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Description and organization of comprehensive management operation and maintenance information particle swarm based on cobie standard

Songtao Lu[1,3], Li Ten[2,3], Li Zhou[3,4]

Abstract. BIM technology is important technology innovation in comprehensive industry and efficiency and level of facility management will be greatly improved by applying BIM technology to comprehensive management. According to requirements of comprehensive management operation and maintenance informatization management, firstly, the conception of comprehensive management operation and maintenance informatization management based on BIM-CoBie technology is proposed by combining BIM technology with Cobie and particle swarm algorithm., Based on analyzing current situation of comprehensive management and BIM technology application in China, the comprehensive management operation and maintenance informatization management mode based on BIM-CoBie technology is put forward so as to establish theoretical frame of comprehensive management operation and maintenance informatization management system based on BIM-CoBie technology. Secondly, in order to further improve performance of PSO algorithm in model solution process, self-adaptive learning will be implemented to relevant parameters of PSO algorithm by utilizing automatic contraction and expansion to improve convergence of algorithm. Finally, feasibility of the system is verified by experiment, which provides reference to promote comprehensive management operation and maintenance informatization management and improve comprehensive management level.

Key words. CoBie standard, BIM technology, Operation and maintenance information, Particle swarm.

[1]Department Of Civil Engineering, Shanghai University, Shanghai, China, 200444
[2]Shanghai Underground Space Design and Research Institute, Shanghai, China, 200444
[3]Shanghai University-Shanghai Urban Construction Industrialization Research Center, Shanghai, China, 200444
[4]Sydney Business College,Shanghai University, Shanghai, China, 201800

1. Introduction

Comprehensive management operation and maintenance information is the basis to realize comprehensive scientific management. The key problem of facility management is how to store information generated in all stages of whole life circle and share information with various formats. Comprehensive engineering project is characterized by large scale, numerous participants, long construction period and numerous function targets, etc. and data information generated by all-party participants is characterized by complex structure and various formats and application demands to data information are different in different stages, which leads to numerous information loss during comprehensive information transfer process in all stages. BIM model contains rich data information and integration management thoughts, which provids corresponding information resource and technical platform for comprehensive scientific management.

Application of BIM technology in comprehensive management mainly focuses on establishment of BIM model information, classification and extraction of information and sharing and application of information, of which main problems to be solved are as follows: (1) insufficient compatibility and sharing degree of BIM model information. At present, BIM technology is mainly applied to design and construction stage and based on three-dimension modeling, different professional software is required for support according to different function requirements. Different development platforms and document transmission agreements of professional software lead to information loss and information error, etc. during transmission, which has influenced information sharing and application contained in model. (2) Storage scheme of BIM model information lacking integration. At present, main BIM information storage mode is based on central data storage in IFC agreement and sharing and exchange modes of data stored in the mode shall be subject to IFC agreement, that is to say that information interaction cannot be realized if information format or transmission interface does not conform to requirements. (3) Effective classification, extraction and application to BIM model information are still key points to promote BIM technology according to use requirements. Transmission of BIM information mainly depends on input and output conversion by professional BIM modeling software plug-in, but data extracted by plug-in are comprehensive and integrated, which can not be applied directly and definition, classification and integration to BIM model information shall be implemented according to expected target.

Therefore, this paper combines BIM technology with CoBie standard and has researched classification, assignment, extraction and comprehensive application of BIM model information according to requirements of comprehensive maintenance and management. By combining with particle swarm algorithm, conception of comprehensive management operation and maintenance informatization management based on BIM-CoBie technology is proposed. Based on analyzing current situation of comprehensive management and BIM technology application in China, the comprehensive management operation and maintenance informatization management mode based on BIM-CoBie technology is put forward so as to establish theoretical

frame of comprehensive management operation and maintenance informatization management system based on BIM-CoBie technology.

2. BIM model information extraction by CoBie Plug-in

2.1. Connotation of CoBie

CoBie (Construction Operations Building information exchange) is the international standard for transmission and management of comprehensive management operation and maintenance information. CoBie is a kind of standard method, which integrates, stores and shares relevant comprehensive document information obtained with data materials and realizes exchange among different comprehensive stakeholders by IFC and other formats. It specifies acquisition and exchange technology, exchange standard and exchange process for information from design to operation and maintenance stages. Formation process of CoBie data information is shown in Fig.1. All-party project participants in comprehensive whole life circle can input comprehensive information in all stages for use of later managers, so as to support asset operation, maintenance and management of the Employer or managers. Use of CoBie is very helpful to establish a set of efficient and intelligent comprehensive management mechanism.

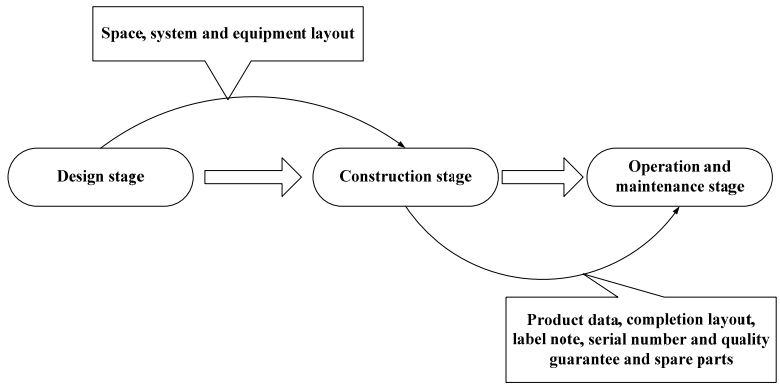

Fig. 1. CoBie process

2.2. Data characteristics and advantages of CoBie

CoBie data information can provide three-kind of data formats: IFC, ifcXML, SpreadsheetML from planning stage of comprehensive project until operation and maintenance stage and CoBie data can acquire data and realize recycling and sharing of BIM information in the whole project life cycle according to organization structure mode.

CoBie includes three kinds of comprehensive management, operation and maintenance information. The first is comprehensive operation and maintenance informa-

tion established by designer, as shown in blue box in Fig.3; the second is information established by the Contractor, as shown in purple box in Fig.3; the third is information supporting design and construction, namely common part of both parties, as shown in yellow box in Fig. 2.

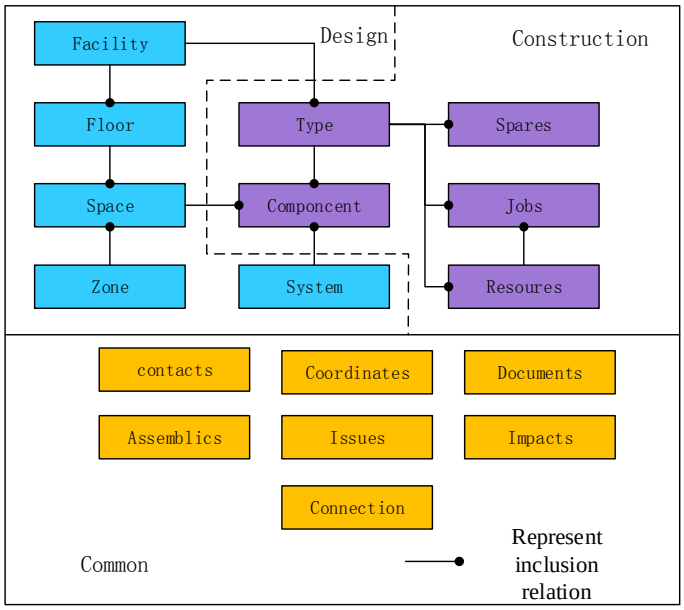

Fig. 2. CoBie organization and structure

Establishment of CoBie data runs through the whole life cycle of project and has unique advantages for comprehensive management: (1) CoBie data run through the whole life cycle of project and comprehensive management, operation and maintenance information is completed continuously in each stage. (2) Space area division of CoBie data to comprehensive project is more detailed and reasonable. Space division of a BIM model to comprehensive space is realized by axis net and elevation and each space is independent without correlation and interaction; however, CoBie concludes and integrates same-attribute small spaces, which are divided into Zone, Floor, Room, of which integration is more beneficial for managers to search and locate a comprehensive project and to clear correlation and interaction among same-attribute small spaces. (3) CoBie data have provided description to comprehensive spares, resources and documents, etc. Any specific component can be known or located accurately and quickly by definition to all indexes in table. If only depending on BIM model, components can only be defined by establishing family and the component information is not complete. As a kind of information transmission method and international standard, CoBie does not exist aiming at certain specific software, but solves different data interfaces among different application software effectively according to information material exchange mechanism established by comprehensive operation and maintenance function and following certain sharing standard.

3. Improved particle swarm algorithm based on automatic contraction and expansion of factors

3.1. Basic particle swarm algorithm

In PSO algorithm calculation, random initialization is implemented to particle swarm and solution of the optimal solution is realized by evolution process from a group of random candidate solutions. In solution process of PSO algorithm, each particle realizes its own foraging position update by tracking two extremum particles, which are respectively current optimal solution of PSO algorithm swarm *pbest* and historical optimal value of current particle *gbest*; specific model of PSO algorithm is as follows [14∼15]:

It is assumed that real-time evolution position of particle $i$in PSO algorithm is X_i=(X_{i1}, X_{i2}, ..., X_{in}); real-time velocity of particle $i$in PSO algorithm is V_i=(V_{i1}, V_{i2}, ..., V_{in}); optimal position in historical evolution process of particle i in PSO algorithm is $P_i(t)$=(P_{i1}, P_{i2}, ..., P_{in}), that is to say the optimal position of particle i in PSO algorithm and the optimal position of particle individual. For the minimal solution of model, the smaller the target is, the optimal the position that the particle represents is. Then, the optimal particle position in current PSO algorithm is $P_g(t)$=(P_g1, P_{g2}, ..., P_{gn}), which is also called as overall optimal adaptive value (position) of PSO algorithm swarm. Then, standard particle swarm evolution model is:

$$\begin{aligned} &V_{ij}\,(t+1) = V_{ij}\,(t) + c_1 r_{1j}\,(t) \\ &(P_{ij}\,(t) - X_{ij}\,(t) + c_2 r_{2j}\,(t)\,(P_{gj}\,(t) - X_{ij}\,(t))\,. \end{aligned} \tag{1}$$

$$X_{ij}(t+1) = X_{ij}(t) + V_{ij}(t+1)\,. \tag{2}$$

Where, subscript "j" in parameter represents particle with dimension j in particle swarm; similarly, subscript t is algebra of particle swarm evolution; "i" is particle i in particle swarm; c_1 and c_2 are acceleration constant of particle swarm algorithm and value interval is 0∼2. Random function $r_1 \sim \bigcup(0,1)$ and $r_2 \sim \bigcup(0,1)$ meet mutual independence.

According to particle evolution model in formula (1)∼(2), there are two parameters $c_1$and$c_2$in model; function of the former is to adjust evolution direction of particle in algorithm, so that it will evolve toward the optimal position; the latter is also to adjust evolution direction of particle in algorithm, so that it will always evolve to the optimal overall position. To prevent particle of PSO algorithm from deviating from value interval in evolution process, value interval to V_{ij} is generally set; namely, setting interval $V_{ij} \in [-V_{\max}, V_{\max}]$. If value interval of comprehensive management problem is $[-V_{\max}, V_{\max}]$, then $V_{\max} = k \cdot X_{\max}$, where, $0.1 \le k \le 1.0$. Therefore, initialization of PSO algorithm can be implemented according to the following steps:

Step 1: swarm scale size parameter of particle swarm optimization is N;

Step 2: for particles with subscripts i and j in swarm, swarm individual x_{ij} is selected in interval $[-X_{\max}, X_{\max}]$ by utilizing even distribution function;

Step 3: for particles with subscripts i and j in swarm, swarm individual y_{ij} is selected in interval $[-X_{\max}, X_{\max}]$ by utilizing even distribution function;

Step 4: for particle with subscripts i in swarm, relation is set as $y_i = x_i$.

Calculation process of standard particle swarm algorithm is:

Step 1: according to initialization steps of foresaid particle swarm algorithm, initialization is implemented to velocity and position information of particle swarm algorithm;

Step 2: adaptive value calculation is implemented to all particles in particle swarm algorithm;

Step 3: for all particles in particle swarm algorithm, by comparing all historical optimal positions P_i with current adaptive value, if adaptive value of current position is better, it will be taken as optimal position of current particle;

Step 4: for all particles in particle swarm algorithm, by comparing all overall optimal positions P_g with current adaptive value, if adaptive value of current position is better, it will be taken as optimal position of current particle;

Step 5: according to evolution model of standard particle swarm algorithm, position and velocity model of particle swarm algorithm are updated;

Step 6: if algorithm evolution process of particle algorithm fails to reach preset termination condition, it will shift to step 2 for algorithm evolution.

3.2. Automatic contraction and expansion and improvement of factors

Main problem of particle swarm algorithm in convergence process is premature convergence and to effectively avoid such premature convergence, automatic contraction and expansion process of factors is introduced to particle swarm algorithm; by expansion and attraction of factors, particle swarm individual presents diversity characteristics and has better convergence rate. Improvement velocity evolution model of automatic contraction and expansion particle swarm algorithm of factors extracted is as follows:

$$\begin{aligned} V_i(t+1) = \chi(V_i(t) + dir(c_1 r_1(P_i - X_i(t) \\ + c_2 r_2(P_g - X_i(t)))). \end{aligned} \tag{3}$$

Where:

$$dir = \begin{cases} -1, if(dir > 0)\&(diversity < d_{low}) \\ 1, if(dir < 0)\&(diversity > d_{high}) \end{cases} \tag{4}$$

At the same time, model form to keep diversity of swarm is:

$$diversity(S) = \frac{1}{|S| \cdot |L|} \cdot \sum_{i=1}^{|S|} \sqrt{\sum_{j=1}^{N} (Pij - \overline{Pj})^2}. \tag{5}$$

Where, S is swarm of particle swarm algorithm for evolution and $|S|$ is the quantity of the evolution swarm individuals and $|L|$ is the maximal interval radius of particle swarm searching interval and N is dimension of particle swarm evolution process and P_{ij} is component j of particle i. In particle swarm algorithm evolution, if diversity of swarm individuals meets condition $diversity(S) < d_{low}$, then, it can

be set that dir=-1; at that time, particle swarm evolution process terminates and particle operates away from the position gradually, which is called as "diffusion" process; at the same time, if diversity of particle swarm individuals increases and exceeds its upper limit, then, it can be set that dir=1; then, particle swarm evolution operates towards the optimal direction, which is called as "attraction" process. At the same time, value d_{low} is set as 5.0×10^{-6} and reference value d_{high} is 0.25; then:

$$\chi = \frac{2}{|2 - \ell - \sqrt{\ell^2 - 4\ell}|} . \tag{6}$$

Where, parameter $\ell = c_1 + c_2$, $\ell > 4$, parameter is set as $c_1 = c_2 = 2.05$, and $\ell = c_1 + c_2 = 4.1$ is substituted into formula (10), model result $\chi = 0.7298$ can be obtained and then the result is substituted to formula (7), then:

$$\begin{aligned} &V_i\,(t+1) = 0.7298(V_i\,(t) + \\ &dir(2.05r_1(P_i - X_i\,(t) + 2.05r_2(P_g - X_i\,(t)))) . \end{aligned} \tag{7}$$

Because of $2.05 \times 0.7298 = 1.4962$, parameters $c_1 = c_2 = 1.4962$ and $W = 0.7298$ used in the model and rate update model in standard PSO algorithm evolution process are equivalent to that in obtained model.

4. Experiment analysis

4.1. Experiment condition

The comprehensive project is seven-floor commercial accommodation, located in Nanjing and with stripe foundation, comprehensive gross area 6660.24 m2. Floor height is 3m and indoor and outdoor altitude difference is 0.6m. Designed service life is 70 years and roof waterproofing class is class 111 and durable years are 10 years and comprehensive fire-resistance class is class 111. Design sketch after modeling in Revit is shown in Fig. 3.

Fig. 3. Comprehensive model effect

To realize verification to analysis efficiency to comprehensive management process of improved particle swarm algorithm, hardware platform is selected as: CUP i5-

6500K, memory RAM 6G ddr4-2400K and operation platform of simulation system is Win7 flagship version. Comparison algorithm is selected as genetic algorithm and standard particle swarm algorithm.

It can be known from results in Fig. 4 that if the quantity of selected comprehensive management information samples increases from 6, 12, 54 to 410, analysis efficiency of comprehensive management information sample of genetic algorithm presents decrease trend in selected comparison algorithm, that is to say that the index presents inverse relation to the quantity of comprehensive management information samples. If sample quantity of comprehensive management information is 6, efficiency indexes of comparison algorithm and GA algorithm on foresaid three groups of comprehensive management problems are respectively 95.12%, 98.42% and 81.35%. If the quantity of comprehensive management information samples increases to 410, by comparing efficiency indexes of comparison algorithm and GA algorithm, efficiency indexes of comparison algorithm and GA algorithm on foresaid three groups of comprehensive management problems respectively have decreased to 60.48%, 58.21% and 53.68%. In addition, the experiment results show that efficiency index of selected comparison algorithm and genetic algorithm is always the lowest on selected different sample quantities among the three kinds of algorithms.

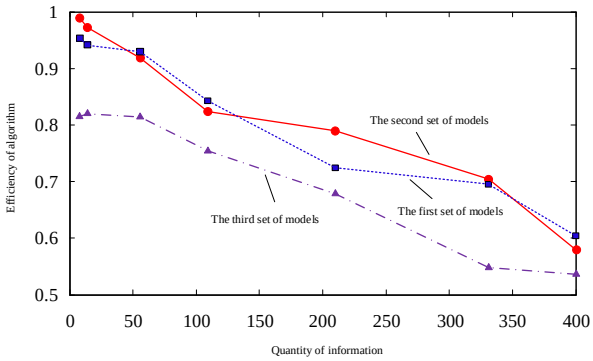

Fig. 4. Comparison of efficiency index

4.2. Experiment result of simulation data

Similarly, GA and PSO algorithms are selected for comparison and Fig. 5 shows adaptation evolution process of algorithm in this paper with GA and PSO algorithms with algorithm evolution process.

According to Fig. 5, compared with two kinds of comparison algorithms GA and PSO, algorithm in this paper is more outstanding in convergence velocity. At the same time, convergence fluctuation of overall extremum of algorithm in this paper is not large in later period of algorithm evolution. Seen from results in Fig.3, algorithm in this paper has more outstanding solution and is more accurate. Compared with GA and PSO algorithms, possibility of algorithm in this paper to be caught in local extremum is less.

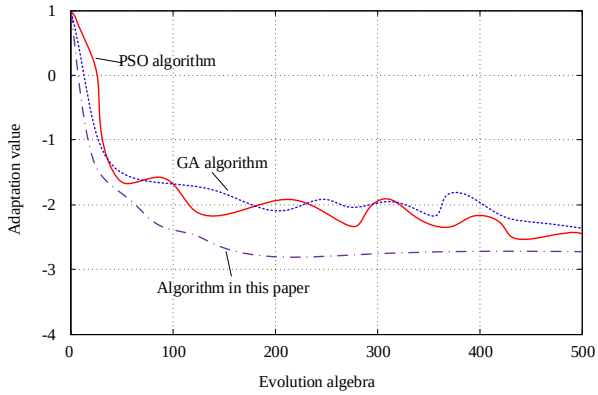

Fig. 5. Adaptation comparison curve

See Table 1 for the optimal calculation result of selected three kinds of comparison methods.

Table 1. Optimal solutions of all algorithms

Algorithms	GA	PSO	IAFS
1	0.165	0.155	0.161
2	0.123	0.144	0.140
3	0.052	0.142	0.131
4	0.065	0.039	0.049
5	0.121	0.143	0.098
6	0.194	0.027	0.062
7	0.007	0.117	0.122
8	0.065	0.031	0.046
9	0.140	0.011	0.017
10	0.060	0.184	0.169
Optimal solution	-0.241	-0.273	-0.293

It can be seen from results in Table 2 that algorithm in this paper has relatively less risk and scheme is more reasonable and satisfaction degree is better for the same setting constraint. Foresaid experiment results show that algorithm proposed in this paper is efficient for solution process of comprehensive management analysis model and has more outstanding performance.

5. Conclusion

This paper puts forward a kind of comprehensive management analysis model based on automatic contraction and expansion particle swarm algorithm of factors (PSO). By combining BIM technology with CoBie standard and by combining with particle swarm algorithm, the conception of comprehensive management operation and maintenance informatization management based on BIM-CoBie technology is

proposed. Based on analyzing current situation of comprehensive management and BIM technology application in China, the comprehensive management operation and maintenance informatization management mode based on BIM-CoBie technology is put forward so as to establish theoretical frame of comprehensive management operation and maintenance informatization management system based on BIM-CoBie technology. It is shown from experimental result that algorithm in this paper has better performance compared with GA and standard PSO, which can realize better comprehensive management scheme, so as to reduce risk and obtain greater income.

References

[1] S. L. Fernandes, V. P. Gurupur, N. R. Sunder, N. Arunkumar, S. Kadry: *A novel nonintrusive decision support approach for heart rate measurement.* Pattern Recognition Letters. https: //doi.org/10.1016/j.patrec.2017.07.002 (2017).

[2] N. Arunkumar, K. Ramkumar, V. Venkatraman, E. Abdulhay, S. L. Fernandes, S. Kadry, S. & Segal: *Classification of focal and nonfocal EEG using entropies.* Pattern Recognition Letters *94* (2017), 112–117.

[3] J. W. Chan, Y. Y. Zhang, and K. E. Uhrich: *Amphiphilic Macromolecule Self-Assembled Monolayers Suppress Smooth Muscle Cell Proliferation*, Bioconjugate Chemistry *26* (2015) No. 7, 1359–1369.

[4] Şaban Gülcü, H. Kodaz: *A novel parallel multi-swarm algorithm based on comprehensive learning particle swarm optimization*[J]. Engineering Applications of Artificial Intelligence *45* (2015), 33–45.

[5] Y. Liu, D. Luo, Q. Zhao, et al.: *Particle Swarm Optimizer Based on Small-World Topology and Comprehensive Learning*[M]// Advanced Intelligent Computing Theories and Applications. Springer Berlin Heidelberg (2010), 595–601.

[6] J. J. Liang, A. K. Qin, P. N. Suganthan, et al.: *Evaluation of Comprehensive Learning Particle Swarm Optimizer*[C]// International Conference on Neural Information Processing. Springer Berlin Heidelberg (2004), 230–235.

[7] Z. Hu, Y. Bao, T. Xiong: *Comprehensive learning particle swarm optimization based memetic algorithm for model selection in short-term load forecasting using support vector regression*[J]. Applied Soft Computing *25(C)* (2014), 15–25.

[8] C. Hu, Y. Gao, A. Q. Huang: *Power management strategy of hybrid electric vehicles based on particle swarm optimization*[C]// Transportation Electrification Conference and Expo. IEEE (2015). 1–6.

[9] W. F. Gao, S. Y. Liu, L. L. Huang: *Particle swarm optimization with chaotic opposition-based population initialization and stochastic search technique*[J]. Communications in Nonlinear Science & Numerical Simulation *17* (2012), No. 11, 4316–4327.

[10] Y. Song, N. Li, J. Gu, S. Fu, Z. Peng, C. Zhao, Y. Zhang, X. Li, Z. Wang, X. Li: *β-Hydroxybutyrate induces bovine hepatocyte apoptosis via an ROS-p38 signaling pathway.* Journal of Dairy Science *99* (2016), No. 11, 9184–9198.

[11] N. Arunkumar, V. S. Balaji, S. Ramesh, S. Natarajan, V. R. Likhita, S. Sundari: *Automatic detection of epileptic seizures using independent component analysis algorithm.* IEEE-International Conference on Advances in Engineering, Science and Management, ICAESM-2012, art (2012) No. 6215903, 542–544.

[12] R. Hamza, K. Muhammad, N. Arunkumar, G. R. González: *Hash based Encryption for Keyframes of Diagnostic Hysteroscopy*, IEEE Access, https: //doi.org/10.1109/ACCESS.2017.2762405 (2017).

[13] J. W. Chan, Y. Y. Zhang, and K. E. Uhrich: *Amphiphilic Macromolecule Self-Assembled Monolayers Suppress Smooth Muscle Cell Proliferation*, Bioconjugate Chemistry *26* (2015) No. 7, 1359–1369.

[14] Y. J. Zhao, L. Wang, H. J. Wang, and C. J. Liu: *Minimum Rate Sampling and Spectrum Blind Reconstruction in Random Equivalent Sampling.* Circuits Systems and Signal Processing *34* (2015), No. 8, 2667–2680.

[15] H. L. Wei, N. A. M. Isa: *Bidirectional teaching and peer-learning particle swarm optimization*[J]. Information Sciences *280* (2014), No. 4, 111–134.

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