] Available: http://en.wikipedia.org/wiki/Accuracy_and_precision, [Accessed: 02-Feb-2013]
- [67]. ISO. ISO/PDTR 22971 Practical guide to ISO 5725-2:1994 – Accuracy (trueness and precision) of measurement methods and results – Part2: Basic method for the determination of repeatability and reproducibility of a standard measurement method, International Standards Organization, Geneva, Switzerland, 2001.
- [68]. T. H. Davenport, "Enterprise Analytics: Optimize Performance, Process, and Decisions through Big Data", FT Press, 2012.
- [69]. R. Maddock, J. Taylor, "Experts' Perspective - Predictive Analytics", Business Intelligence Journal - The Leading Publication For Business Intelligence And Data Warehousing Professionals, Vol. 11, No. 1, 2006. [Online] Available: <http://tdwi.org/~media/6E22E38D9CC74FB689B395ECF0B7E126.pdf#page=31>
- [70]. L. Hattori, et al., "On the precision and accuracy of impact analysis techniques", International Conference on Computer and Information Science, 0:513-518, 2008.
- [71]. S. Banerjee, H. Srikanth and B. Cukic, "Log-based Reliability Analysis of Software as a Service (SaaS)", In Proceedings of the 21 IEEE 21st International Symposium on Software Reliability Engineering, 2010.
- [72]. ISO, ISO/IEC 15939, Information Technology - Software Measurement Process. 2000, Geneva: International Organization for Standardization.
- [73]. J. Shaikh, M. Fiedler, and D. Collange., "Quality of experience from user and network perspectives." *Annales des T e ecommunications*, vol.65, (1-2), pp. 47-57, 2010.
- [74]. S. Jalali and C. Wohlin, "Systematic literature studies: database searches vs. backward snowballing," in Proceedings of the International Conference on Empirical Software Engineering and Measurement (ESEM 2012), Lund, Sweden, September 19–20, 2012,pp. 29–38.
- [75]. M. Svahnberg, et al., "A systematic review on strategic release planning models", *Information and Software Technology*, vol.52, (3), pp.237-248, 2010.

8 Appendix A

Process of Literature Review

The purpose of the literature review was to find out research gap and related works on web analytics, software use measurement and software product planning. The literature review was completed in eight steps as suggested by Creswell [52]. In addition snowball sampling was also applied [74]. The following steps are described below -

Step1:

In step 1, keywords were identified based on the goal of finding research gap and related works on web analytics and product planning. More keywords were identified after a preliminary study of research papers. Search strings were constructed by important keywords which included "web analytics", "software use", "software analytics", "SaaS", "Software as a Service", "product planning", "feature usage", "product management", "product plan", "product manager", "feature management", "portfolio management", "product roadmap", "roadmapping" "release planning", "decision", "decision-making", "decision making", "decision support".

Step2:

In step 2, IEEE Xplore, Engineering Village, Google Scholar, Springer Link and ACM Digital Library were selected as search databases and search engine.

Step 3:

In step 3, the irrelevant search results were excluded using inclusion criteria. We consider journal articles, conference papers, and workshop papers as primary sources. We only considered those papers that are written in English.

Inclusion criteria's are [75] -

- The full text of the article should be available.
- The article can be published as journals, conference papers, workshops and eBooks.
- The article can be case study, empirical study, experimental study, comparative study, literature review, systematic review, and survey or action research.
- The article will include at least one of the key words or search terms.

- The article will discuss an empirical evaluation about software product planning, web analytics, SaaS, product feature, models, tools or decision support for release planning or roadmapping.
- The article will be chosen if it includes general knowledge about web analytics categories, software product planning or software product planning techniques, tools, methods and supports
- The article will be chosen if it is related with the comparison among different analytics techniques or an analysis for page-based or feature-based analytics.
- The article will be chosen if it is related with the evaluation or validation of software product planning or categories for collecting user interaction analytics.

Step 4:

In step 4, the primary search results were first scrutinized with respect to the relevant titles.

Step 5:

In step 5, the search results were further scrutinized through abstracts and conclusions to identify the relevant papers.

Step 6:

In step 6, the selected search results were further reviewed through reading contents, results, discussions and conclusions.

Step 7:

In step 7, the gray literatures were reviewed using the similar steps like step 4 and 5 and the resulted sources are added to existing primary search results.

Step 8:

In step 8, the criteria of software measurements were summarized.

Step 9:

Finally, snowball sampling was performed on the results that were extracted from Step 6.

Search Strings of Literature Review:

We select different search key strings that are mentioned in the literature review step1. We perform search in different databases like IEEE Xplore, Engineering village including Inspec and Compedex, Google Scholar, Springer Link and ACM Digital Library. We

also search in Google search engine and other websites to find out gray literatures that are relevant to understand software use measurements and analytics with respect to software product planning. We slightly change the search patterns for different databases in order to obtain better search results. The search results in different databases are presented below-

Table 16: Results of Literature Review

Key words	Database	Step 3	Step 4	Step 5	Step 6
((((web analytic*) AND (use OR measurement OR experiment OR SaaS OR Software as a Service)) AND ("product manager" OR "product planning" OR "product management" OR "feature planning" OR "release planning" OR roadmap OR "roadmapping" OR "portfolio management" OR decision OR "decision making" OR "decision-making" OR "decision support"))))	IEEE Xplore	187	45	14	5
((("web analytics") AND (("Saas") OR ("Software as a Service") OR ("product roadmap*") OR ("Product Planning") OR ("decision-making") OR ("software use") OR ("measurement") OR ("product management") OR ("product plan*") OR ("product manager") OR ("feature") OR ("feature management") OR ("portfolio management") OR ("roadmap*") OR ("release planning") OR ("decision") OR ("decision making"))))	Engineering Village	29	16	9	5

<p>("web analytics" AND (("SaaS") OR ("Software as a Service") OR ("product roadmap*") OR ("Product Planning") OR ("decision-making") OR ("software use") OR ("measurement") OR ("product management") OR ("product plan*") OR ("product manager") OR ("feature management") OR ("portfolio management") OR ("roadmap*") OR ("release planning") OR ("decision") OR ("decision making"))))</p>	<p>Google Scholar</p>	<p>1420</p>	<p>70</p>	<p>35</p>	<p>10</p>
<p>((("web analytics") AND (("SaaS") OR ("Software as a Service") OR ("product roadmap*") OR ("Product Planning") OR ("decision-making") OR ("software use") OR ("measurement") OR ("product management") OR ("product plan*") OR ("product manager") OR ("feature management") OR ("portfolio management") OR ("roadmap*") OR ("release planning") OR ("decision") OR ("decision making"))))</p>	<p>Springer Link</p>	<p>175</p>	<p>28</p>	<p>7</p>	<p>3</p>
<p>((("web analytics") AND (("Saas") OR ("Software as a Service") OR ("product roadmap*") OR ("Product Planning") OR ("decision-making") OR ("software use") OR ("measurement") OR ("product management") OR ("product plan*") OR ("product manager") OR ("feature management") OR ("portfolio management") OR ("roadmap*") OR ("release planning") OR ("decision") OR ("decision making"))))</p>	<p>ACM</p>	<p>148</p>	<p>39</p>	<p>12</p>	<p>4</p>

9 Appendix B

Definition of Analytics Indicators and Sub-indicators

Table 17: Definition of Feature Metrics

Feature Metrics (Indicators & Sub-indicators)	Definition
Usage	The use of features by visitors
Visit count	The number of visits on a particular feature of the SaaS website
Unique visitor	The number of unique visitors on a particular feature of the SaaS website
New unique visitor	The number of new unique visitors on a particular feature of the SaaS website
Returning visitor	The number of returning visitors on a particular feature of the SaaS website
Visitor location	The location of unique visitors, new unique visitors or returning unique visitors while visiting a particular feature of the SaaS website
Visit time	The access time of unique visitors, new unique visitors or returning unique visitors while visiting a particular feature of the SaaS website
Average bounce rate	The percentage of single feature view visits by visitors
Reliability	The safety and failure frequency of features to visitors
Down rate	The avg. number of times, a particular feature of the SaaS website, unavailable to provide service to visitors during feature usage
Error rate	The avg. number of times, a particular feature of the SaaS website, fail with error code (e.g., 404, 408 etc.) and unable to provide service to visitors during feature usage
Performance	The successful and efficient service response of features to visitors
Service response time	The response time in millisecond it takes to serve a particular feature usage of the SaaS website to visitors
Throughput	The avg. response time in millisecond it takes to serve a particular feature usage of the SaaS website to visitors

10 Appendix C

Different features of the Analytics Tool

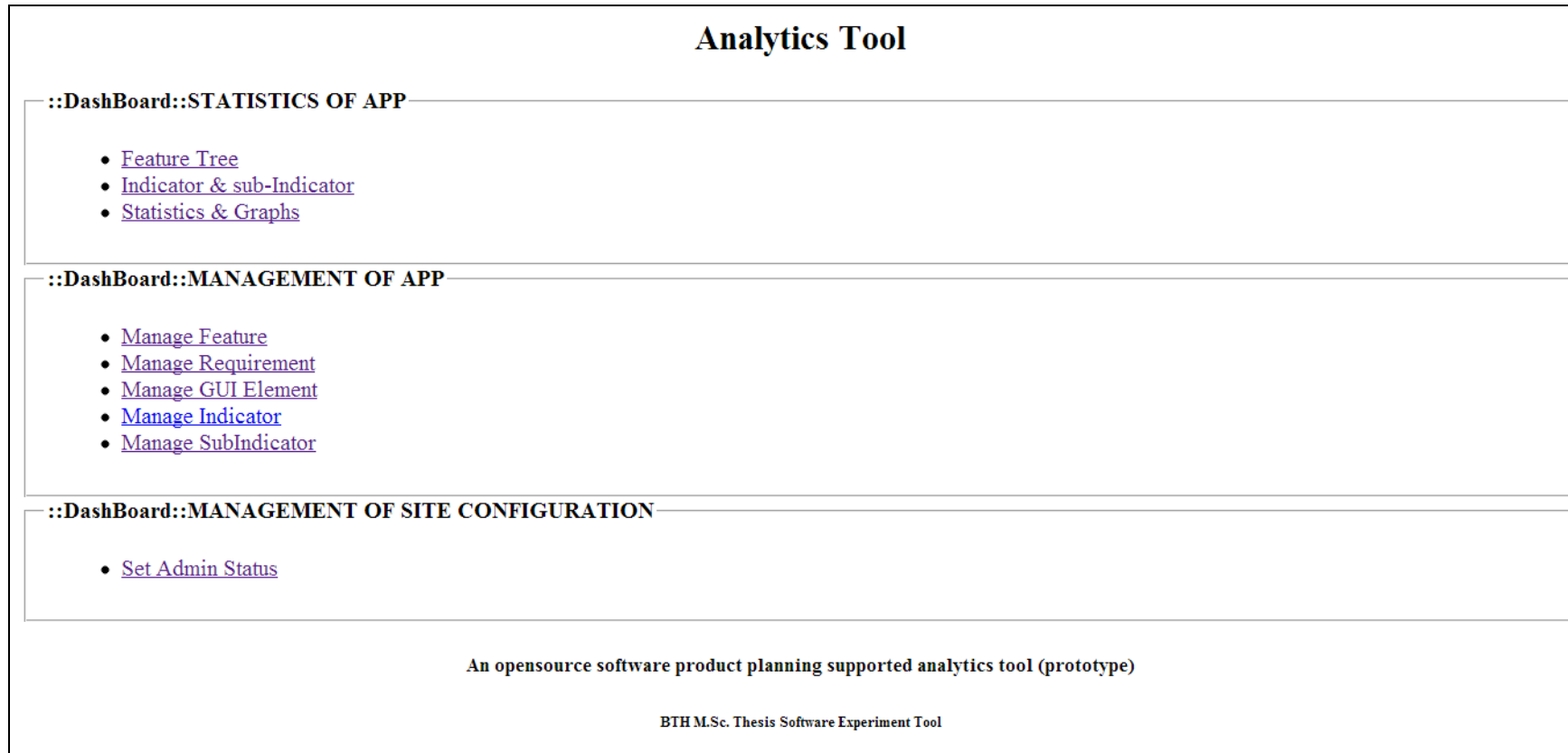


Figure 22: Dashboard of the Prototype Analytics Tool

Add New Indicator

The time on the server is den 1 april 2013 12:45:51 CEST.

Indicator Name:

Indicator Description:

Add Indicator

[Home](#)

Figure 23: Create new Indicators in the Analytics Tool

::Dashboard::Indicator Management

Id	Name	Description	Action
1	Usability	Usability of SAAS Application	Modify
2	Reliability	Reliability of SAAS Application	Modify
3	Performance	Performance of SAAS Application	Modify

[Add Indicator](#)

[Home](#)

Figure 24: Manage Indicators in Analytics Tool

Add New SubIndicator

The time on the server is den 1 april 2013 12:47:38 CEST.

Select Indicator:

SubIndicator Name:

SubIndicator URL:

Status:

SubIndicator Description:

[Home](#)

Figure 25: Create sub-Indicators in the Analytics Tool

::Dashboard::Manage SubIndicator

ID	IndicatorId	Name	URL	Description	Status	Action
1	1	Visit Count	http://localhost:8080/featureTree/graphTest	Count User Visit	1	Modify
2	1	Unique Visitor	#		1	Modify
3	1	New Unique Visitor	#		1	Modify
4	1	Returning Visitor	#		1	Modify
5	1	Visitor Location	#		1	Modify
6	1	Visit Time	#		1	Modify
7	1	Average Bounce Rate	#		1	Modify
8	1	PageVisit	#		0	Modify
9	1	NewVisitors	#		0	Modify
10	1	Returning Users	#		0	Modify
11	2	Down Rate	#		1	Modify
12	2	Error Rate	#		1	Modify
13	2	HTTP Error	#		0	Modify
14	2	Throughput1	#		0	Modify
15	3	Average Service Response Time	#		1	Modify
16	3	Throughput	#		1	Modify

[Add SubIndicator](#)
[Home](#)

Figure 26: Manage sub-Indicators in the Analytics Tool

Add New Feature

The time on the server is den 1 april 2013 12:41:01 CEST.

Feature Name:

Status:

Feature Description:

[Home](#)

Figure 27: Create new Features in the Analytics Tool

Feature Tree

- Product
 - F1(R1): Anforderungen Home
 - F2(R2): Anforderungen Invitation
 - F3(R3): MyProfile
 - F4(R4): Anforderungen Members
 - F5(R5): Anforderungen Events
 - F6(R6): Anforderungen Groups
 - F7(R7): Anforderungen Blogs
 - F8(R8): Anforderungen Registration
 - F9(R9): Anforderungen Login
 - F10(R1+R2): Home & Invitation
 - F11(R1+R2+R3): Home & Invitation & MyProfile
 - F12(R8+R9): Registration & Login
 - F13(R4+R7): Members & Blogs
 - F14(F11.R3+F12.R8+F12.R9): MyProfile & Registration & Login
 - F15(F11.R2+F12.R8): Invitation & Registration

The time on the server is den 1 april 2013 12:40:12 CEST.

::Dashboard::Feature Management

Id	Name	Description	Status	Action
1	F1(R1): Anforderungen Home		1	Modify
2	F2(R2): Anforderungen Invitation		1	Modify
3	F3(R3): MyProfile		1	Modify
4	F4(R4): Anforderungen Members		1	Modify
5	F5(R5): Anforderungen Events		1	Modify
6	F6(R6): Anforderungen Groups		1	Modify
7	F7(R7): Anforderungen Blogs		1	Modify
8	F8(R8): Anforderungen Registration		1	Modify
9	F9(R9): Anforderungen Login		1	Modify
10	F10(R1+R2): Home & Invitation	Home & Invitation	1	Modify
11	F11(R1+R2+R3): Home & Invitation & MyProfile		1	Modify
12	F12(R8+R9): Registration & Login		1	Modify
13	F13(R4+R7): Members & Blogs		1	Modify
14	F14(F11.R3+F12.R8+F12.R9): MyProfile & Registration & Login		1	Modify
15	F15(F11.R2+F12.R8): Invitation & Registration		1	Modify

[Add Feature](#)
[Home](#)

Figure 28: Manage Features in the Analytics Tool

Add New Requirement

The time on the server is den 1 april 2013 12:43:09 CEST.

Select Feature:

Requirement Name:

Requirement Description:

[Home](#)

Figure 29: Create new Requirements in the Analytics Tool

::Dashboard::Manage Requirement

Id	FeatureId	Name	Description	Action
1	1	Anforderungen Home		Modify
2	2	Anforderungen Invitation		Modify
3	3	Anforderungen My Profile		Modify
4	4	Anforderungen Members		Modify
5	5	Anforderungen Events		Modify
6	6	Anforderungen Groups		Modify
7	7	Anforderungen Blogs		Modify
8	5	Anforderungen Workshop		Modify
9	3	Anforderungen Edit Profile		Modify
10	6	Workshop FHNW: RE 2iCb 2012		Modify
11	6	Workshop FHNW: RE 2iCa 2012		Modify
12	7	Workshop FHNW: afana 2011 11a		Modify
13	7	Workshop FHNW: afana 2011 11b		Modify
14	7	Workshop FHNW: RE 2011		Modify
15	8	Anforderungen Registration		Modify
16	9	Anforderungen Login		Modify
17	10	Home and Invitation	Home and Invitation	Modify
18	11	Home & Invitation & MyProfile		Modify
19	12	Registration & Login		Modify
20	13	Members & Blogs		Modify
21	14	MyProfile & Registration & Login		Modify
22	15	Invitation & Registration		Modify

[Add Requirement](#)
[Home](#)

Figure 30: Manage Requirements in the Analytics Tool

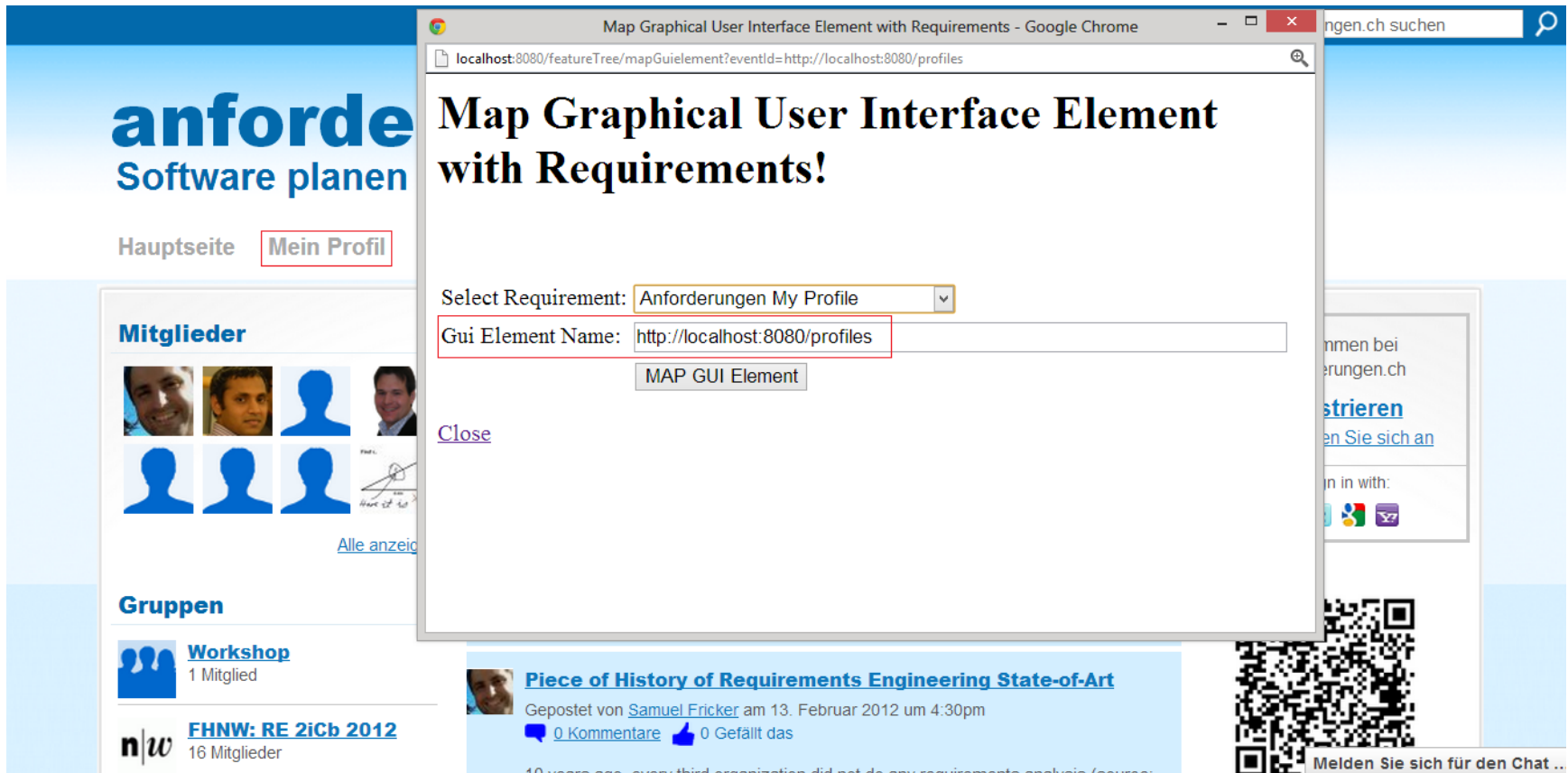


Figure 31: Map Requirements with GUI elements in the Analytics Tool

Visual Analytics of Product Features | Home

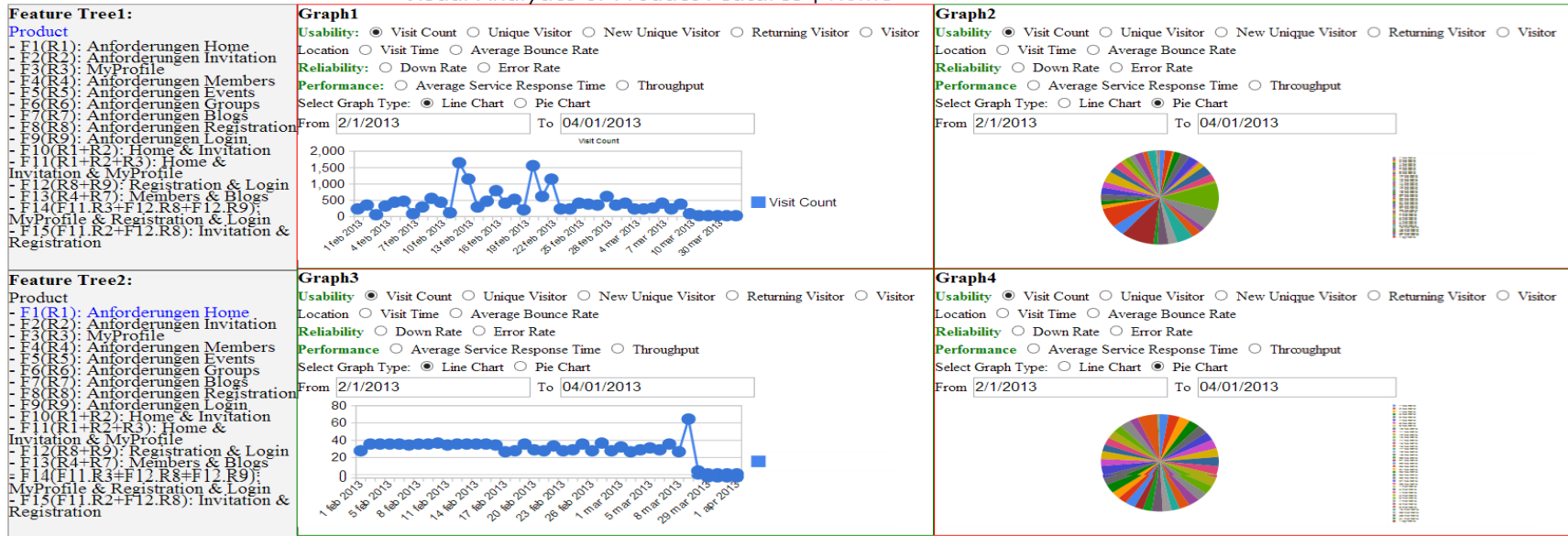


Figure 32: Compare Features Analytics in the Analytics Tool

Update Admin Status

The time on the server is den 1 april 2013 12:50:19 CEST.

Admin Status:

[Home](#)

Figure 33: Set Admin Configurations in the Analytics Tool

11 Appendix D

Track Feature usage of a SaaS website by the prototype Analytics Tool



Figure 34: Defined Features and Requirements of the SaaS Website

::DashBoard::MANAGEMENT OF APP

- [Manage Feature](#)
- [Manage Requirement](#)
- [Manage GUI Element](#)
- [Manage Indicator](#)
- [Manage SubIndicator](#)

Feature Tree

- [Product](#)
 - [Feature1: Blog posts](#)

The time on the server is den 6 april 2013 20:21:07 CEST.

::DashBoard::Feature Management

Id	Name	Description	Status	Action
1	Feature1: Blog posts	Post a new Blog	1	Modify

[Add Feature](#)
[Home](#)

Add New Feature

The time on the server is den 6 april 2013 20:23:10 CEST.

Feature Name:

Status:

Feature Description:

Figure 35: Create Feature (Click on 'Manage Feature', then 'Add Feature' and then enter Feature Info)

::Dashboard::MANAGEMENT OF APP

- [Manage Feature](#)
- [Manage Requirement](#)
- [Manage GUI Element](#)
- [Manage Indicator](#)
- [Manage SubIndicator](#)

::Dashboard::Manage Requirement

Id	FeatureId	Name	Description	Action
1	1	Add blog post	Requirement1 of Featre1: Add a new blog post	Modify

[Add Requirement](#)
[Home](#)

Add New Requirement

The time on the server is den 6 april 2013 20:35:53 CEST.

Select Feature:

Requirement Name:

Requirement Description:

Figure 36: Create Requirement (Click on 'Manage Requirement', then 'Add Requirement' and then enter Requirement Info)

::Dashboard::MANAGEMENT OF SITE CONFIGURATION

- [Set Admin Status](#)

Update Admin Status

The time on the server is den 6 april 2013 20:42:05 CEST.

Admin Status:

[Home](#)

Figure 37: Set Admin Status as Active (Click on 'Set Admin Status' and select Active)

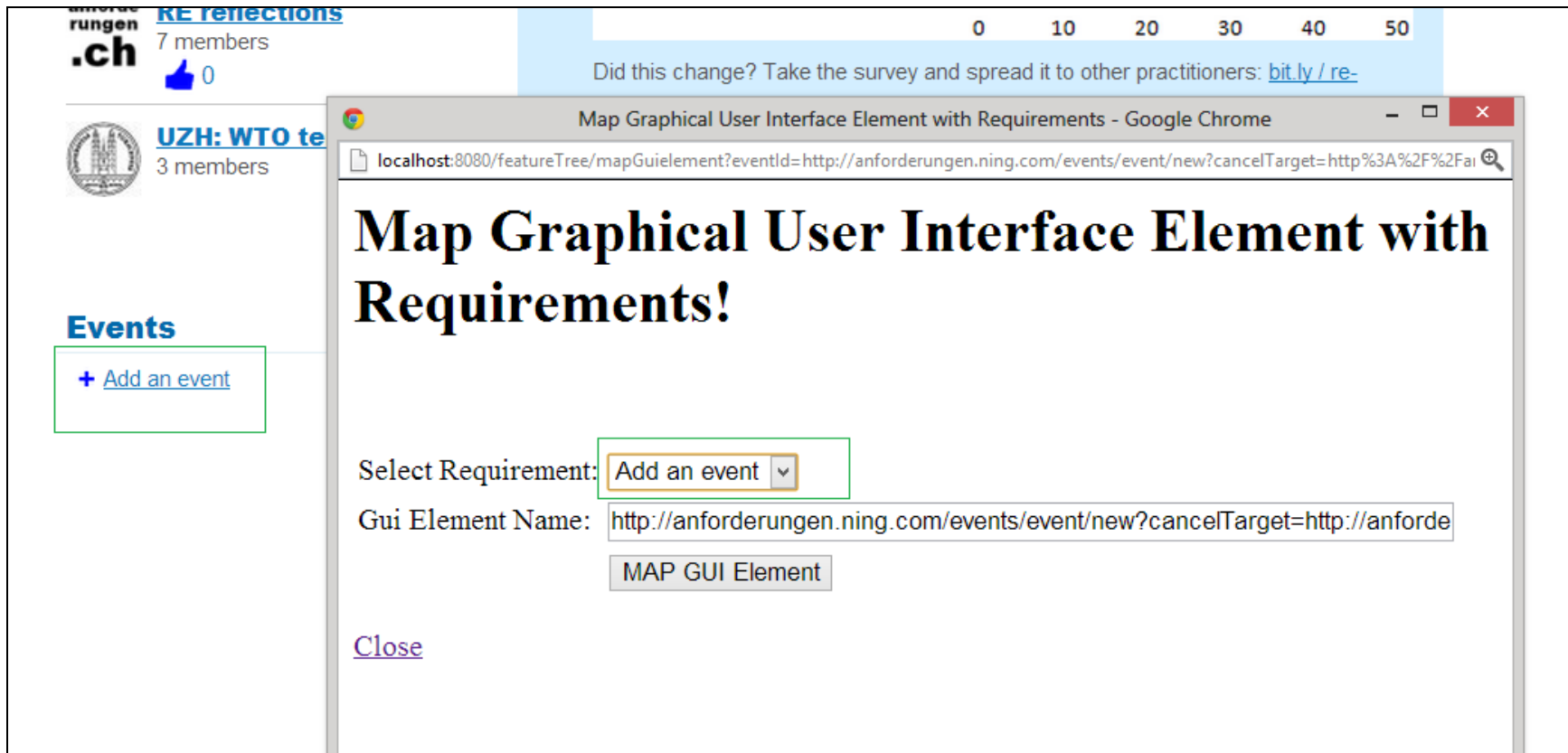


Figure 38: Map the GUI element of the SaaS webpage with created Requirement of Analytics Tool to track feature (Click on 'Add an event' on the SaaS webpage, then select Requirement from pop-up window and press 'MAP GUI Element' button to map)

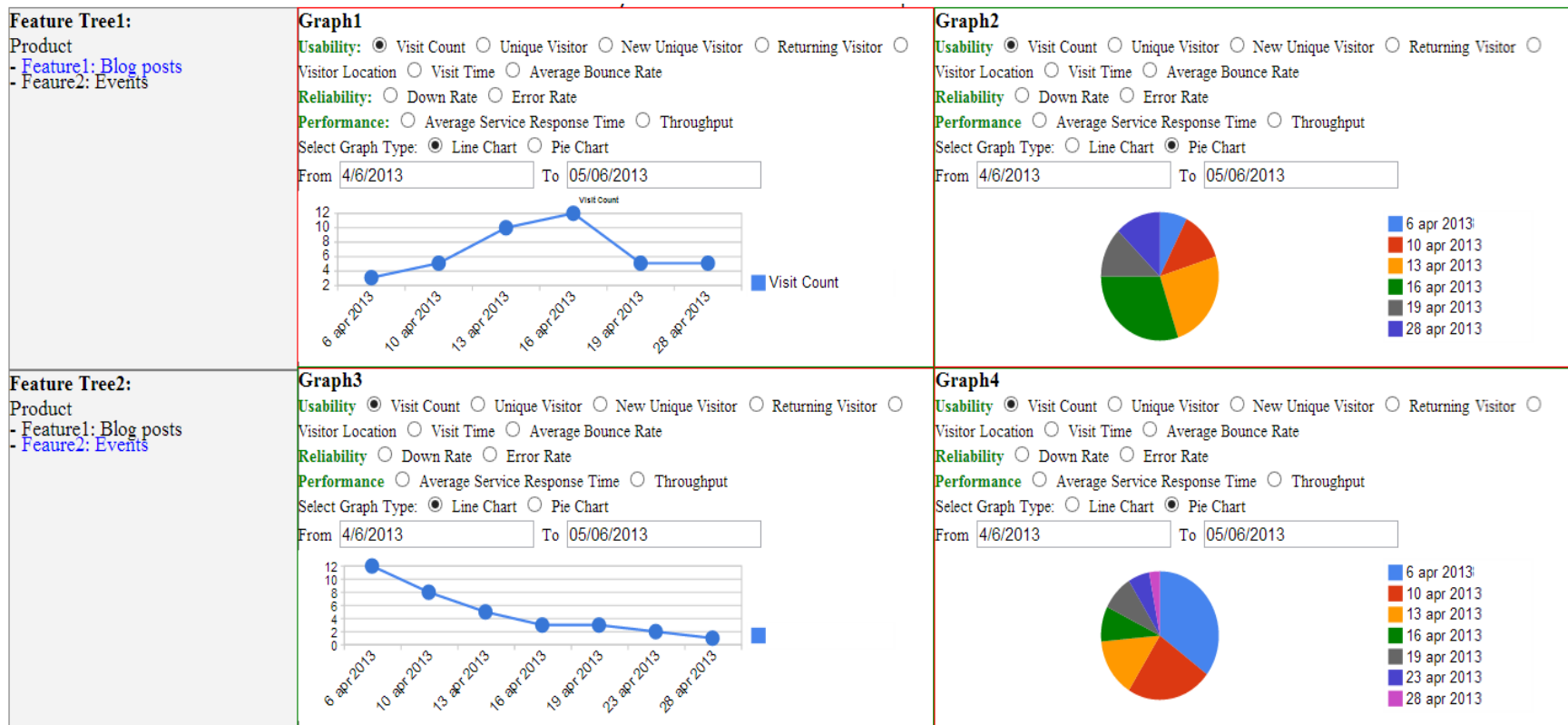






Figure 39: Compare feature usage by interactive graphs (Select Features, sub-Indicators, To-From Date & Graph Type to generate graph)

12 Appendix E

The usage pattern (one click feature usage) based on the predefined scenarios capture the following outcome in analytics tool.

Page Clutter (Scenario1):

<p>Feature Tree1: Product - Web Page (P1) - Feature1 (F1) - Feature2 (F2) - Feature3 (F3) - Feature4 (F4)</p>	<p>Graph1 Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  Visit Count</p>	<p>Graph2 Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  17 apr 2013</p>
<p>Feature Tree2: Product - Web Page (P1) - Feature1 (F1) - Feature2 (F2) - Feature3 (F3) - Feature4 (F4)</p>	<p>Graph3 Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  Visit Count</p>	<p>Graph4 Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  17 apr 2013</p>
<p>Feature Tree1: Product - Web Page (P1) - Feature1 (F1) - Feature2 (F2) - Feature3 (F3) - Feature4 (F4)</p>	<p>Graph1 Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  Visit Count</p>	<p>Graph2 Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  17 apr 2013</p>
<p>Feature Tree2: Product - Web Page (P1) - Feature1 (F1) - Feature2 (F2) - Feature3 (F3) - Feature4 (F4)</p>	<p>Graph3 Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  Visit Count</p>	<p>Graph4 Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  17 apr 2013</p>

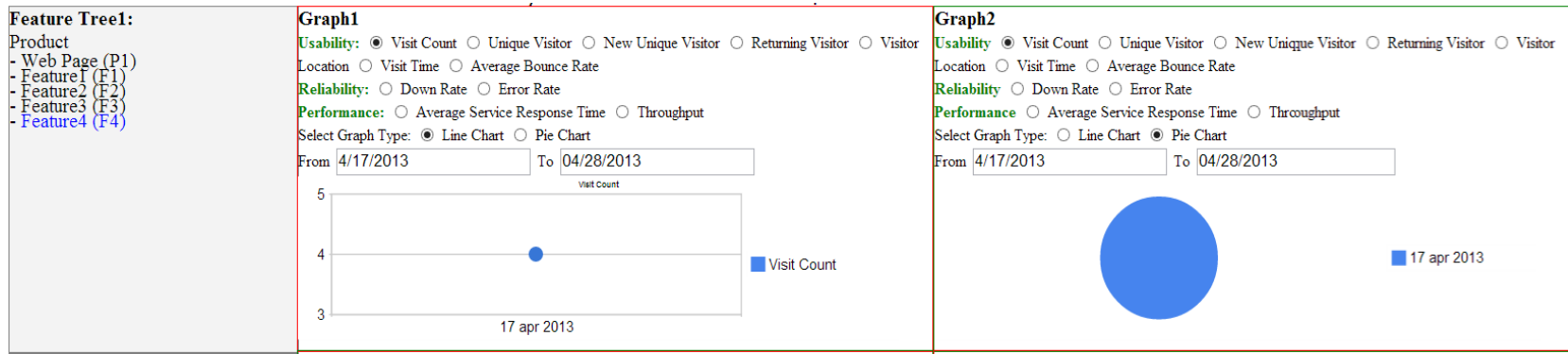


Figure 40: Scenario1 in Page-based Analytics: Web Page (P1), Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4)

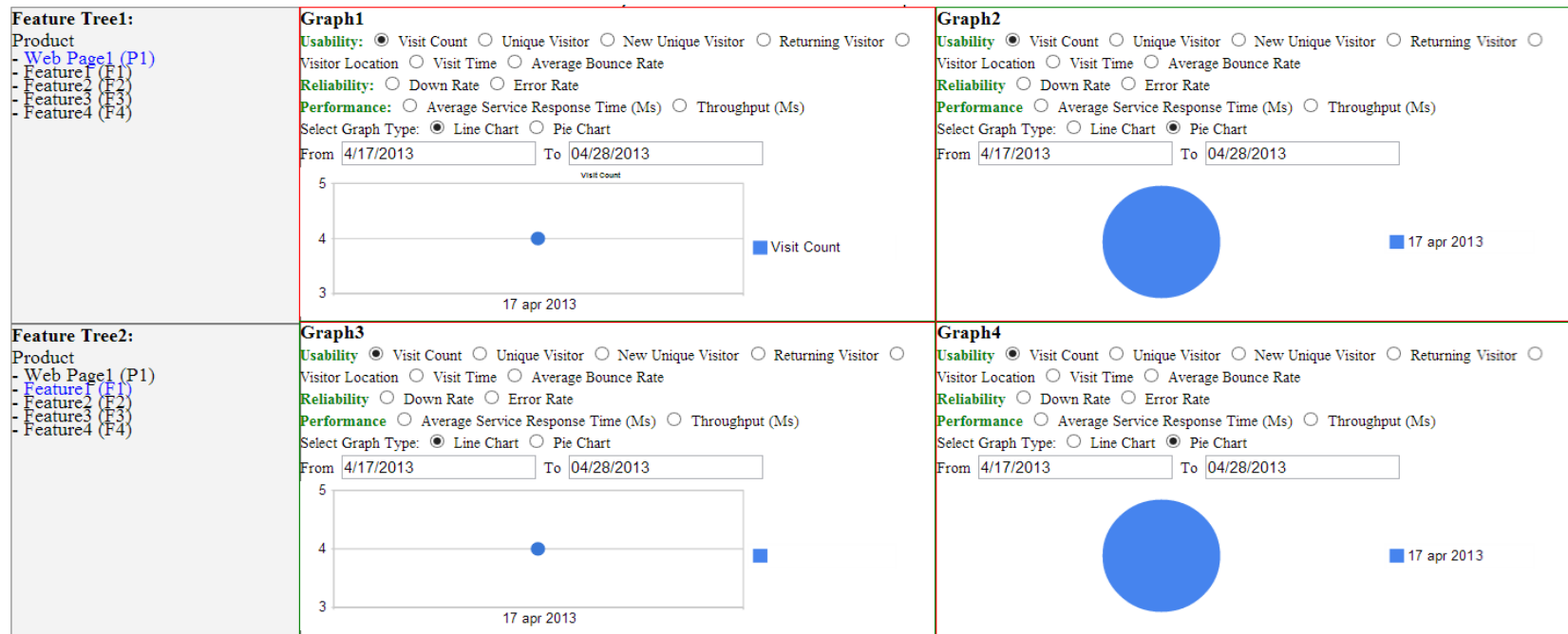



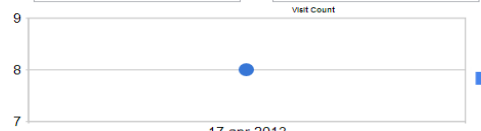





Figure 41: Scenario1 in Feature-based Analytics: Web Page (P1), Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4)

Page Clutter (Scenario2):

<p>Feature Tree1:</p> <ul style="list-style-type: none"> Product - Web Page (P1) - Feature1 (F1) - Feature2 (F2) - Feature3 (F3) - Feature4 (F4) 	<p>Graph1</p> <p>Usability <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>Visit Count</p> <p>17 apr 2013</p>	<p>Graph2</p> <p>Usability <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>17 apr 2013</p>
<p>Feature Tree2:</p> <ul style="list-style-type: none"> Product - Web Page (P1) - Feature1 (F1) - Feature2 (F2) - Feature3 (F3) - Feature4 (F4) 	<p>Graph3</p> <p>Usability <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>Visit Count</p> <p>17 apr 2013</p>	<p>Graph4</p> <p>Usability <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>17 apr 2013</p>
<p>Feature Tree1:</p> <ul style="list-style-type: none"> Product - Web Page (P1) - Feature1 (F1) - Feature2 (F2) - Feature3 (F3) - Feature4 (F4) 	<p>Graph1</p> <p>Usability <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>Visit Count</p> <p>17 apr 2013</p>	<p>Graph2</p> <p>Usability <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>17 apr 2013</p>
<p>Feature Tree2:</p> <ul style="list-style-type: none"> Product - Web Page (P1) - Feature1 (F1) - Feature2 (F2) - Feature3 (F3) - Feature4 (F4) 	<p>Graph3</p> <p>Usability <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>Visit Count</p> <p>17 apr 2013</p>	<p>Graph4</p> <p>Usability <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>17 apr 2013</p>

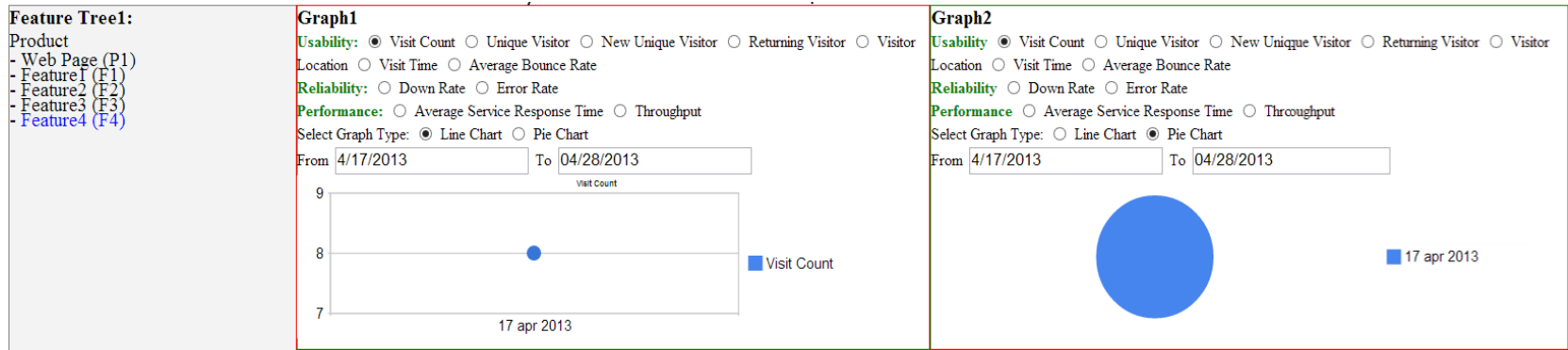
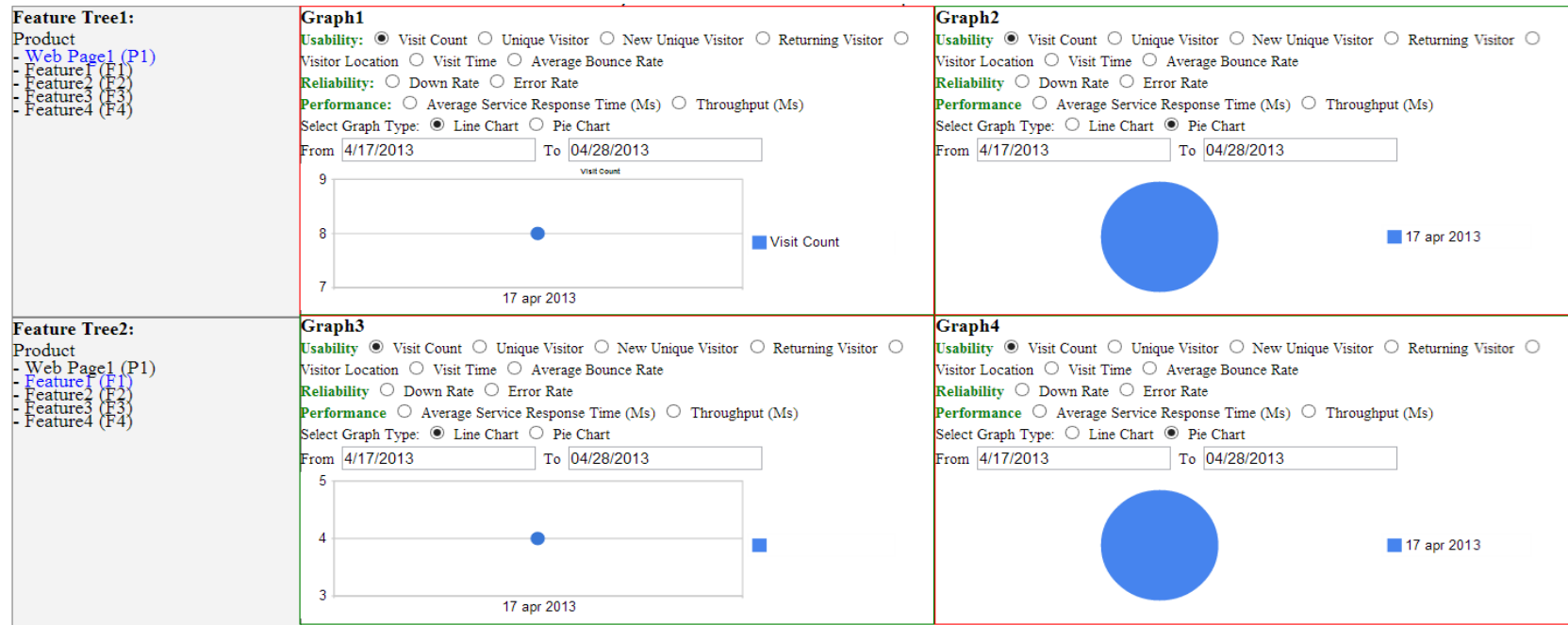


Figure 42: Scenario2 in Page-based Analytics: Web Page (P1), Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4)



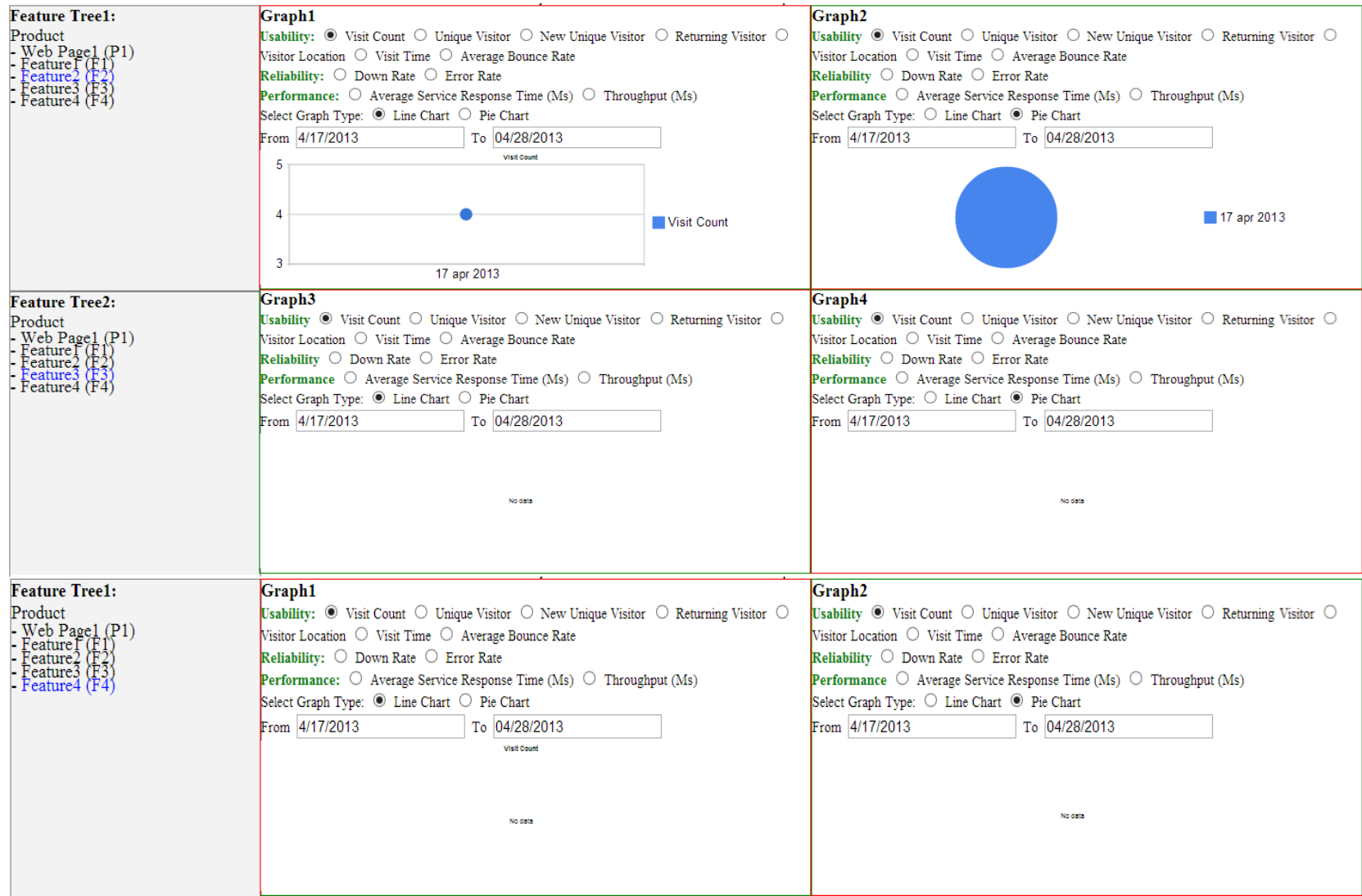


Figure 43: Scenario2 in Feature-based Analytics: Web Page (P1), Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4)

Feature Spread (Scenario3):

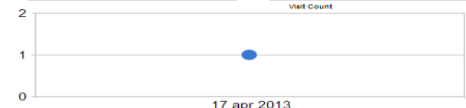



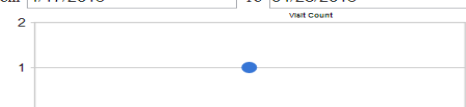
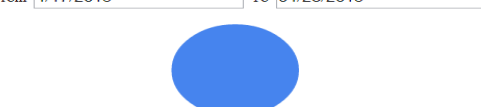
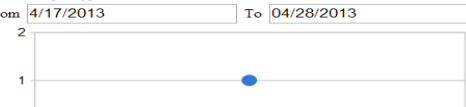

<p>Feature Tree1:</p> <ul style="list-style-type: none"> Product - Web Page1 (P1) - Web Page2 (P2) - Web Page3 (P3) - Web Page4 (P4) - Webpage1 Feature1 (F1.E1) - Webpage2 Feature1 (F1.E2) - Webpage3 Feature1 (F1.E3) - Webpage4 Feature1 (F1.E4) 	<p>Graph1</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>17 apr 2013</p>	<p>Graph2</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>17 apr 2013</p>
<p>Feature Tree2:</p> <ul style="list-style-type: none"> Product - Web Page1 (P1) - Web Page2 (P2) - Web Page3 (P3) - Web Page4 (P4) - Webpage1 Feature1 (F1.E1) - Webpage2 Feature1 (F1.E2) - Webpage3 Feature1 (F1.E3) - Webpage4 Feature1 (F1.E4) 	<p>Graph3</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>17 apr 2013</p>	<p>Graph4</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>17 apr 2013</p>
<p>Feature Tree1:</p> <ul style="list-style-type: none"> Product - Web Page1 (P1) - Web Page2 (P2) - Web Page3 (P3) - Web Page4 (P4) - Webpage1 Feature1 (F1.E1) - Webpage2 Feature1 (F1.E2) - Webpage3 Feature1 (F1.E3) - Webpage4 Feature1 (F1.E4) 	<p>Graph1</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>17 apr 2013</p>	<p>Graph2</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>17 apr 2013</p>
<p>Feature Tree2:</p> <ul style="list-style-type: none"> Product - Web Page1 (P1) - Web Page2 (P2) - Web Page3 (P3) - Web Page4 (P4) - Webpage1 Feature1 (F1.E1) - Webpage2 Feature1 (F1.E2) - Webpage3 Feature1 (F1.E3) - Webpage4 Feature1 (F1.E4) 	<p>Graph3</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>17 apr 2013</p>	<p>Graph4</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p>  <p>17 apr 2013</p>



Figure 44: Scenario3 in Page-based Analytics: Web Page1 (P1), Web Page2 (P2), Web Page3 (P3), Web Page4 (P4), Web Page1 Feature1 (F1.E1), Web Page2 Feature1 (F1.E2), Web Page3 Feature1 (F1.E3) and Web Page4 Feature1 (F1.E4)

<p>Feature Tree1:</p> <ul style="list-style-type: none"> Product - Web Page1 (P1) - Web Page2 (P2) - Web Page3 (P3) - Web Page4 (P4) - Webpage1 Feature1 (F1.E1) - Webpage2 Feature1 (F1.E2) - Webpage3 Feature1 (F1.E3) - Webpage4 Feature1 (F1.E4) 	<p>Graph1</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p> <p>17 apr 2013</p>	<p>Graph2</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p> <p>17 apr 2013</p>
<p>Feature Tree2:</p> <ul style="list-style-type: none"> Product - Web Page1 (P1) - Web Page2 (P2) - Web Page3 (P3) - Web Page4 (P4) - Webpage1 Feature1 (F1.E1) - Webpage2 Feature1 (F1.E2) - Webpage3 Feature1 (F1.E3) - Webpage4 Feature1 (F1.E4) 	<p>Graph3</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p> <p>17 apr 2013</p>	<p>Graph4</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p> <p>17 apr 2013</p>
<p>Feature Tree1:</p> <ul style="list-style-type: none"> Product - Web Page1 (P1) - Web Page2 (P2) - Web Page3 (P3) - Web Page4 (P4) - Webpage1 Feature1 (F1.E1) - Webpage2 Feature1 (F1.E2) - Webpage3 Feature1 (F1.E3) - Webpage4 Feature1 (F1.E4) 	<p>Graph1</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p> <p>17 apr 2013</p>	<p>Graph2</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p> <p>17 apr 2013</p>
<p>Feature Tree2:</p> <ul style="list-style-type: none"> Product - Web Page1 (P1) - Web Page2 (P2) - Web Page3 (P3) - Web Page4 (P4) - Webpage1 Feature1 (F1.E1) - Webpage2 Feature1 (F1.E2) - Webpage3 Feature1 (F1.E3) - Webpage4 Feature1 (F1.E4) 	<p>Graph3</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p> <p>17 apr 2013</p>	<p>Graph4</p> <p>Usability: <input checked="" type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor</p> <p>Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate</p> <p>Reliability: <input type="radio"/> Down Rate <input type="radio"/> Error Rate</p> <p>Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput</p> <p>Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart</p> <p>From 4/17/2013 To 04/28/2013</p> <p>17 apr 2013</p>

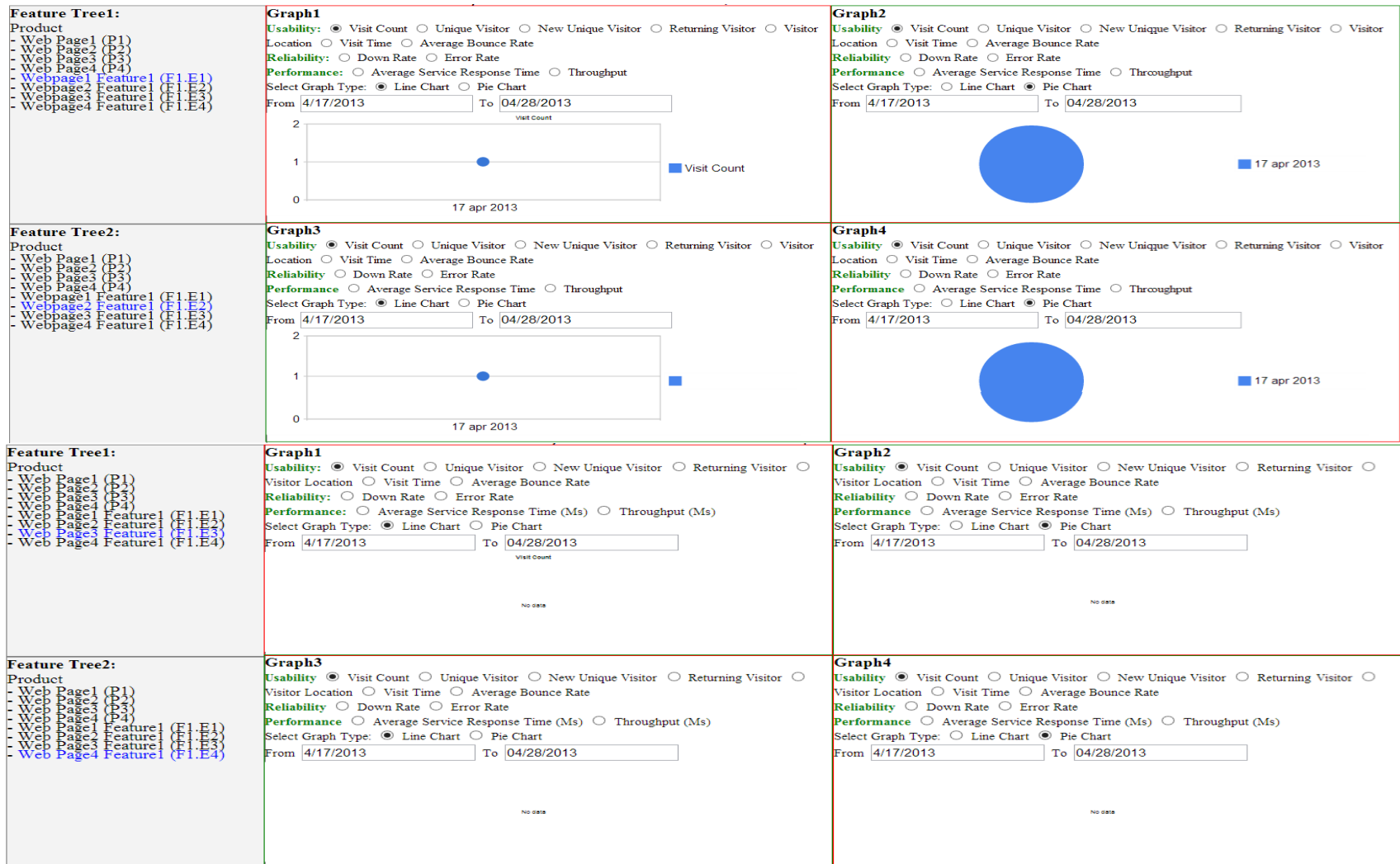


Figure 45: Scenario3 in Feature-based Analytics: Web Page1 (P1), Web Page2 (P2), Web Page3 (P3), Web Page4 (P4), Web Page1 Feature1 (F1.E1), Web Page2 Feature1 (F1.E2), Web Page3 Feature1 (F1.E3) and Web Page4 Feature1 (F1.E4)

Erroneous Page Presentation (Scenario4):

<p>Feature Tree1: Product - Web Page (P1) - Feature1 (F1) - Feature2 (F2) - Feature3 (F3) - Feature4 (F4)</p>	<p>Graph1 Usability: <input type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input checked="" type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  Error Rate</p>	<p>Graph2 Usability: <input type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input checked="" type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  17 apr 2013</p>
<p>Feature Tree2: Product - Web Page (P1) - Feature1 (F1) - Feature2 (F2) - Feature3 (F3) - Feature4 (F4)</p>	<p>Graph3 Usability: <input type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input checked="" type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  Error Rate</p>	<p>Graph4 Usability: <input type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input checked="" type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  17 apr 2013</p>
<p>Feature Tree1: Product - Web Page (P1) - Feature1 (F1) - Feature2 (F2) - Feature3 (F3) - Feature4 (F4)</p>	<p>Graph1 Usability: <input type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input checked="" type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  Error Rate</p>	<p>Graph2 Usability: <input type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input checked="" type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  17 apr 2013</p>
<p>Feature Tree2: Product - Web Page (P1) - Feature1 (F1) - Feature2 (F2) - Feature3 (F3) - Feature4 (F4)</p>	<p>Graph3 Usability: <input type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input checked="" type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input checked="" type="radio"/> Line Chart <input type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  Error Rate</p>	<p>Graph4 Usability: <input type="radio"/> Visit Count <input type="radio"/> Unique Visitor <input type="radio"/> New Unique Visitor <input type="radio"/> Returning Visitor <input type="radio"/> Visitor Location <input type="radio"/> Visit Time <input type="radio"/> Average Bounce Rate Reliability: <input type="radio"/> Down Rate <input checked="" type="radio"/> Error Rate Performance: <input type="radio"/> Average Service Response Time <input type="radio"/> Throughput Select Graph Type: <input type="radio"/> Line Chart <input checked="" type="radio"/> Pie Chart From 4/17/2013 To 04/28/2013  17 apr 2013</p>

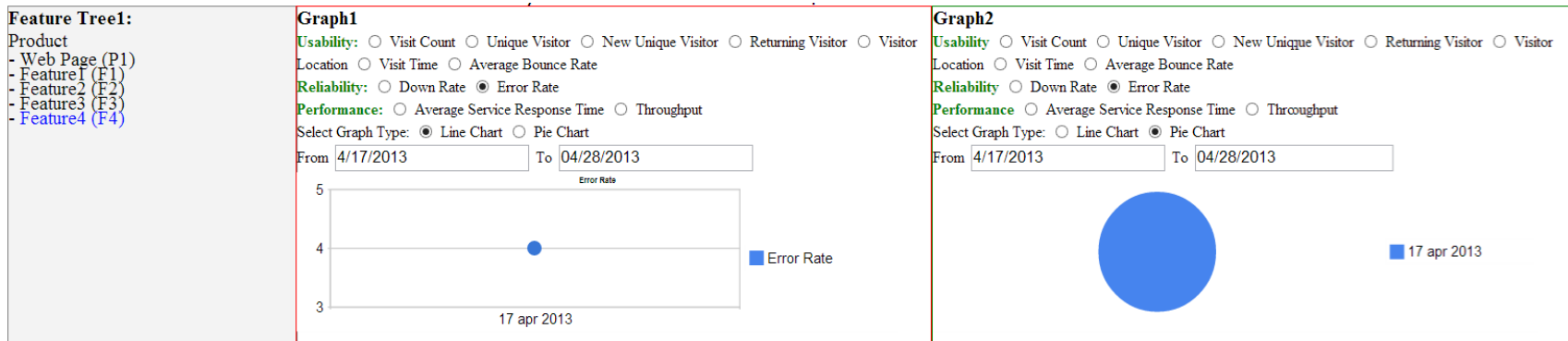


Figure 46: Scenario4 in Page-based Analytics: Web Page (P1), Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4)

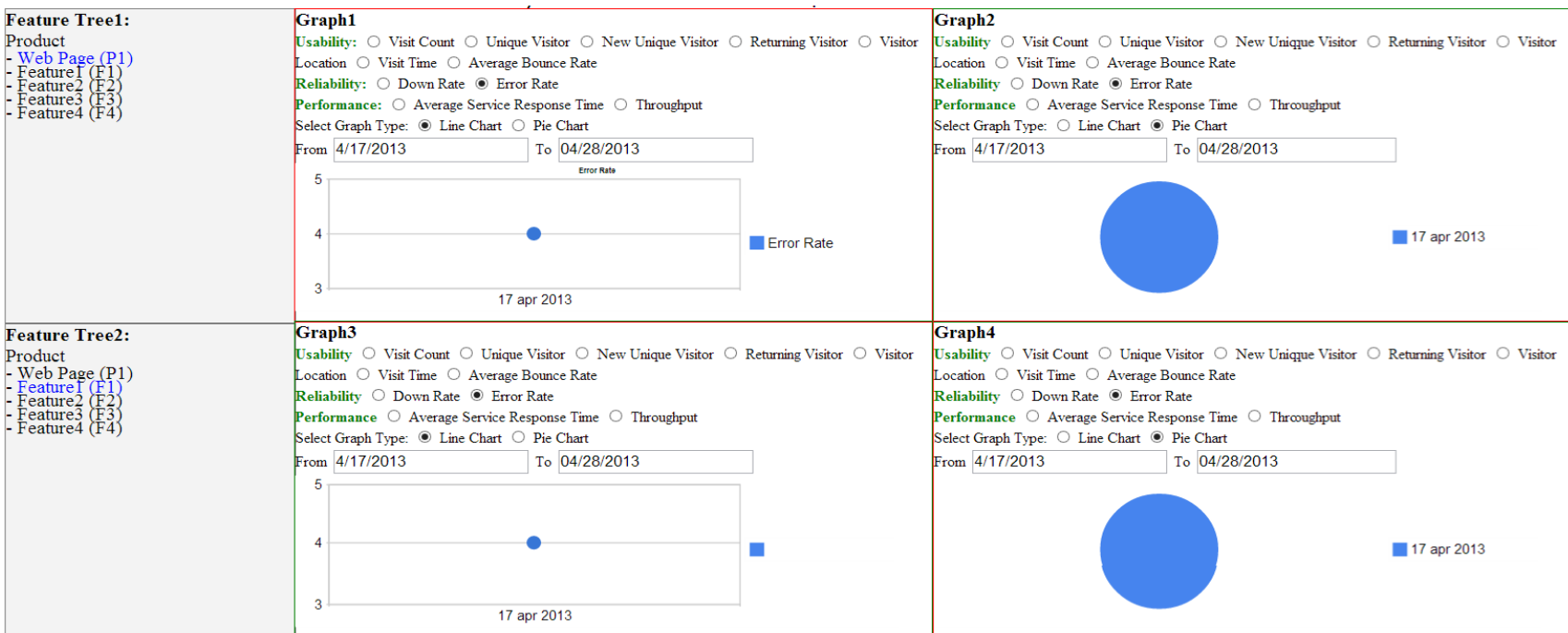




Figure 47: Scenario4 in Feature-based Analytics: Web Page (P1), Feature1 (F1), Feature2 (F2), Feature3 (F3) and Feature4 (F4)