Multi-party Interactive Visioneering Workshop for Smart Connected Products in Global Manufacturing Industry Considering PLM

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Abstract. Currently, Internet of Things (IoT) is a dominant technology and a core mechanism for the third Information Technology (IT) revolution. Many benefits are expected to be enabled by implementing the IoT technologies through the product lifecycle management (PLM) process, such as remote monitoring of field service and predictive quality reliability engineering design in R&D. Smart connected products (SCPs) are forecast to produce tremendous business value. However, significant business challenges are associated with SCPs. Manufacturers have difficulty in rapidly launching IoT products in the market. This paper proposes a pragmatic visioneering workshop framework informed by real-world industry practices. The group facilitation for visioneering focuses on identifying the relation between the 26 practical IoT use cases through the PLM process. Moreover, the proposed workshop format will also enable the participants to engage in a discussion and interact with the framework through use case analysis.

Keywords: Internet of Things (IoT), PLM Process, Smart Connected Products (SCPs), Multi-Party Interaction, Visioneering Workshop Facilitation

1 Introduction

Currently, Internet of Things (IoT) is a dominant technology and is called the third information technology (IT) revolution [7]. The IoT technology enables multiple opportunities and business values through the entire product life cycle management (PLM) process [12]. Remote monitoring of field service and predictive quality reliability engineering design in R&D. Smart factories are alone valuated as a $3.7 trillion dollar industry and are forecast to produce tremendous business value [5]. It is estimated that 30 billion connected "things" will exist by 2020 [4].

Global discrete manufacturing companies such as automotive and high-tech electronics and industrial equipment manufacturers are currently facing significant IoT related business challenges. It is very difficult for these companies to rapidly launch IoT products in the market because of the new complexity derived from the

addition of software applications and connectivity components. According to the results of IDC research, it was found that 66% of the discrete manufacturers pursue IoT initiatives and 40% of them are still at the pilot trial stage [4]. In addition, top-level executives are faced with new strategic challenges such as identifying new corporate models to accelerate the investment in R&D. Moreover, they are still struggling to get started. The PLM experts who are assigned the task of IoT promotion in such companies have various individual opinions and pursue different directions. This causes difficulties in choosing a single direction and achieving consensus regarding the development of smart connected products (SCPs). Therefore, companies spend more time in the planning stage of SCPs as compared to general products. In this new era of SCP development, the first critical step is to coordinate the early stages of the PLM process. Thus, a multi-party interactive consensus-building approach is very important; such an approach must be rapid.

This paper proposes a pragmatic visioneering workshop framework informed by real-world industry practices. The group facilitation of visioneering focuses on identifying the relation between the key issues and challenges in some of the 26 practical IoT use cases. It identifies how a company can plan an SCP solution and craft a high-level IoT value roadmap chart understanding each phase of the PLM process. This paper also proposes to incorporate a workshop format that will enable participants to engage in a discussion and interact with the framework through customer value chain analysis (CVCA) [3] referring to the IoT use cases as a guide during the group discussion session.

The paper is organized as follows: Section 2 briefly presents the 26 IoT use cases that are categorized through the entire product lifecycle stages. Section 3 proposes a framework of IoT visioneering workshop agenda. A case study of a workshop conducted by a leading global discrete manufacturer is discussed in Section 4. We discuss whether the visioneering framework was valuable to the participants in group facilitation in the SCP concept planning phase. Finally, in Section 5, it is concluded that the workshop provided a benefit of achieving consensus in a shorter time period than that expected by the participants. Moreover, an outlook on this study is also mentioned in the conclusion of this paper.

2 IoT Use Cases throughout Product Lifecycle Stages

To overcome the stuck business situation described in Section 1, templates of the 26 IoT use cases have been developed [9, 10, 11]. These templates are used as a guide to help the stakeholders who seek to understand how to create a business value of SCP solutions in the early stage of product strategy planning. Each use case is defined as a typical IoT practice example that is experienced by hundreds of manufactures through the PLM processes. The 26 use cases are also categorized by six key product lifecycle stages (Table 1) so that the use cases aligned with the PLM process can be recognized.

Table 1. IoT Use Cases aligned with PLM processes [11]

Category (a.k.a. PLM process)	IoT Use Case

A) Marketing and Sales	1. Customer Insights and Opportunities 2. Flexible Billing and Pricing Models 3. New Value Added Services
B) Product Development	4. Connected Product Usage Analysis 5. Connected Product Quality Analysis 6. Connected Software Management
C) Operations and Manufacturing	7. Asset and Material Tracking 8. Connected Operations Intelligence 9. Unified Key Performance Indicators 10. Real-time Asset Health Monitoring 11. Operations Management Improvements
D) Service and Support	12. Monitoring and Diagnostics 13. Remote Service 14. Automated Service Execution 15. Condition-based Predictive Maintenance 16. Connected Service Parts Planning
E) Information and Operational Technology	18. Flexible Product and Asset Connectivity 19. Identity and Security Management 20. Scalable IoT Operations Management 21. Seamless IoT Data Integration 22. Automated Analytics and Actions 23. Rapid IoT Application Development
F) Customers	24. Usage and Performance Dashboard 25. Customer Self-service 26. Product Personalization

The contents of the above 26 use cases are mainly utilized at the proposed visioneering session during the group activity; the participants can clearly determine what they need to focus on for their IoT initiatives. One of the benefits is that it helps the group to quickly understand and easily choose key IoT initiatives in shorter discussion time, for example, in 15–20 min. A more specific description of this is provided in Section 3.

3 Design of IoT Visioneering Workshop

3.1 Background and Aim

This workshop is designed for product managers and lead engineers who are working at manufacturing companies. As a background, C-level executives assigned them to be as corporate led IoT product promotion members. However, the workshop members are not always available to work full-time on the assigned mission. Thus, an efficient and more productive approach is required that will enable consensus building over a shorter time. The members need to rapidly provide a single common SCP solution idea that contributes to the executives' strategic goals. This paper aims to provide a procedure for thinking through facilitated group visioneering approaches in such business situations.

3.2 Proposed Workshop Agenda & Timetable

Table 2 shows the proposed agenda for the visioneering workshop for multi-party participants invited from the various product and service development organizations in the company. The timetable is very compact, and an intensive configuration for such busy participants is a necessary and sufficient condition. The workshop is designed to be completed in a total of 5 hours and is configured in 7 step-by-step sessions.

Table 2. Proposed Agenda Template for the Visioneering Workshop

Round #	Session Agenda	Interval (min.)	Clock Time (as sample)
1	Introduction/Agenda Review	15	13:00–13:15
2	IoT Introduction & Strategy Overview	30	13:15–13:45
3	Global Industry IoT Case Studies	45	13:45–14:30
	Break Time	15	14:30–14:45
4	Group Work for Visioneering *Step 1. Identify Stakeholders* *Step 2. Select major IoT Use Cases* *Step 3. Narrow-down Use Cases* *Step 4. Craft IoT Value Roadmap* *Step 5. Set Metrics for IoT Business*	120	14:45–16:45
5	Group Presentation	15	16:45–17:00
	Break Time	15	17:00–17:15
6	IoT Enablement	30	17:15–17:45
7	Wrap-up/Next Steps Discussion	15	17:45–18:00
	Total	300	13:00–18:00

3.4 Preliminary Questionnaire

A preliminary questionnaire is an efficient approach for obtaining the participant's individual thoughts and insights in advance and is employed to facilitate the smooth running of the workshop. The following is the proposed format for the questionnaire comprising two parts.

Part 1: Ask for Business Strategies (Value Drivers)

Part 1 of the questionnaire asks the questionee about Business Strategies and comprises 6 options (Fig. 1) called "Value Drivers" [9, 10, 11]. These 6 options are organized into two categories. Options 1–3 are based on "Operational Effectiveness" and are aimed at helping to improve the optimization of the operational performance. Options 4-6 are for strategic differentiation. The idea of Part 1 is based on the competitive strategy framework developed by Professor Michael Porter [6, 7].

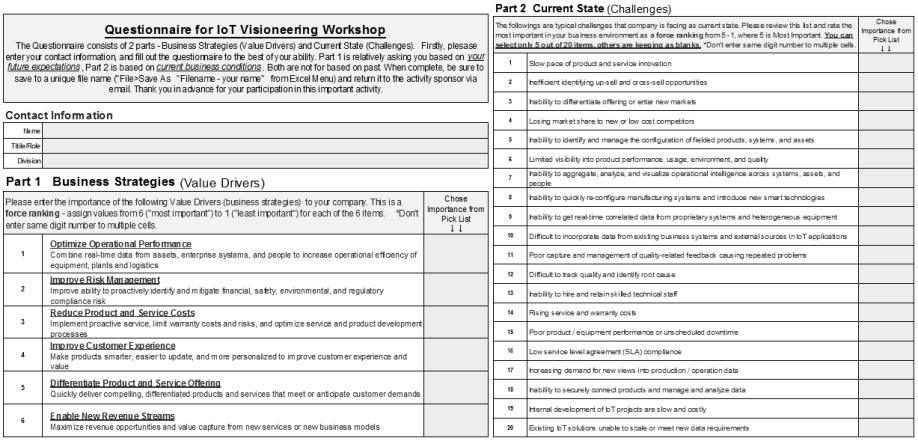
Part 2: Ask for Current States (Challenges)

Part 2 is focused on typical common business challenges (Fig. 1). Twenty options are given that comprehensively describe the end users' problems through the entire product lifecycle process with examples such as the slow pace of product innovation and expensive internal development process for SCP projects.

Web-based Assessment Tool

The proposed preliminary questionnaire is also available as a Web-based system for the workshop participants so that they can respond to the questionnaire on the Web

(https://jp.surveymonkey.com/r/XKQ9ZFV). The questionnaire must be submitted a couple of days prior to the date of the workshop. The option selection for Parts 1 and Part 2 is very easy for the questionee, and it normally takes 15 minutes to complete each Part. The Web system is a freeware that everyone can use on the Web [13]. An Excel sheet is also available for the participants who cannot access the internet environment (Fig. 1).



Questionnaire for IoT Visioneering Workshop

The Questionnaire consists of 2 parts - Business Strategies (Value Drivers) and Current State (Challenges). Firstly, please enter your contact information, and fill out the questionnaire to the best of your ability. Part 1 is relatively asking you based on *your future expectations*, Part 2 is based on *current business conditions*. Both are not for based on past. When complete, be sure to save to a unique file name ("File>Save As "Filename - your name" from Excel Menu) and return it to the activity sponsor via email. Thank you in advance for your participation in this important activity.

Contact Information

Name	
Title/Role	
Division	

Part 1 Business Strategies (Value Drivers)

	Please enter the importance of the following Value Drivers (business strategies) to your company. This is a **force ranking** - assign values from 6 ("most important") to 1 ("least important") for each of the 6 items. *Don't enter same digit number to multiple cells.	Chose Importance from Pick List ↓ ↓
1	**Optimize Operational Performance** Combine real-time data from assets, enterprise systems, and people to increase operational efficiency of equipment, plants and logistics	
2	**Improve Risk Management** Improve ability to proactively identify and mitigate financial, safety, environmental, and regulatory compliance risk.	
3	**Reduce Product and Service Costs** Implement proactive service, limit warranty costs and risks, and optimize service and product development processes	
4	**Improve Customer Experience** Make products smarter, easier to update, and more personalized to improve customer experience and value	
5	**Differentiate Product and Service Offering** Quickly deliver compelling, differentiated products and services that meet or anticipate customer demands	
6	**Enable New Revenue Streams** Maximize revenue opportunities and value capture from new services or new business models	

Part 2 Current State (Challenges)

	The followings are typical challenges that company is facing as current state. Please review this list and rate the most important in your business environment as a **force ranking** from 5 -1, where 6 is Most Important. You can select only 5 out of 20 items, others are keeping as blanks. *Don't enter same digit number to multiple cells.	Chose Importance from Pick List ↓ ↓
1	Slow pace of product and service innovation	
2	Inefficient identifying up-sell and cross-sell opportunities	
3	Inability to differentiate offering or enter new markets	
4	Losing market share to new or low cost competitors	
5	Inability to identify and manage the configuration of fielded products, systems, and assets	
6	Limited visibility into product performance, usage, environment, and quality	
7	Inability to aggregate, analyze, and visualize operational intelligence across systems, assets, and people	
8	Inability to quickly re-configure manufacturing systems and introduce new smart technologies	
9	Inability to get real-time, correlated data from proprietary systems and heterogeneous equipment	
10	Difficult to incorporate data from existing business systems and external sources in IoT applications	
11	Poor capture and management of quality-related feedback causing repeated problems	
12	Difficult to track quality and identify root cause	
13	Inability to hire and retain skilled technical staff	
14	Rising service and warranty costs	
15	Poor product / equipment performance or unscheduled downtime	
16	Low service level agreement (SLA) compliance	
17	Increasing demand for new views into production / operation data	
18	Inability to securely connect products and manage and analyze data	
19	Internal development of IoT projects are slow and costly	
20	Existing IoT solutions unable to scale or meet new data requirements	

Fig. 1. Preliminary Questionnaire (Part 1 and Part 2)
https://jp.surveymonkey.com/r/XKQ9ZFV

3.5 Design of Group Facilitation for Visioneering Session

This workshop emphasizes intensive group work (round #4 in Table 2), wherein 4 or 5 people per group and 2 or 3 groups per workshop are reasonable. Moreover, 2 facilitators support all the group activities. During the group session, many debating situations are possible. In one case, each person has his own opinion and may try to push his own idea to others. In another roundtable, the group discussion would be very quiet and low-key; nobody tries to speak up and the participants are just watching each other until someone makes a comment. Either one of these two cases is not always ideal for building a consensus for a single direction. Furthermore, a difficulty in reaching the final goal of the group discussion outcome will be faced in both cases. Therefore, the following five pragmatic steps are proposed as an engineering facilitation methodology aiming to smoothly achieve a consensus for a single direction (Table 3).

Table 3. Five Steps for Group Facilitation at a Visioneering Session

Step #	Group Discussion Topic
1	***Identify Stakeholder***—utilizing Customer Value Chain Analysis (CVCA)
2	***Select Top 6 IoT Use Cases***—aligning with corporate Value Drivers
3	***Narrow-down the Use Cases***—selecting 3 out of 6 for to be more specific
4	***Craft IoT Value Roadmap***—positioning the Use Cases on the value maturity
5	***Set Metrics (KPIs)***—qualifying Business Goals

Step 1: Identify Stakeholders—utilizing Customer Value Chain Analysis (CVCA)
Using CVCA methodology [3], the group members are encouraged to discuss all the people and processes that impact or depend on the product or asset. First, this requires the group members to select a product or asset to focus the discussion on; the members will select and identify as many stakeholders as possible, such as internal/external and direct/indirect. The roles of the stakeholders should be specific. The discussed stakeholders should then be connected with a line. As a result, a CVCA diagram is drawn surrounding the selected product or asset. This task is aimed to help the members realize that there are many influencers and to expand the value of the product or asset connecting various stakeholders. For this step, 20 minutes is an appropriate amount of time.

Step 2: Select Top 6 IoT Use Cases—aligning with corporate Value Drivers
In the second step, the group members will review the 26 use case examples and select 6 use cases. This is to support their conclusion whether their selected product or asset will become worthwhile as a future SCP solution. In addition, they need to understand which of the selected use cases provide business impact for the specific Value Drivers (Business Strategies) based on the preliminary results of Part 1 of the questionnaire. For this step, 15 minutes is an appropriate amount of time.

Step 3: Narrow-down selected Use Cases—selecting 3 out of 6 for to be more specific
In the third step, the participants review and prioritize the above selected 6 use cases and select the top 3 use cases. Then, the members will discuss why these use cases were selected. Finally, they will unanimously agree on the most important use case for the first action on the future roadmap. For this step, 10 minutes is an appropriate amount of time.

Step 4: Craft IoT Value Roadmap—positioning the Use Cases on the value maturity
The members will use the selected top 3 use cases to consider the steps and value maturity. Considering the As-Is situation and examining the result of the preliminary questionnaire, they will create an IoT Value Roadmap to add a To-Be objective and goal for each step [Fig. 2]. For this step, 45 minutes is an appropriate amount of time.

Step 5: Set Metrics (KPIs)—qualifying Business Goals
During step 5, the group members will identify action items to move forward utilizing the use cases. In parallel, they discuss key metrics (KPIs) for each use case. KPI examples should be provided by the facilitator to the group members. The selected metrics would be significant indicators of whether the planned business transformation is correctly promoted with the SCP solutions that they would develop. Finally, they will draw one single page as a high-level IoT value roadmap putting all of the insights that they discovered through the steps 1–4. For example, how to better qualify selected use cases, from which use case should we begin, and what are the "quick wins" or "strategic values." For this step, 30 minutes is an appropriate amount of time.

3.6 Key Achievements of Visioneering Workshop

Through the visioneering session, the following are achieved as group work outcomes recognizing the group members' efforts.

All-hands Intensive Group Presentation

Regarding the visioneering session, it is most important to recognize its group efforts. The participants intensively work together during the limited session time such as for 120 minutes. At the end of the group session, the group presentation time is required by the facilitator. The aim of this step is that all of the participants at the workshop are able to get a mutual understanding and compare with other group members' outcomes. The presentation time for each group is only 5 minutes. It should include the group CVCA diagram and the high-level SCP value roadmap discussed during the group work (Fig. 2). After the presentation time, the audience (other groups) must ask constructive questions to the presenter group (at least 2 questions). Thus, presentation time provides critical insights regarding the value propositions.

Tailored IoT Value Roadmap with Maturity Curve

At the end of the group discussion, a value roadmap is crafted as a one-page summary. Figure 1 is an example that is configured with Value Driver, Value Area, Sensing Information, Challenge, Metric, and IoT Solutions.

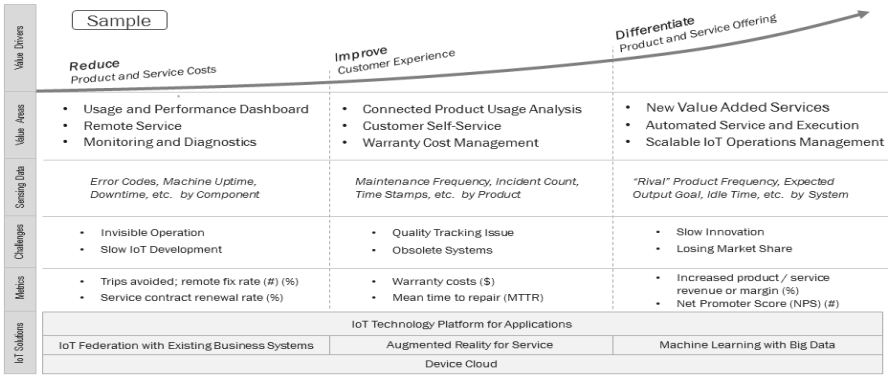


Fig. 2. Tailored IoT Value Roadmap with Maturity Curve (a Sample Template)

4 Case Study

4.1 Background and Opportunity

Company-X (as anonym) is a leading global manufacturer of specific precision instruments. Company-X's product development process is globally distributed, e.g., among countries A, B, C, and D. For example, the hardware design team is located in country A, whereas the software application development team is located in country B. These teams have been developing high-quality hardware centric products over a period of time, and the company has built a dominant position in the specific global market. The market is quite oligopolistic and has a high entry barrier because of the severe industry-specific regulations. Because the IoT technology is recently recognized as a disruptive innovation that can transform the existing product functionalities, the boundaries of the competition shift and expand from the exiting industry to a broader system of products. Moreover, there was a threat of a severe

battle for Company-X. This was a new competitive era with not only the existing competitors but also with the newly entering cost-competitive emerging companies.

In such a new business transformation, the senior executive officer in charge of a global business unit in Company-X decided to start a "vision definition" for their future IoT-enabled SCP solutions. This required collaboration with the corporate product management team and the local development members who are distributed among the various countries. A critical challenge was how the differences of cultures and opinions among the members can be efficiently controlled to enable the formulation of a single and common future vision in a short time frame such as a half-day internal big meeting.

This was an opportunity for our study team to propose our developed visioneering workshop framework to the officer, supporting Company-X's vision-making initiative as an independent third party. It was a significant empirical study opportunity for us to examine whether the workshop framework can validate our study concept and its assumption.

4.2 Characteristic of Participants

The following distributed members were gathered at a single location in country A (Table 4). They came from four different regions around the world and their nationalities and mother tongues were different. To support mutual communication, a dedicated interpreter staff was assigned for translation between English and the local language of country A.

Table 4. Attendees List of the Visioneering Workshop at Company-X

Group Name	Participant (individual #)	Business title	Region (Work location)	Mother tongue
Group-A *(w/ global managers)*	1	VP	Americas	*language-a*
	2	Director	EMEA	*language-b*
	3		Americas	*language-a*
	4			*language-a*
	5	General Mgr.	Asia-Oceania	*language-c*
	6		EMEA	*language-b*
	7	Manager	Asia-Oceania	*language-c*
Group-B *(w/ local managers)*	8	General Mgr.	Asia-Oceania	*language-c*
	9			
	10			
	11			
Group-C *(w/ local engineers)*	12	Manager	Asia-Oceania	*language-c*
	13	Sr. Engineer		
	14			
	15	Engineer		

4.3 Discussions

In this paper, we focus our discussion on the "Group Work for Visioneering" session for Round #4 in Table 2 based on the result for the actual case of Company-X. The

developed group facilitation approach has comprehensively provided significant insights to the workshop group members. This allowed them to identify IoT values that they have never previously realized. The following three items were particularly significant discussion points.

Well-balanced PLM process as IoT use cases.

The predefined IoT use case templates allowed the group members to provide well-balanced strategy planning workflow in IoT topics and discussions. Although most of the participants were basically from the "engineering department," they realized the value of selecting some of the IoT initiatives of the product manufacturing and field service processes that were not within their specialties. The initiatives they selected were also well-aligned with the corporate strategy. These potential values would not have been discovered without the use of such templates. In addition, the participants from the "*hardware*" design team recognized the importance of the value of "*software*" rather than hardware innovation. Another remarkable contribution by the facilitator was that the 26 use cases were prepared as "26 cards." This means that the group members enjoyed the group discussion time as if they were playing cards, which had a positive effect by relaxing the participants and enabling them to think about brand new ideas.

Doubling productivity vs. negative busyness?

During the group work session, the facilitator was rigidly measuring the session time with a stopwatch. This brought about a remarkable increase in productivity. Moreover, the predefined timetable was a quite a useful guide for the facilitator. In fact, there was a very positive endorsement from a lead participant in the workshop, *"Without such time management and use case templates, we could not complete on time. We would spend twice as much time as we actually did."* On the other hand, the rigid timing also identified some of the participants' mental stress due to the busyness forced by the facilitator. This should be a topic for improvement in a future study.

Multi-linguistic party and challenges on remote facilitation.

Although each group (A, B, and C) comprised people with different backgrounds and cultures from overseas countries, no operationally fatal problems were identified during the group discussion time. All three groups achieved the final conclusions. However, we have to admit the contribution of the professional interpreter's savvy. Such multinational and multi-linguistic group activities are currently estimated to be increasing. We are still dependent on such a talent of the interpreter for better human communication for the solution of the problems involved in the discussion in such a diverse environment. Furthermore, in this case, another facilitator joined remotely through the Web from his base country. Currently, Web meeting applications such as WebEx on a smartphone are very convenient and cheaper than ever before. Thus, we actually applied a remote facilitation style during round #3 in Table 2. This had a negative influence because it was quite difficult for the remote facilitator to recognize the audiences' personal perceptions. Generally, it is very important to understand how a remote facilitator can be acceptable in such an unknown situation [2]. This should be improved in the workshop agenda design based on the previous literature and cross-disciplinary studies and research.

5 Conclusions and Future Work

We proposed a visioneering workshop approach utilizing the 26 IoT use cases through the PLM process. We have identified some significant values during the proposed group facilitation approach at a global manufacturing company focused on specifically planning an SCP concept as a part of IoT product solution suite. We also recognized that the proposed approach was acceptable for the workshop participants because they were able to achieve a common vision and consensus on a single SCP concept in a shorter time than they initially estimated. For the workshop participants, the largest contribution was made by the ability to use the comprehensive formatted 26 IoT use case examples. The participants clearly imagined future candidates of IoT solutions because the use cases were pragmatic business templates and were demonstrated in the actual industry environment.

On the other hand, we need to consider the remote facilitator's role at the requirement gathering phase described in the literature [2] as a possibility of virtual meeting space with ICT remote environment. As the next step, we are building on the research of previous studies in directions such as visual planning for virtual multi-site teams [1, 8]. Furthermore, we would like to investigate the effects of adopting innovative user experiences such as augmented reality. This would provide a supportive effect for the globally distributed participants as if they worked together in-person in the same workshop room.

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