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Title	PROPOSAL OF BRIDGE MANAGEMENT SYSTEM USING CLOUD COMPUTING FOR LOCAL GOVERNMENT
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Description	The Thirteenth East Asia-Pacific Conference on Structural Engineering and Construction (EASEC-13), September 11-13, 2013, Sapporo, Japan.
Relation	Proceedings of the Thirteenth East Asia-Pacific Conference on Structural Engineering and Construction (EASEC-13), September 11-13, 2013, Sapporo, Japan, B-3-5.
Citation	Proceedings of the Thirteenth East Asia-Pacific Conference on Structural Engineering and Construction (EASEC-13), B-3-5
Issue Date	2013-09-11
Doc URL	https://hdl.handle.net/2115/54249
Type	conference paper
File Information	easec13-B-3-5.pdf

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PROPOSAL OF BRIDGE MANAGEMENT SYSTEM USING CLOUD COMPUTING FOR LOCAL GOVERNMENT

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ABSTRACT

The management for bridges is required for the guarantee of the safety of daily life. A bridge management system is expected to be useful to conduct the sustainable maintenance activity with actual and reasonable costs. However, the system is more likely to be not cost-effective because it usually becomes large scale and is not used frequently. In addition, the enhancement of the practical utility of system requires a large number of data. For these reasons, the introduction and use of a management system in local governments does not proceed positively. In this study, an attempt is made to propose a practicable support system for the bridge management under the circumstances. By introducing the technology of cloud computing, local governments can use the proposed system through paying the on-demand use fees. Furthermore, it is expected that a small local government can receive the cost-effective support by sharing the data among various organizations. This paper describes the practical utility of the proposed system through discussing the examples of application.

Keywords: bridge management, local government, support system, cloud computing.

1. INTRODUCTION

In Japan, there are many bridges that require appropriate maintenances for keeping their soundness. Under recent economic circumstances, the extension of the service life of bridges is more reasonable to ensure the daily life than the new constructions. Therefore, the establishment of the sustainable bridge management is the important issue which should be addressed urgently. In order to perform effective maintenances with cost saving, it is necessary to formulate a maintenance plan by checking bridges' states accurately and frequently. However, many local governments have faced the shortage of experienced human resources. Thus, the bridge management system is expected to be useful for the improvement of the circumstances.

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In past researches, the support systems such as the planning for bridge maintenance (Furuta et al.2006; Nakatsu et al. 2012a), the damage assessment (Nakatsu et al. 2011) and the use of database (Nakatsu et al. 2012b) have been developed and verified their applicability respectively. Through these attempts, it is guessed that the enhancement of the practical utility of system involves the expansion of its scale and requires a large amount of data. However, the system is required for the actual maintenance activity in limited situations. And, it is difficult to observe the case data about the high damage level because the reduction of maintenance cost is performed by early reinforcement or repair to bridges before worsening their states. Moreover, it is difficult for small organizations to store data enough to effective applications because the number of bridges that they manage is small. For these reasons, the introduction of bridge management system is not cost-effective to improve the maintenance activity.

In this study, an attempt is made to propose a practicable support system for the bridge management by using the technology of cloud computing. The cloud computing is the utilization form that provides the on-demand service via the internet (Mell and Grance 2009). In a system with this technology, the usage fees are decided based on the users' used amount. In addition, by sharing the data on the system, all users can receive the service with effective applications of database. These features are expected to enable the bridge management system to overcome the problems for the practical use. Furthermore, this study discusses the method for the utilization of proposed system in the actual maintenance activity. These attempts are presented to demonstrate the feasibility and effectiveness of the proposed system.

2. BRIDGE MANAGEMENT SYSTEM WITH CLOUD COMPUTING

2.1. Outline

The outline of the proposed system is shown in Figure 1. The proposed system is composed of various subsystems for the decision-making support of bridge maintenance. Each subsystem is used in response to the users' necessity. And, by coordinating each subsystem in the process of maintenance activity, the proposed system attempts to improve the effectiveness for the practical maintenance. In addition, the case data is shared on this system in order to enhance the usefulness of the data analysis and applications. A user can introduce the proposed system into the organization by the license agreement. Then, the functions of system are used as a web application via the internet.

The major difference among the approach of this study and past researches is the way of support for the maintenance activity. Existing systems usually assist maintenance activities such as the inspection and maintenance, the damage assessment and the planning respectively. On the other hand, the proposed system helps users to make effective decisions in the flow of works as shown in Figure 1 by taking into account the following works. For example, a maintenance plan is formulated in consideration of the changes of circumstances in the proposed system. This is because a plan is

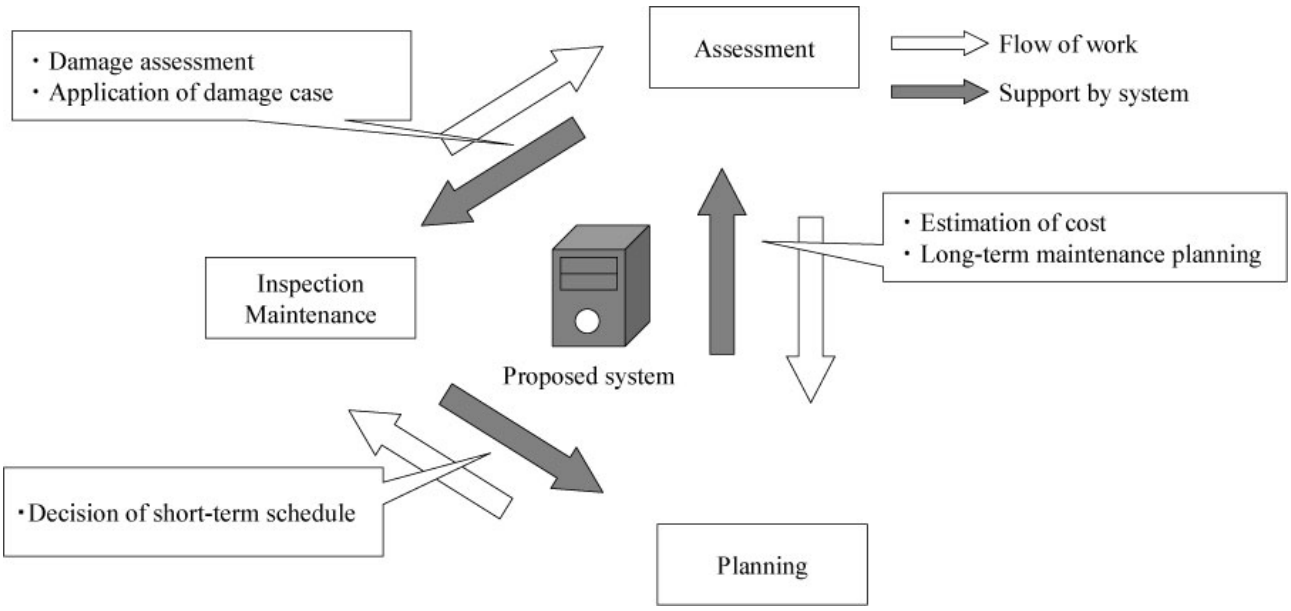

Figure 1: Outline of proposed system.

required to modify the schedule of works in response to the result of checks and damage assessments. In this way, the proposed system attempts to enhance the practical utility for the maintenance activity by paying attention to the interaction between the human and machine along with the process of works.

2.2. Advantages of bridge management with proposed system

By introducing the technology of cloud computing, the bridge management system can obtain several advantages for the practical use. Firstly, local government can use the proposed system without spending a large amount of cost for introduction and operation. The maintenance activity for bridges consists of various works. Thus, a practicable support system is more likely to become large. In addition, works requiring a support, such as the maintenance planning and the damage assessment, are not implemented frequently. The proposed system is available by only the license agreement and the network environment. And, the usage cost is decided according to the used amount. Therefore, it is expected that local governments can receive the support for the maintenance activity reasonably.

Secondly, by sharing the case data owned by various local governments on the proposed system, the usefulness of database can be enhanced. The accuracy of the applications of data significantly depends on the number of data. Thus, the collection of a large amount of data is effective for the enhancement. However, there is a limit to the number of case data that one local government owns. Furthermore, it is difficult to increase the case data in a short term because the data observation

needs to be performed as time passes. Therefore, if the data sharing is realized, all local governments can use more effective services with the proposed bridge management system.

Finally, the proposed system can improve the support of subsystems by merging them. Each subsystem for the maintenance activity usually uses the common database. In systems without using the technology of cloud computing, the coordination of multiple subsystems involved the expansion of scale. On the other hand, the proposed system can be introduced easily even if its scale becomes larger because users can use it as the web application on demand. Therefore, it is expected that the effectiveness of proposed system be improved totally in the maintenance activity. In addition, the proposed system can extend its function without influencing on subsystems due to the updating.

3. APPLICATION OF PROPOSED SYSTEM

The proposed system assists the decision-making for various works along with the process of maintenance activity as shown in Figure 1. Thus, by being used in the following ways, it is expected that the proposed system is useful in the actual works.

3.1. Check for Bridges

In the bridge management, various works such as the damage assessment and the maintenance planning are performed based on the result of checks. The daily check is necessary for the early detection of damage and the detailed inspection is indispensable for the damage assessment. Because these results are used as the observed data, a computation significantly depends on the check of bridges. Hence, the frequency and accuracy of this work is quite important in the bridge management. However, it is difficult to implement enough checks under the current circumstances which involve the shortage of experienced engineers.

The proposed system attempts to support the decision-making for the budget estimation and the appropriate countermeasure by using the case data effectively. In the proposed system, many cases of damage are stored through the data sharing. Thus, by providing the service of the search for similar cases to the observed data, it is expected that the proposed system enables any users to estimate the cost of countermeasure and make an appropriate decision regardless of the ability and experience.

3.2. Damage Assessment

It is impossible to identify the damage level perfectly by evaluating with the system. This is because the mechanism of the occurrence and progression of damage has not been clarified yet. Furthermore, the evaluation criterion is not unique because the current damage assessment is performed based on the subjective view of various engineers. Hence, the final judgment is usually done by the engineer’s experience despite the guideline for the assessment.

In order to overcome these circumstances, the damage assessment in the proposed system attempts to output the information useful for the decision-making. By providing a similar case data from the

database and improving the reliability of identification result, the proposed system promotes a user to make an appropriate decision. For example, the proposed system outputs the information useful to verify the difficulty of the identification of damage level toward the input data. Then, a user reviews the necessity of the additional inspection by the human. In this way, the proposed system can improve the reliability and practical utility of the identification result. In addition, by the numerical simulation that takes into account the judgment of assessment, it is expected that a user can estimate the effect of decision.

3.3. Maintenance Planning

In Japan, the extension of the service life of bridges is effective to reduce the life-cycle cost. Thus, a long term planning is useful for the reduction and estimation of cost in the actual maintenance activity. However, the modification of schedule is required in response to the change of circumstances due to the uncertainties such as the deterioration prediction and the economic situation. The rescheduling is effective for the reduction of cost but the large modification loses the effectiveness of long-term estimation. For these reasons, it is necessary to review the practical utility of the long-term plan.

In the proposed system, a long-term plan is formulated in consideration of the period in which the execution year of maintenance can be changed without the increase of cost and the loss of the safety of bridges. This flexible period in the schedule is estimated based on the preventive maintenance. Thus, the formulated plan by the proposed system is effective for the guarantee of safety level and the cost saving. In addition, it is expected that the plan that can modify the schedule within the estimated flexible period is useful for the change of schedule in response to the annual budget and the condition of bridges.

4. CONCLUSIONS

In this study, an attempt was made to propose a useful system for the actual bridge management. By using the technology of cloud computing, the proposed system enables any local governments to receive the support for the maintenance activity reasonably. In this paper, the applicability and effectiveness of the proposed system were discussed by describing the application ways in practical maintenance works.

In Japan, the establishment of the sustainable bridge management is the one of the problem that has to be addressed. In order to solve this problem, it is necessary to coordinate humans with the support system. Therefore, the proposed system aimed to interact with users by assisting them in the process of actual bridge management. In the future work, several investigations through the practical use in local governments are presented to demonstrate the effectiveness of the proposed system.

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