

EFFECTIVENESS OF PARKING GUIDANCE AND INFORMATION SYSTEM CONSIDERING DRIVER'S SEARCHING BEHAVIOUR TO AVAILABLE CAR PARKS

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Abstract: There has been various experience of PGI system installation in urban areas in developed countries. However, there is few consideration in relation to searching behaviour to available car parks based on observation survey, although decrease of such additional traffic is one of the important roles of the PGI system. The purpose of this study is to identify the driver's searching behaviour in order to evaluate the effects of PGI system introduction.

1. INTRODUCTION

Parking management system consists of several tactics such as enforcement of regulation, control of parking fees, improvement of parking operations, and introduction of parking guidance and information (PGI) system. Among these tactics, PGI system has a possibility to play a more important role to amend the parking environment, because the system will be integrated in the near future as one of the parts of intelligent transport system (ITS).

Despite a number of PGI systems currently in operation, there have been few reported studies outlining their effects and driver reactions. Tsukaguchi and Jung (1989) analyzed the effects of provision of parking information on Osaka CBD before the introduction of the PGI system, when the information was given by written materials. As PGI systems have been introduced into a lot of cities mainly in Japan in these days, Tsukaguchi and Jung (1990), Thompson (1993), Iida *et al.* (1995), Asakura *et al.* (1995), Thompson *et al.* (1995), Muromachi *et al.* (1995), and Tsukaguchi *et al.* (1996) studied the effects of PGI system. Dogaki *et al.* (1993) studied searching behaviour, however, the analysis was not based on a survey to find out driver's practical searching behaviour.

In general, drivers would choose a car park considering the factors which include:

- 1) distance from a car park to a destination;
- 2) parking fee;
- 3) congestion of a car park,
- 4) structure of a car park; and
- 5) road congestion to a car park,

if they would obtain sufficient information for their decision making. However, drivers do not have correct information at least on the factors 3) and 5) which change every moment based on traffic and parking demand, when there is no parking guidance and information system available to them. Therefore, some drivers have to look for other car parks after they have once reached their most preferred car park which was occupied at that time. This

situation not only compels them to make additional trips, but also makes traffic congestion severer.

One of the objectives of PGI systems is to reduce such unnecessary wandering behaviour of drivers to look for available car parks. An analysis on characteristics of driver's wandering behaviour to search available car parks may provide one of useful measures to assess the effect of installation of PGI systems.

The objectives of the study include:

- 1) to make clear how many searching trips exist when a PGI system does not operate and how many searching trips can be decreased by installation of a PGI system; and
- 2) based on the above analysis, to assess the effect of installation of PGI systems.

2. METHODOLOGY

2.1 Definition of Driver's Searching Behaviour

Surveys conducted before and after installation of a PGI system make it possible to understand drivers' searching behaviour to available car parks. The survey items to drivers are as follows:

- (a) a route which a driver used from an entrance point of the study area shown on a map delivered to subjects, to a car park where he/she parked in practice;
- (b) time when the driver reached the practically used car park, and time when the driver dropped in another car park which could not be used, if that existed; and
- (c) reasons the driver chose the most preferred car park, and those the driver changed his/her parking location, if the behaviour existed.

In addition to these, in order to know operating condition of all car parks participated in the PGI system at any time of the survey day, the following two surveys are performed:

- (d) waiting time and queue length observation in front of car parks; and
- (e) an analysis of parking cards that drivers used when paying parking fee.

Generally, based on these surveys, drivers' parking location choice patterns can be classified into the following three categories:

- Category 1 The most preferred car park is chosen without any wandering, which includes the case with or without waiting for entering into the car park;
- Category 2 The most preferred car park is abandoned before a driver reaches there, mainly because of the severe road traffic congestion; and
- Category 3 After once reaching the most preferred car park, he/she changes to another car park because the most preferred one is occupied.

Strictly speaking, Category 3 and a part of Category 2 include searching behaviour to available car parks, however, since it is difficult to distinguish wandering behaviour in Category 2, this paper focuses on the Category 3 at the following sections.

2.2 Data Collection

A series of surveys have been performed in the central area of Ibaraki City located in the northern part of Osaka Prefecture, Japan, where a PGI system has been implemented. The operating area of the PGI system is found in Figure 1. Drivers who used the car parks included in the PGI system were asked to answer the questions in relation to the items (a), (b), and (c) described in section 2.1. In addition to these, observation surveys related to the items (d) and (e) in section 2.1 have been conducted at the same time. The first wave of the

survey was done in May 1994 to investigate the condition before implementation, and the second wave of the survey was done in February 1995 to investigate the condition after implementation. The subjects in the second wave were chosen from respondents in the first wave and preparatory survey performed in 1992. The effective sample size of the two waves are 1060 and 1056 respectively.

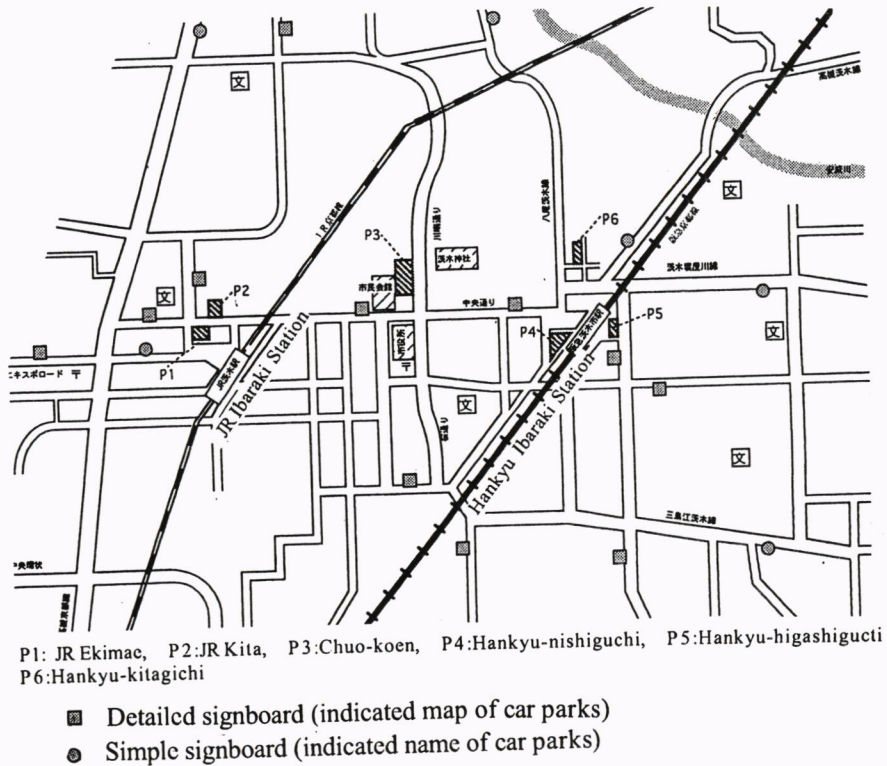


Figure 1. Area of Ibaraki PGI system

3. CHARACTERISTICS OF SEARCHING BEHAVIOUR

3.1 Outline of Ibaraki PGI System

The Ibaraki PGI system has been pre-installed in June 1994 and it has been expanded in December 1994. The car parks including in the system are six municipal car parks and one car park managed by private sector. The parking fees are the same for all municipal car parks, e.g. 100 yen per 30 minutes at that time. Since the capacity of the car park managed by private sector is small, this study focuses on the municipal car parks in the following chapter. There are more than fifty cities which have PGI systems in Japan. Among these PGI systems, Ibaraki PGI system is a medium size one in terms of the operational area and number of signboards. The full system is composed of 6 map type detailed signboards which inform drivers of conditions of a few surrounding car parks and 11 area-wide but simple signboards. The locations of signboards are also found in Figure 1.

3.2 Characteristics of Searching Behaviour

3.2.1 Procedures to Identify Searching Behaviour

Based on the survey described in chapter 2, this study identifies the searching behaviour by the following steps include:

Step 1: Based on the survey items (a), drivers who have possibility to be included in Category 3 are identified.

Step 2: Among these drivers, if they have either of the following characteristics, then they are classified into Category 3.

- (1) the reason why they have changed car parks is "the most preferred car park was occupied",
- (2) even if they do not point out "occupied" for the reason, the result of survey item (d) indicates that a car park was "occupied" at the time when the driver reached the car park.

3.2.2 Difference of Searching Behaviour before and after PGI System Installation

The searching trips obtained through the above procedure are found in Figures 2 and 3 for before and after implementation respectively. Based on the two figures, rates of searching behaviour are summarized in Table 1.

Table 1. Percentages of wanderings before and after PGI implementation (%)

	Weekday		Holiday		Total	
	before	after	before	after	before	after
JR-ekimae	1.2 (1)	1.7 (1)	3.8 (4)	3.7 (2)	2.6 (5)	2.7 (3)
JR-kita	5.7 (1)	3.8 (1)	19.0 (8)	13.6 (3)	13.0 (9)	8.3 (4)
Chuo-koen	4.5 (8)	3.2 (5)	8.3 (11)	0.9 (1)	6.1 (19)	2.2 (6)
Hankyu-nishiguchi	2.5 (3)	0.9 (1)	2.8 (3)	1.9 (2)	2.7 (6)	1.4 (3)
Hankyu-higashiguchi	5.9 (3)	1.7 (1)	5.6 (9)	3.5 (2)	5.7 (12)	2.6 (3)
Hankyu-kitaguchi	4.8 (1)	3.8 (1)	4.2 (1)	0.0 (0)	4.4 (2)	2.4 (1)
Total	3.7 (17)	2.3 (10)	6.3 (36)	2.7 (10)	5.1 (54)	2.5 (20)

Note: Observed trips are shown within parenthesis

Findings in Table 1 include:

- (1) The percentage of wandering trips before the PGI system implementation is 5.1 %, whereas that decreases to 2.5 % after the implementation. Comparison between the percentages of searching trips before and after the implementation makes clear that the system has an important role to decrease such behaviour.
- (2) The wandering trips in holidays are larger than those in working days before PGI system implementation, while their percentages are all most the same after implementation of the system.
- (3) Comparing the six car parks, the percentage of searching behaviour in JR Kita is larger than other car parks. That may be because that this relatively small car park is located in a inconvenient place, and so the car park is likely to be the second choice when more convenient car parks are occupied.

3.2.3 Attributes of Wandering Drivers

This study investigates the attributes of drivers who are likely to do wandering behaviour. Table 2 shows that the characteristics of the drivers. First, female drivers are more likely to wander than male drivers. The feature is very clear in holidays before the PGI system

Effectiveness of Parking Guidance and Information System Considering Driver's Searching Behaviour to Available Car Parks

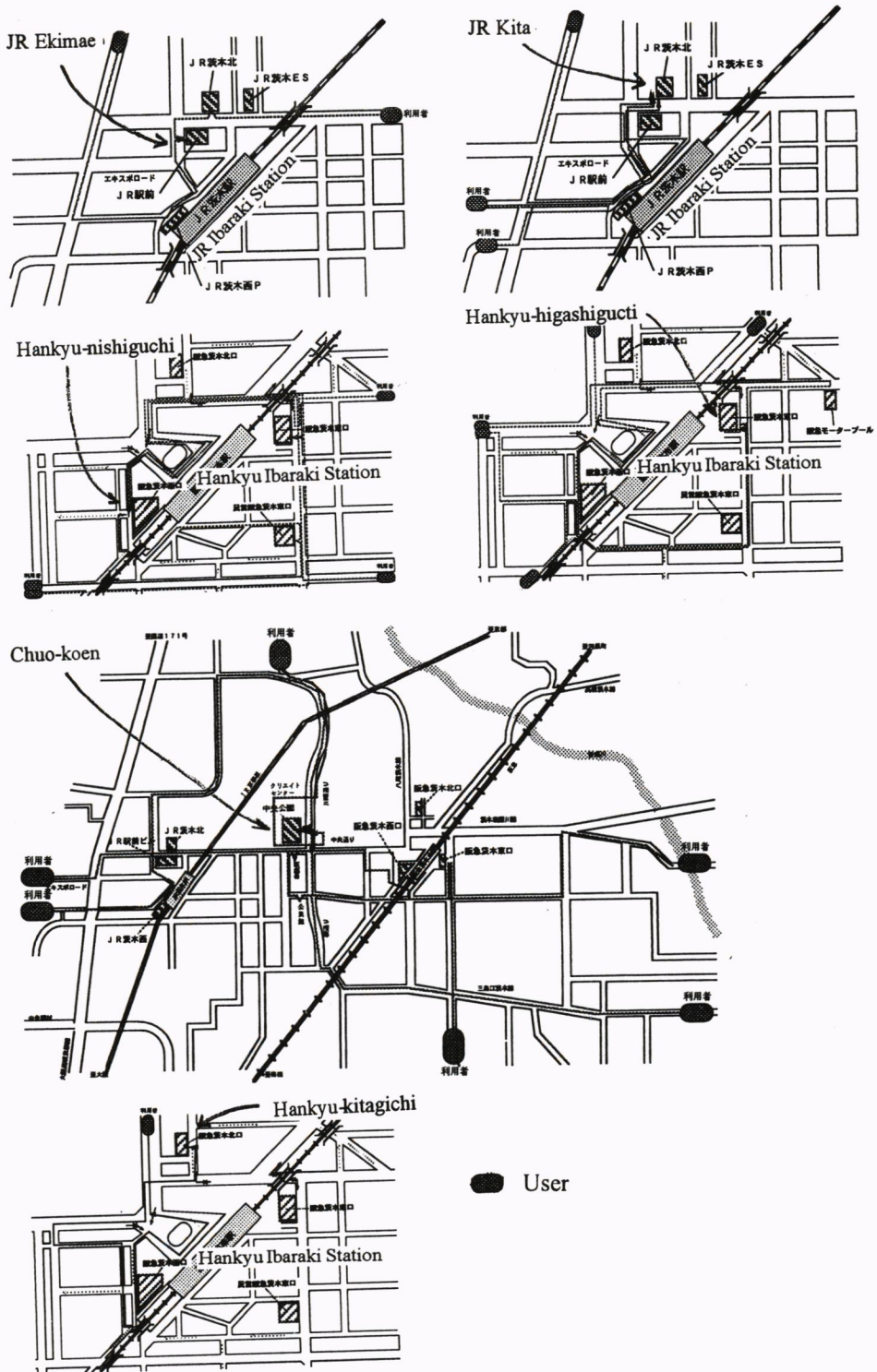


Figure 2. Searching Trip Patterns before PGI Implementation

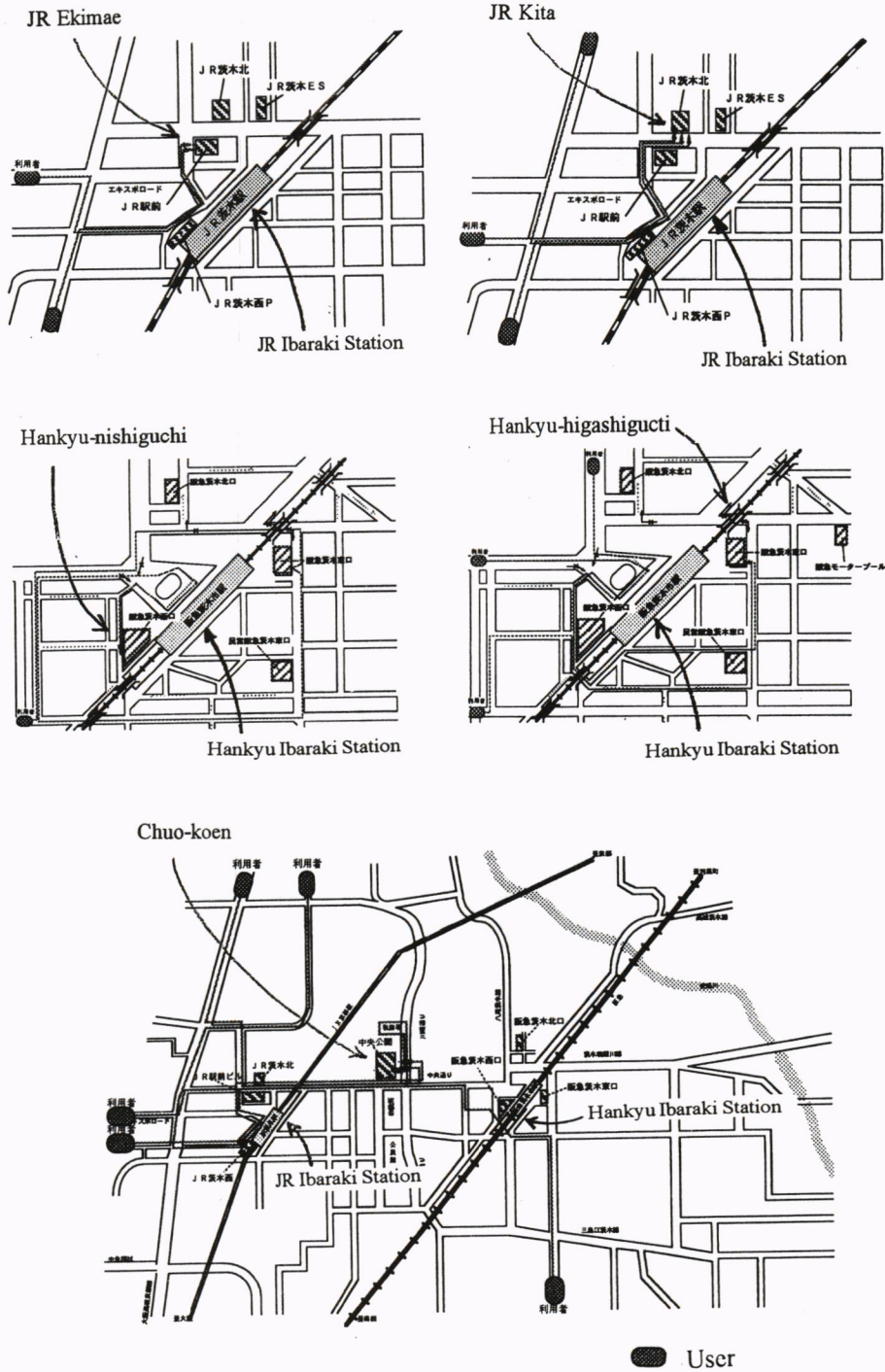


Figure 3. Searching Trip Patterns after PGI Implementation

implementation. If we consider subject's occupation, it can be seen that the percentage of housewives in wandering trips before the implementation is large, comparing with the percentage in total trips. Secondly, as to age, the age bracket of 30s years old is more likely to wander than other age brackets before the implementation. Thirdly, after installation of the system, such characteristics described above cannot be seen. Therefore, the Ibaraki PGI system seems to have been more effective to these drivers described above.

Table 2. Percentages of sex and age of wandering drivers before and after implementation (%)

Sex	Weekday		Holiday		Total	
	before	after	before	after	before	after
Male	52.9	54.2	50.0	73.9	50.9	63.8
Female	47.1	45.8	50.0	26.1	49.1	36.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Age	Weekday		Holiday		Total	
	before	after	before	after	before	after
under 20	0.0	0.0	2.8	0.0	1.9	0.0
20 - 30	17.6	8.3	22.2	34.8	20.8	21.3
30 - 40	41.2	33.3	33.3	21.7	35.8	27.7
40 - 50	11.8	29.2	30.6	17.4	24.5	23.4
50 - 60	17.6	20.8	11.1	26.1	13.2	23.4
over 60	11.8	8.3	0.0	0.0	3.8	4.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

4. SIMULATION APPROACH TO ESTIMATE SEARCHING BEHAVIOUR

4.1 Objectives of Simulation Approach

A simulation model including parking location choice sub-models and car park performance sub-models is developed. The purpose of the simulation approach is to make sure of the mechanism of searching behaviour from a viewpoint of providing information on congestion of car parks.

First, parking location choice models have been developed. The parking location choice models developed in this study focus on Hankyu Ibaraki and Chouo Koen areas where Hankyu-nishiguchi, Hankyu-higashiguchi, Hankyu-kitaguchi, and Chuo-koen car parks. Since the parking fees of the car parks are the same, explanatory variables are the distances from a car park to a destination, e.g. walking distance and distance from a previously mentioned entrance point of the study area to a car park, and available car park information in the case of model A) or waiting time to enter a car park in the case of model B). Alternative car parks for major destination are two or three for a destination in the case of the above mentioned area, and also routes from the entrance point to the specific car parks are limited to a few, the study regards a pair of a car park and the route to the car park as an alternative to users. Significant logit models are developed for the seven entrance points.

Secondly a simulation model, which consists of above mentioned parking location choice sub-models and car park performance sub-models, makes it possible to estimate driver's searching behaviour. Users obtain available car parks information in the case of model A) and a waiting time information in the case of model B). As to determination of searching and waiting behaviour, this study uses the maximum waiting length in front of the car parks

provided by the survey item (d) described in section 2.1. The outline of the simulation model developed for the above purpose is found in Figure 4.

4.2 Searching Behaviour Estimated by Simulation Analysis

The simulation model estimates that the percentage of wandering trips is 7.7 % for model A) and 4.4% in the case of model B) after the PGI system implementation. And also when drivers obtained no information on the congestion of car parks, the wandering percentage is 15.0 % in the simulation analysis. The rates are larger than the values obtained based on the survey. It can be suggested that there are searching trips in practice classified into category B that are not considered in chapter 3. In addition to this, other factors except for congestion of car parks such as easiness to enter them, road congestion in the way to them may affect parking location choice behaviour, which are not considered directly in this study.

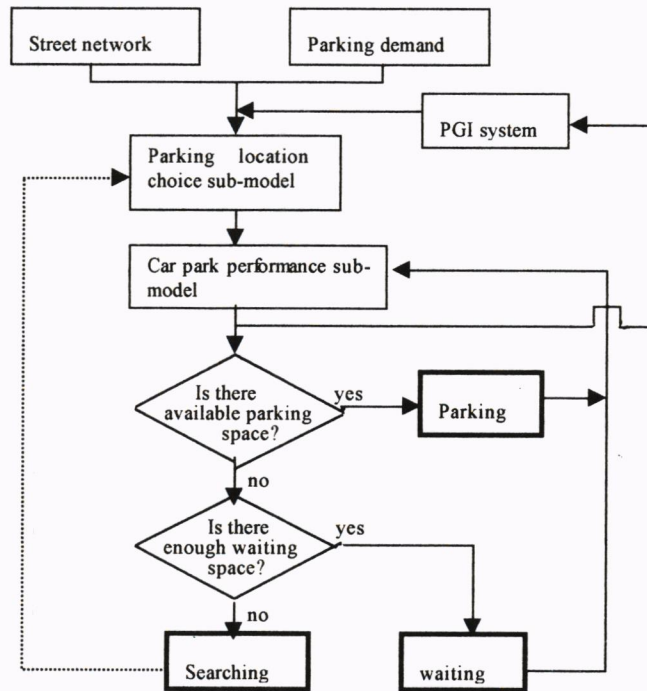


Figure 4. Conceptual diagram of the simulation approach

5. CONCLUSION

This paper has described searching behaviour to available car parks before and after PGI system installation.

The route analysis of drivers who used the car parks included in the Ibaraki PGI system clarifies that the percentage of the searching behaviour is about 5 % before introduction of the PGI system, and the rate decreases by one half after introducing the PGI system.

Consideration based on observation survey and simulation approach indicate that provision

of car park information has a significant role to decrease the percentage of searching behaviour.

ACKNOWLEDGEMENT

The authors appreciate Mr. Takeshi Yamaguchi (Graduate student of Ritsumeikan University at that time) for his contribution of data processing. Also, authors appreciate Professor Yasunori Iida, and Dr. Nobuhiro Uno of Kyoto University for their cooperation in the study.

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