How to Model Value-Creating Communication

Collaboration Process as an Example

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Abstract. The authors are conducting research on "Value-creating communication". Value-creating communication process is a process that people embody and clarify their own values and form new values through communication. Therefore, we analyze the collaboration process of interior coordination as an example of value-creating communication. First, we took notice of remarks and analyzed collaboration process qualitatively. Then, we revealed the characteristics of the internal value creation. Second, we modeled collaboration process using Bayesian network and examined the validity and usefulness of the constructed model. A feature of the Bayesian network is to predict the likelihood and possibility of occurrence of an uncertain event by expressing the causal structure as a network and then performing probabilistic reasoning. As a result, we found that the point which participants pay attention to is different in respective items. Furthermore, "conception" affected the choice of the item, and it was suggested that the share of "conception" is important to support collaboration process.

Keywords: Communication · Collaboration · Bayesian network

1 Introduction

The authors are conducting study on value-creating communication process. Value-creating communication process is a process that people embody and clarify their own values and form new values through communication. It is defined as value creation including not only creation of new ones but also refinement of ambiguous ones. Here, the value handled in this study refers to internal value.

In modern society, the focus is on how to make a rational decision, however in communication, participants are not necessarily rationally deciding solutions. Fujii points out the limit of optimization method in consensus building [1]. Optimization is to reasonably determine the solution so that the degree of satisfaction of people is high as average. Fujii cited as not having enough consistency for each person's preference as its problem. Kuwako is conducting field communication observations on social consensus formation [2]. In consensus building, not only the opinions of participants but also the history of reasons for opinions are important. And it is important that setting of the place considering Kansei of participants. From this also, participants are thought to

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have derived solutions that each person can convince, while sharing their opinions and history with each other through communication.

Therefore, in this paper, we analyze cooperative process of interior coordination as an example of value creation communication. First, we extract the characteristics of the process by conversation analysis. Next, we construct a model of value creation communication process using Bayesian network. Then, we investigate the validity and usefulness of the constructed model.

2 Observation and Analysis of Collaboration Process

We introduce the observation and analysis of the collaborative work process we conducted. See [3] for details.

2.1 Observation Method

The theme of collaborative work is "to create a layout of a common living room", and the subjects created a layout using an interior coordinate system [4]. The user can select a furniture such as a chair or desk and place it as many as desired in the space. Subjects were two pairs and observed the collaboration process of the five groups.

2.2 Features of Collaboration Process

In order to clarify the characteristics of the collaboration process, we visualized the process with the remarks of subjects as indicators. Subject's remarks on items were classified according to Table 1. "Conception" is a remark that includes intention and grounds, I think that the conception reflects the values of the members.

As a result of visualizing the process, it seems that the items and emphasis items differ depending on the item. In addition, the conception often appeared with other items. From this, it was suggested that the selection of items will change according to the conception determined.

Table 1. Reason classification table

Conception	Remarks including intention, grounds
Place	Remarks on impression of location and distance
Hotel	Remarks in accommodation type, bathing facilities, amenity
Surrounding Facilities	Remarks on facilities and incidental facilities around the accommodation
Cost	Remarks on accommodation expenses, usage fee of surrounding facilities, food expenses, transportation expenses
Transportation	Remarks on transportation means such as trains, buses, cars
Other	Remarks on conference rooms, services, etc.

2.3 Influence of Conception

Next, we examine the influence of the conception.

In Group II, the table initially agreed to the conception of "place to eat". But while comparing the tables, B said "I want to use this space as a study, not as a dining table." By this remark, the space where the desk is located was decided to study. By becoming a conception of "study space" they chose chairs those that are likely to be in the office, with casters. Regarding the storages as well, saying, "Because it's a study, let's make it a bookshelf," they decided "storage for placing books." In this way, Group II initially agreed on the conception of "place to eat", but as the table was compared, the conception was changed to "study space". And, according to that conception, it was observed that they chose chairs and storages.

3 Analysis and Discussion by Bayesian Network

3.1 Bayesian Network

The feature of the Bayesian network is to predict the likelihood and possibility of occurrence of an uncertain event by expressing the causal structure as a network and then performing probabilistic reasoning [5]. The Bayesian network is a network-like probabilistic model defined by three variables: random variable, conditional dependency between random variables, and conditional probability. According to Motomura [5], the Bayesian network uses random variables as nodes and expresses dependency relationships between variables as effective links. For example, the conditional dependency between random variables is denoted by, and the node (in this case) that comes before the link is called a child node, and the node under the link (in this case) is called the parent node. When there are multiple parent nodes, let be a set of parent nodes of child node. The dependence between and is quantitatively expressed by the following conditional probability.

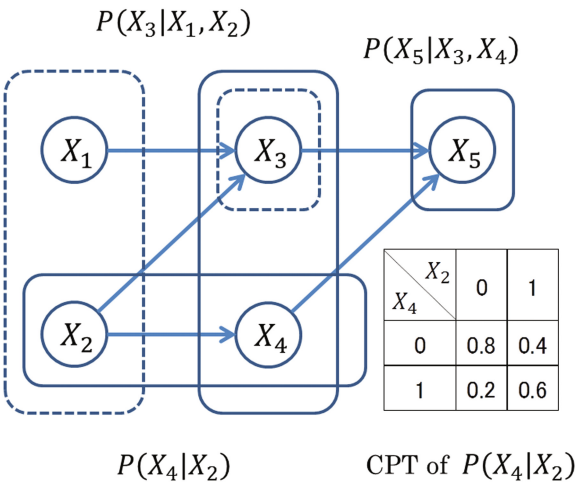
$$P(X_j|P_a(X_j))$$

Furthermore, considering each of the individual random variables as child nodes in the same way, the joint probability distribution of all the random variables is expressed by the following equation.

$$\mathrm{P}(X_1, \ldots, X_n) = P(X_1|P_a(X_1)) \cdot \ P(X_2|P_a(X_2)) \ldots \cdot P(X_n|P_a(X_n))$$

A probabilistic dependency between these variables can be modeled by a Bayesian network constructed by linking each child node and its parent node (Fig. 1). The probability distribution of all variables is obtained by calculating the previous joint probability distribution.

In this study, we use BAYONET [6] to construct a Bayesian network. BAYONET is a Bayesian network construction support system implemented by Java developed by Motomura et al. [7–9]. In this study, "reason" for "object" is a factor, "evaluation" is the result. We analyze by Bayesian network by expressing the remarks in the consensus building process as a causal structure.



X_4 \ X_2	0	1
0	0.8	0.4
1	0.2	0.6

Fig. 1. Bayesian network

3.2 Constructing a Bayesian Network Model

In this section, we construct a Bayesian network model. We construct the network using a node with "conception", "color", "size", "shape/design", "functionality", "material/image", "balance", "quantity/placement", "other" (Fig. 2). The state of "reason" is "A" if it is described for each item, and "None" if it is not stated. The state of "object" is one of "Wall Color", "Floor and Door Color", "Table", "Chair", "Sofa", "Law Table", "TV Lack" and "Storage". "Evaluation" status is "Positive" or "Negative". One sentence is one remark and the item of "reason" necessarily selects "A" or "None." However, since BAYONET has a function to complement missing values using a neural network [7], "choices", "evaluation" does not necessarily need to select a state and there may be a blank.

A part of the data used for the analysis is shown in Table 2. For example, the remark of number 1 in Table 2 is a classification of the remarks that "this low table is not good because legs are black (Color)". Therefore, we set "Object" is "Low Table", "Evaluation" is "Negative", "color" is "A", and other nodes are "None".

3.3 Analysis Focusing on Items that Each Group Places Importance on

Sensitivity analysis was performed using the constructed Bayesian network model. Sensitivity analysis is a method of quantitatively calculating the influence of each factor in a model where an event is generated from a plurality of factors. BAYONET has a sensitivity analysis tool, it can infer with the specified explanatory variable and search for explanatory variable with a large influence on the objective variable. In Sect. 2.2, we stated that items to be emphasized are different when selecting each item in the collaboration process. Therefore, we clarify by sensitivity analysis what "reason" which greatly influences "object". We analyzed the objective variable as "object",

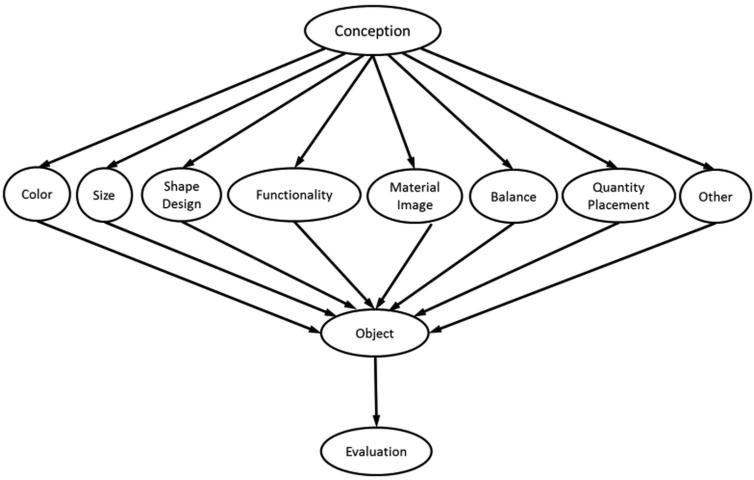


Fig. 2. Bayesian network model constructed

Table 2. Data used for analysis (partial excerpt)

Number	Item	Evaluation	Conception	Color	Size	Shape Design	Functionality	Material Image	Balance	Quantity Placement	Other
1	Low Table	Negative	None	A	None	None	None	None	None	None	None
2	Low Table	Positive	None	None	None	None	None	A	None	None	None
3	Low Table	Negative	None	A	None	None	None	None	None	None	None
4	Low Table	Negative	None	None	None	None	None	None	None	None	None
5	Low Table		None	None	None	A	None	None	None	None	None
6	Low Table	Positive	None	None	None	A	None	None	None	None	None
7	Low Table	Positive	A	None	None	A	None	None	None	None	None
8	Low Table	Positive	None	None	None	None	None	None	A	None	None

explanatory variable as “conception”, “color”, “size”, “shape/design”, “functionality”, “material/image”, “balance”, “quantity/placement”, “others”. In the sensitivity analysis, we make several pairs of values from explanatory variables and input them into the model to infer. Here, it is possible to specify the upper limit of the number of input values to the model, but in this study the maximum number of combinations is set to 2. This is because as can be seen from the remarks of “Because I want to eat (conception), a big desk is good”, not the conception which is an explanatory variable appears alone but the concept often appears together with other items.

For each items, a part of the result of sensitivity analysis is shown in Tables 3, 4. “Probability value” in Tables 3, 4 is the probability value (posterior probability) of the objective variable under the condition that the value of the explanatory variable is input. This indicates the probability that item is selected when a value of a specific explanatory variable is inputted. “Difference in probability” is the difference between the prior probability and the posterior probability for the objective variable. “Lift value” represents the ratio of the probability (certain posterior probability) of occurrence of a certain

Table 3. Sensitivity analysis result (Low Table)

Number	Conception	Color	Size	Shape Design	Functionality	Material Image	Balance	Quantity Placement	Other	Probability Value	Difference in Probability	Lift Value
1	A				A					0.313	0.175	2.257
2					A			None		0.308	0.169	2.219
3		None			A					0.306	0.167	2.200
4					A	None				0.300	0.161	2.157
5			None		A					0.283	0.144	2.037
6				None	A					0.278	0.140	2.004
7					A				None	0.278	0.139	2.000
8					A		None			0.277	0.138	1.996
9					A					0.271	0.133	1.954
10	None				A					0.262	0.123	1.883

Table 4. Sensitivity analysis result (Chair)

Number	Conception	Color	Size	Shape Design	Functionality	Material Image	Balance	Quantity Placement	Other	Probability Value	Difference in Probability	Lift Value
1						A		None		0.288	0.072	1.334
2		None				A				0.277	0.061	1.283
3					None	A				0.263	0.047	1.217
4			None			A				0.263	0.047	1.217
5						A			None	0.260	0.044	1.203
6						A	None			0.259	0.043	1.200
7				None		A				0.259	0.043	1.198
8						A				0.254	0.038	1.176
9	None					A				0.254	0.038	1.176
10	A					A				0.253	0.037	1.171

state when observation is input and the probability (prior probability) of occurrence of that condition irrespective of the condition. That is, the higher the lift value, the greater the influence of the selected "reason" set on "evaluation". The data in Tables 3, 4 are arranged in descending order of the lift value. In addition, the prior probability value of Low Table (Table 3) is 0.139, Chair (Table 4) is 0.216. According to Table 3, since "functionality" is located at the top of Low Table and the combination of "Conception" and "functionality" is also confirmed, it is found that they emphasized on the item "functionality" and considering "Concept". Equally, according to Table 4, in the chair, it is found that they emphasized on the item "material/image" and considering "Concept". From this, it is understood that the items to be emphasized are different according to each item, and the items associated with the "concept" also change.

3.4 Analysis Focused on the Influence of Conception

We analyze the influence of the conception described in Sect. 2.3. In Group II, in the process of choosing Table, the conception of "Let this space be a study" emerged, and this conception seems to influence the choice of Chair and Storage. Therefore, the process is divided before and after the conception "study" appears and we performed analysis by Bayesian network.

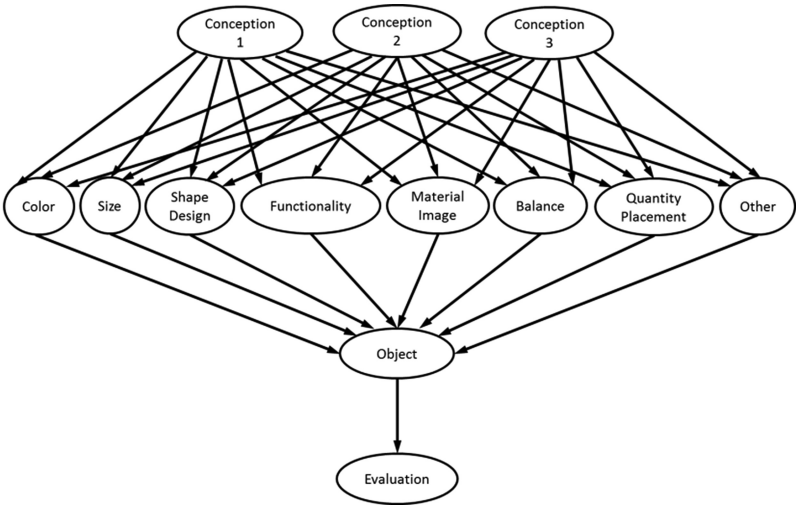


Fig. 3. Bayesian network model constructed (first half)

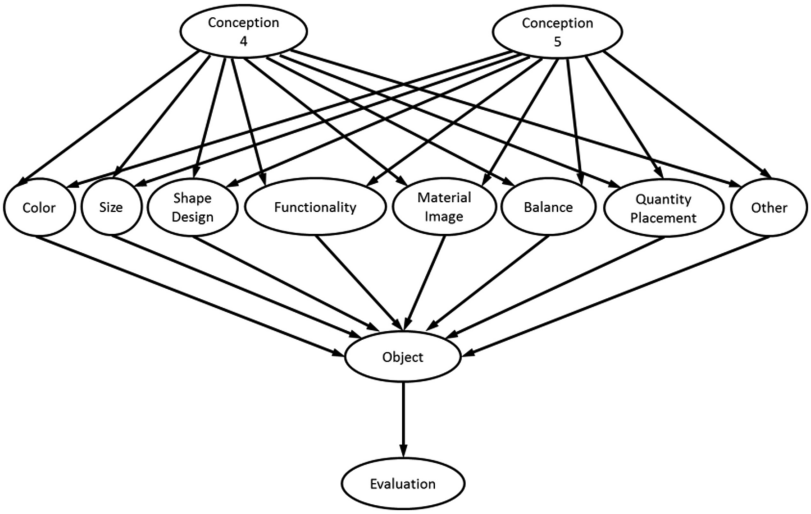


Fig. 4. Bayesian network model constructed (latter half)

The conceptions that appeared in Group II could be classified into five. "Conception 1" means "They want to sleep", "Conception 2" means "They want to put drinks such as tea", "Conception 3" is "Places to eat", "Conception 4" is "Study", "Conception 5" is "They want to place a fancy vase". Conceptions 1, 2, 3 appeared in the first half of the process, and conceptions 4, 5 appeared in the latter half. Also, the items determined in the first half are TV Rack, Sofa, Low Table, and the items determined in the latter half are Table, Chair and Storage. Figures 3 and 4 show the constructed Bayesian network model.

Table 5. Sensitivity analysis result of TV Rack (first half)

	Conception1	Conception2	Conception3	Color	Size	Shape Design	Functionality	Material Image	Balance	Quantity Placement	Other	Probability Value	Difference in Probability	Lift Value
1					None		A					0.359	0.160	1.800
2							A			None		0.320	0.120	1.603
3							A	None				0.306	0.107	1.535
4		A		None			A					0.303	0.103	1.517
5							A		None			0.296	0.096	1.482
6							A				None	0.293	0.093	1.466
7		None					A					0.291	0.091	1.457
8						None	A					0.289	0.089	1.446
9	None						A					0.288	0.089	1.445
10			None				A					0.284	0.084	1.421
11							A					0.281	0.081	1.408
12					None					A		0.257	0.058	1.289
13						A	A					0.250	0.051	1.255
14					A					None		0.240	0.040	1.201
15					A	None						0.239	0.039	1.195
16					A		None					0.235	0.036	1.178
17						None				A		0.234	0.034	1.172
18							None			A		0.232	0.033	1.164
19					A			None				0.232	0.032	1.162
20				None	A							0.230	0.030	1.152

Table 6. Sensitivity analysis result of Sofa (first half)

	Conception1	Conception2	Conception3	Color	Size	Shape Design	Functionality	Material Image	Balance	Quantity Placement	Other	Probability Value	Difference in Probability	Lift Value
1					None		None					0.230	0.044	1.238
2					None					None		0.222	0.037	1.199
3					None	None						0.221	0.035	1.189
4					None				None			0.214	0.029	1.154
5					None						None	0.213	0.027	1.146
6							None			None		0.212	0.027	1.143
7	None				None							0.211	0.025	1.135
8						None	None					0.210	0.025	1.133
9		None			None							0.210	0.025	1.132
10				None	None							0.210	0.024	1.131
11					None			None				0.210	0.024	1.129
12			None		None							0.209	0.023	1.126
13					None							0.209	0.023	1.123
14						None				None		0.205	0.020	1.107
15							None		None			0.205	0.019	1.104
16			A		None							0.204	0.018	1.099
17							None				None	0.203	0.018	1.096
18					None			A				0.202	0.016	1.089
19	None						None					0.202	0.016	1.086
20				None			None					0.202	0.016	1.086

The sensitivity analysis results in the first half are shown in Tables 5, 6 and 7, and the sensitivity analysis results in the second half are shown in Tables 8, 9 and 10. TV Rack, which was decided in the first half, emphasizes “functionality” and “Conception 2” is associated with “functionality”, and Sofa seems to have been decided without deciding which items to emphasize. The Low Table emphasizes “shape, design” and “size”, and it turns out that “Conception 1” and “Conception 3” are associated with “shape/design”. In the second half, they emphasize “size” in table, “color” and “shape/design” in chair, “quantity/ placement” and “functionality” in the storage. Also,

Table 7. Sensitivity analysis result of Low Table (first half)

	Conception1	Conception2	Conception3	Color	Size	Shape Design	Functionality	Material Image	Balance	Quantity Placement	Other	Probability Value	Difference in Probability	Lift Value
1						A	None					0.227	0.076	1.509
2						A				None		0.226	0.076	1.506
3						A		None				0.221	0.071	1.471
4					None	A						0.220	0.070	1.467
5				None		A						0.218	0.068	1.454
6						A					None	0.214	0.064	1.423
7	None					A						0.213	0.062	1.416
8						A			None			0.212	0.062	1.415
9		None				A						0.212	0.062	1.410
10			None			A						0.209	0.059	1.393
11						A						0.208	0.058	1.383
12					A	A						0.186	0.036	1.237
13			A			A						0.183	0.033	1.217
14	A					A						0.174	0.024	1.159
15					A					None		0.170	0.020	1.132
16					A		None					0.169	0.019	1.123
17					A			None				0.168	0.018	1.117
18				None	A							0.167	0.017	1.113
19					A				None			0.167	0.017	1.112
20					A						None	0.166	0.015	1.102

Table 8. Sensitivity analysis result of Table (latter half)

	Conception4	Conception5	Color	Size	Shape Design	Functionality	Material Image	Balance	Quantity Placement	Other	Probability Value	Difference in Probability	Lift Value
1				A					None		0.372	0.113	1.437
2				A		None					0.369	0.110	1.425
3				A	None						0.366	0.107	1.412
4		None		A							0.358	0.099	1.383
5			None	A							0.356	0.097	1.374
6					None				None		0.355	0.096	1.371
7				A			None				0.355	0.096	1.369
8	A					None					0.354	0.095	1.366
9	A			A							0.349	0.090	1.347
10						None			None		0.346	0.087	1.336
11				A				None			0.337	0.078	1.302
12				A						None	0.337	0.078	1.302
13				A							0.337	0.078	1.302
14			None						None		0.328	0.069	1.266
15	A								None		0.327	0.068	1.263
16	A				None						0.321	0.062	1.238
17							None		None		0.321	0.061	1.237
18	None			A							0.317	0.058	1.225
19					None	None					0.315	0.056	1.217
20		None							None		0.313	0.054	1.207

in table, “Size” appeared together with “Conception 4”. In chair, “Shape/Design” appeared together with “Conception4”. In storage, “Quantity/Location” and “Functionality” appeared together with “Conception 4”.

From this, it was possible to select the item at the beginning even if the conception and the items to be emphasized were not clarified. However, the “conception 4” appeared on the way and it affected the item selection. Thus, as the conception emerged, it turned out that items of other furniture were determined according to the conception.

Table 9. Sensitivity analysis result of Chair (latter half)

	Conception4	Conception5	Color	Size	Shape Design	Functionality	Material Image	Balance	Quantity Placement	Other	Probability Value	Difference in Probability	Lift Value
1			A						None		0.482	0.246	2.043
2			A		None						0.458	0.222	1.940
3					A				None		0.444	0.208	1.881
4			A			None					0.432	0.196	1.832
5			A				None				0.424	0.188	1.796
6			A	None							0.419	0.183	1.776
7		None	A								0.410	0.174	1.739
8			None		A						0.406	0.170	1.722
9			A					None			0.403	0.168	1.710
10			A							None	0.403	0.168	1.710
11			A								0.403	0.168	1.710
12	None		A								0.402	0.166	1.705
13					A		None				0.396	0.160	1.679
14					A	None					0.395	0.159	1.673
15				None	A						0.394	0.158	1.669
16		None			A						0.386	0.150	1.636
17					A			None			0.380	0.144	1.613
18					A					None	0.380	0.144	1.613
19					A						0.380	0.144	1.613
20	A				A						0.377	0.141	1.597

Table 10. Sensitivity analysis result of Storage (latter half)

	Conception4	Conception5	Color	Size	Shape Design	Functionality	Material Image	Balance	Quantity Placement	Other	Probability Value	Difference in Probability	Lift Value
1					None				A		0.474	0.181	1.619
2			None						A		0.451	0.158	1.540
3							None		A		0.437	0.145	1.495
4						None			A		0.435	0.143	1.488
5				None					A		0.434	0.142	1.485
6		None							A		0.424	0.132	1.450
7								None	A		0.418	0.125	1.429
8									A	None	0.418	0.125	1.429
9									A		0.418	0.125	1.429
10	None								A		0.414	0.122	1.416
11	A								A		0.406	0.113	1.386
12				None		A					0.388	0.095	1.325
13			None			A					0.384	0.091	1.312
14					None	A					0.382	0.090	1.307
15						A	None				0.381	0.089	1.304
16						A			None		0.381	0.088	1.301
17		None				A					0.377	0.084	1.289
18	A					A					0.373	0.080	1.274
19						A		None			0.366	0.073	1.251
20						A				None	0.366	0.073	1.251

4 Summary

In this paper, as an example of “value-creating communication”, collaboration process of interior coordination was taken up and analysis of value creation process by communication was conducted. As a result, it was found that in the collaborative work of

interior coordination, the items which are important to each items are different. In addition, it was suggested that "Conception" influences selection of items, and sharing "conception" facilitates collaboration process.

In the future, we also analyze interior coordination of other subjects and clarify the tendency of collaboration process. We also analyze the value-creating communication process for participants who have various attributes and backgrounds, such as when they are in a hierarchical relationship or conflict relationship, or in a dialogue between experts and non-experts.

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