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Implementation of Rapid Application Development Method in the Development of Geographic Information Systems of Industrial Centers

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Abstract

Cities in Indonesia include diverse scattered industrial centers comprising industries that can sustain the existing economic pace. For industrial data collection, the city government still relies on census that consumes extensive time and money. The public are unfamiliar with industries owing to their lack of industry information; therefore, the market share is not optimal. In addition, the opportunity to procure investors for business development is limited. A Geographic Information System (GIS) is a computer system that can record, store, write, analyze, and display geographical data. Using the Rapid Application Development (RAD) method, GIS was developed on a website platform to provide information on industry profiles, types of production, investment values, industry maps, and industrial locations in each village and sub-district to a wider community. The RAD method was chosen compared to the waterfall method because it could accelerate website development process.

Index Terms: Geographic Information System, Industry, Rapid application development (RAD)

I. INTRODUCTION

Cities in Indonesia include diverse scattered industrial centers comprising industries that can sustain the existing economic pace. An example of the industrial center is the industrial center located in the city of Tegal. The industrial centers are classified into 4 types:

1. Food and beverage industry
2. Clothing industry
3. Metal and electronics industry
4. Handicraft industry.

For industrial data collection, the city government still relies on census that consumes extensive time and money. The public are unfamiliar with industries owing to their lack of industry information; therefore, the market share is limited. In addition, the opportunity to procure investors for business development is not optimal.

Industrial data are usually presented by the city government through the Central Statistics Agency in "City in Numbers" by displaying tabular data and statistics that are not easily understood by ordinary people.

A GIS is a computer system that can record, store, write, analyze, and display geographical data [1]. It is a formal unit comprising several physical and logical resources related to objects on the earth's surface. It integrates software, hardware, people, procedures, databases, and communication network facilities that are used to facilitate the processes of input, storage, manipulation, display, and output of data/geographical information along with their attributes [2].

Hence, a website-based GIS was developed for the presentation of industrial data in a city that could be accessed freely and in real time, with notable visualization and high

data complexity comprising spatial and non-spatial data. The website-based GIS of industrial centers was developed using the Rapid Application Development (RAD) method, which is a life cycle strategy that provides faster and better quality result compared to the results provided by traditional cycles [3]. Further, RAD is a method of software development with an object-oriented approach to system development [4].

Consequently, in this study, RAD was employed as the development method to design and develop a website-based GIS to optimize the existing industry market share, facilitate the public in conducting industry searches, collect data effortlessly on companies in each industry, and attract investors to invest in the city. The GIS website could display sub-district data, village data, industry location data, maps, coordinate points, industry profiles, satellite photos, producer data, and industrial product data with attractive and better visualization.

II. RELATED WORK

A study result a GIS to estimate and map the occurrence of dengue and chikungunya in Honduras. GIS has been widely applied in the development of epidemiological maps , including for mapping the occurrence of dengue and chikungunya. The implementation of GIS-based epidemiological maps guides decision makers in preventing and controlling diseases that still pose significant challenges in certain regions and countries [5].

Thakur et al. integrated GIS with remote sensing and global positioning system for groundwater hydrological models, resource management, environmental monitoring, and emergency response. This integration helps to provide and handle several large data sizes that are used simultaneously for efficient time and cost [6].

The land-use mapping system built on the website platform was developed in a study conducted by Ginanjar and Nishom. The study was motivated by the lack of media publicity and socialization of land use, which affected the extent of improper and inefficient land use. [7].

Multi-criteria GISs have been employed to measure climate change vulnerability using the weighted ordered weighted average technique. According to the Monte Carlo simulation-based resilience analysis, this aggregation technique can provide more flexible options and has the potential to create a vulnerability index compared to traditional approaches such as weighted linear combinations [8].

GIS can be applied to analyze the performance of sustainable urban transportation based on its five basic indicators—traffic jams, traffic air pollution, traffic noise pollution, traffic accidents, and transportation infrastructure. The study results indicate that the application of GIS in the study of urban transportation performance is dominant in traffic congestion indicators, and GIS is applied to measure the shortest path [9].

RAD was chosen as a methodology to develop Dutatani web applications. Dutatani is a portal and a part of the integrated agriculture information system, which is an agricultural information system comprising several connected subsystems. Dutatani can manage users, contents, and links in this system. The web application was developed in 150 days and had gone through several phases—planning, analysis, special design, main design, implementation, testing, and integration of prototypes. The completion time of 150 days was achieved by the supervision and monitoring of team leaders in optimizing the productivity of all their teams [10].

RAD has been employed as a methodology in designing library information systems, resulting in an efficient development time because it only requires 60 working days. The menu structure displayed in the library information system indicates that there is a relevant relationship between business processes and the interface system. Hence, the development of this system has a positive effect on servicing the members and improving management performance [11].

Fatimah et al. also employed the RAD method to design the personnel information system. This method was applied in the stages of identifying objectives and information requirements, designing systems, building systems, and introducing new systems. Based on the implementation of the RAD method, a more effective and efficient staffing information system was designed. The development of this design required a short time; however, it required an effective coordination between system designers and users [12].

III. THINKING FRAMEWORK

A. Thinking Framework

The thinking framework adopted in this study is presented in Fig. 1.

B. Research Method

Herein, after research, the RAD method was adopted to develop GIS. RAD is an approach to develop information systems that is widely discussed in the practitioner literature [13]. RAD is a set of methods that have been developed to overcome the weaknesses of traditional system development methods such as the waterfall model and its variants [14]. This method is applied in the quick application development cycle and provides good quality software compared to those provided using traditional software engineering approaches. Through a rapid software development process, the organization can cost-efficiently develop and maintain software [15].

RAD is a more flexible and adaptive application development model that can change user requirements and ensure fast-growing system quality at minimal costs [16]. In its
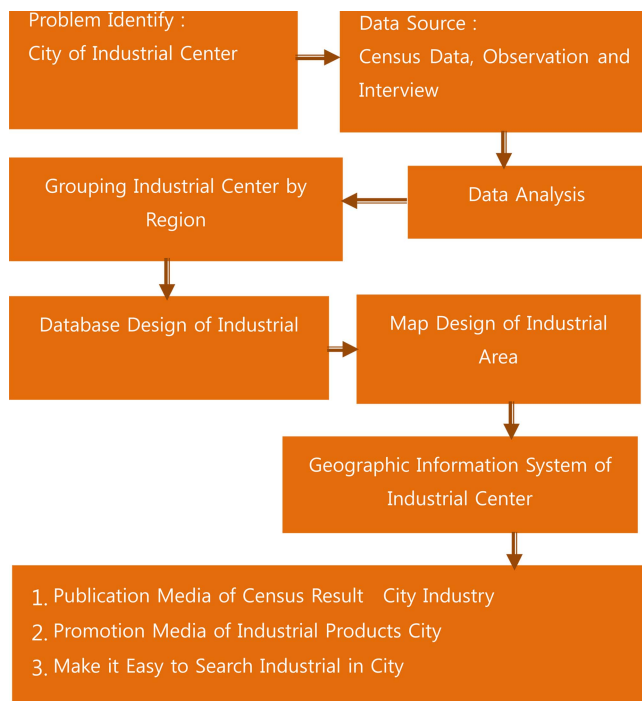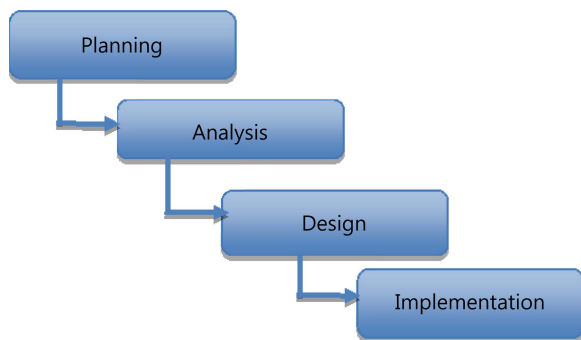
Fig. 1. Thinking framework.

Fig. 2. RAD models.

implementation, RAD emphasizes a short planning process and focuses on the software development process that includes development, testing, and feedback [17].

The phases of the RAD model are illustrated in Fig. 2.

IV. RESULT AND DISCUSSION

The GIS of industrial centers was developed with a website platform; the website platform was implemented in Tegal city, Indonesia.

In this study, the GIS of industrial centers that had been developed using the waterfall method was compared to a recently developed GIS of industrial centers using the RAD method.

The development of the website GIS of the industrial center using RAD method and its implementation in Tegal city are as follows.

A. System Design

The website design of the GIS of the industrial center used Unified Modeling Language (UML). UML is a family of graphical notations supported by single models, which helps to describe and design software systems, particularly systems that are developed using object-oriented programming [18].

A UML model employed in developing WebGIS of industrial centers is based on use case diagrams and sequence diagrams. A use case diagram is a UML diagram that is used to describe the expected functional requirements of a system [19], whereas a sequence diagram is a UML diagram that illustrates the interaction between in and around the system objects (including users, displays, and forms) in the form of messages described with respect to time [20].

B. User Interface

The GIS website of the industrial center was developed with the PHP (Hypertext Preprocessor) programming language and MySQL database. PHP is a programming language that is widely used to handle the creation and development of a website and can be used in conjunction with HTML [21]. MySQL is a database management system that uses basic structure query language commands [22].

C. Discussion

The development team leader, responsible for the completion of the GIS development, plays a vital role in controlling and supervising every team member and their work, such that each stage in the RAD can execute according to the plan; therefore, the completion time is faster and more cost efficient.

The phases of the RAD method applied in the development of the GIS of the industrial center can be explained as follows.

1) Planning

This stage was the initial phase in the development of the system. In this stage, information regarding the problem identification and data collection, in the form of primary data, were directly obtained from users or final result-oriented users. All user requirements related to the design of GIS were obtained. The user and the team conducted meetings to identify the goals of the application or system and the information requirements arising from those objectives. The orientation in this stage involved planning to overcome existing problems. The primary data were obtained from the

industry, trade, cooperatives, and SMEs in the city area.

2) Analysis

In this stage, the data that had to be used in the development of GIS were analyzed. In addition, the GIS users of industrial centers were analyzed according to their individual requirements. There were 4 types of users—super administrators / management, city/district governments, entrepreneurs, and the community. Every user (except the community) had the authority to manage their respective data; this affected the features of each user.

3) Design

Once the analysis stage was completed, the next stage was to create a design based on the results of the analysis conducted. The design referred to in the RAD method was a general and detailed system design overview using UML, user interface / user experience display design, and database table design. Prior to the designs being used as a primary reference in the implementation stage, the design was agreed upon by the user.

4) Implementation

This stage translated the design into programming codes. In this case, the product was a website that had been developed in accordance with user requirements. In building this website, the programming language used was PHP with the CodeIgniter framework and MySQL database and Arc GIS

for the visualization of the map. The GIS of the industrial center appears as illustrated in Figs. 3-5. GIS could display industry locations, maps, coordinate points, industry profiles, and satellite photos. Furthermore, the statistical visualization could present graphs of industry profiles, producer data, industry addresses, number of workers, investment value, production capacity, production value, raw materials, and type of production in each village or sub-district in every month and year.

After the completion of GIS-based coding, the next stage was to test the system, by feeding every input to the developed website platform, processing it, and investigating certain errors. Moreover, the testing was conducted to ensure that the create, read, update, and delete (CRUD) process performed efficiently. Examples of certain system test results are presented in Table 1. The results of the test indicated that all CRUD functions were successfully conducted without errors.

The implementation of the RAD method for developing the GIS of the industrial center, implemented in Tegal city, Indonesia, had been successfully completed within 12 weeks or 84 days in accordance with the explanation presented in Table 2. This was 5 weeks faster than that taken by the waterfall method to develop similar GIS of the industrial center and implement it in the district of Tegal [23]. This success was because of the vital role played by the team leader who was able to manage existing resources optimally and communicate every achievement of the stages of the
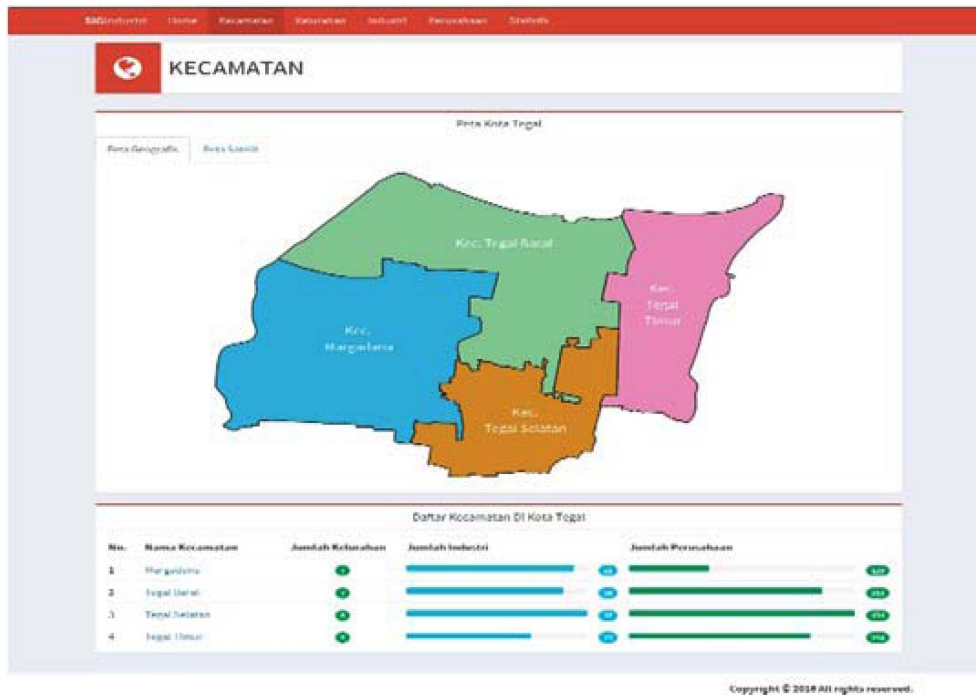

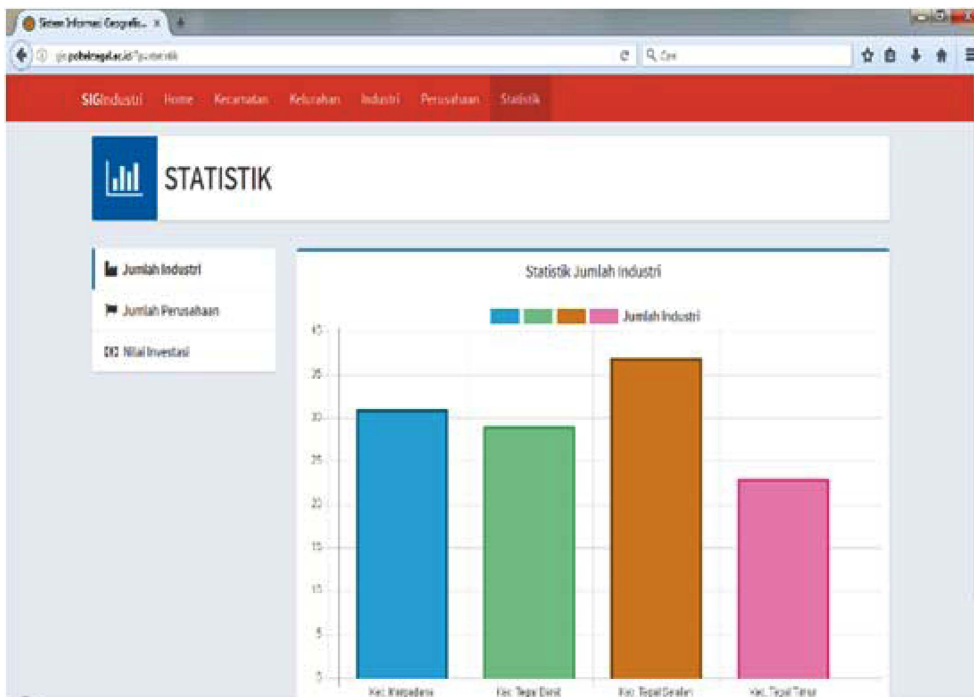**Fig. 3.** Display map of district industrial center.
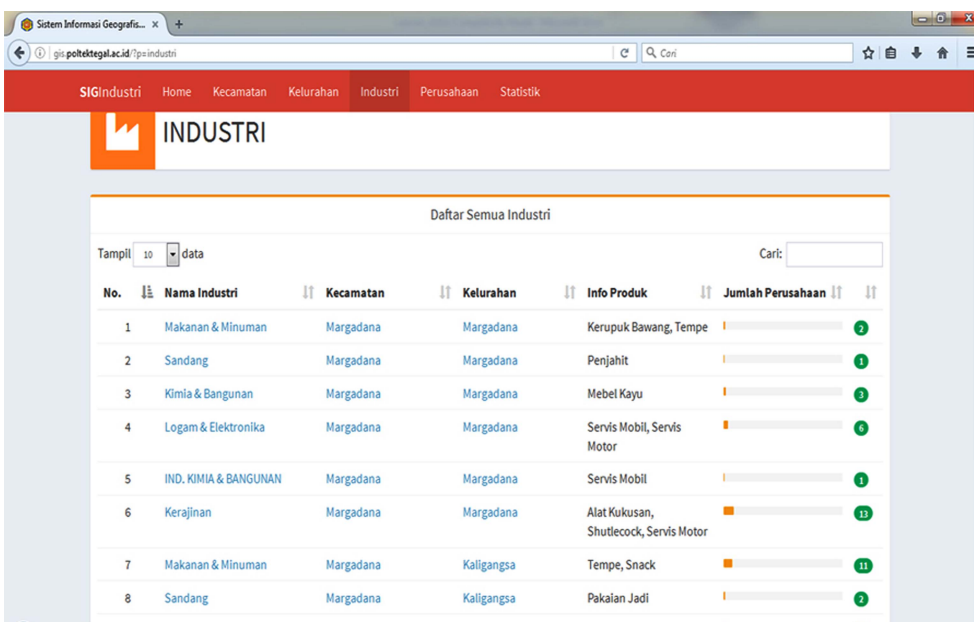
Fig. 4. Display of industrial menu.

Fig. 5. Display of industrial statistics menu.

RAD method with the user; consequently, the completion of software development was faster and ultimately affected the cost efficiency and productivity of resources.

The result was that the RAD method could increase the speed of system development with better software quality [24]. This method was appropriate for software development on a small to medium scale. The effective and efficient communication between team members, team leaders with all team members, and team leaders with users was a determinant of software development using the RAD method being successfully conducted.

Table 1. List of system testing activities

Test ID	Description	Test Input	Result
1	sign in	username, password	successful
2	sign out	-	successful
3	user data	user identity	successful
4	district data	district profile	successful
5	village data	village profile	successful
6	industrial data	industry profile	successful
7	company data	company description	successful
8	statistic data	detailed statistical data	successful
9	news data	content news data	successful
10	comment data	content comment data	successful

Table 2. Development time of GIS of industrial centers

Stages	Duration	Number of Team
Planning	2 weeks	1
Analysis	1 week	1
Design	2 weeks	1
Implementation	7 weeks	2

V. CONCLUSIONS

Based on the aforementioned results and discussion, it could be concluded that the GIS developed with the website platform could provide following information about villages and sub-districts that are industrial centers in a city/regency—industrial locations, maps, coordinate points, industrial profiles, and satellite photos. Furthermore, this GIS could provide outputs in the form of graphs about industry profiles, producer data, industry addresses, number of workers, investment value, production capacity, production value, raw materials, and types of production in every village or sub-district in every month and year. The GIS of the industrial center was achieved faster because it was developed using the RAD method. It was accomplished within 12 weeks or 84 days with better quality; this was faster than the waterfall method running in the district of Tegal. Therefore, it affected the cost efficiency and optimization of the productivity of existing resources.

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