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Simulation Modeling of Tablet PCs Selection Using Weighted-Product Algorithm

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Abstract

The combination about innovation arts, technology, marketing, and ideas among mobile (smart) phones and notebook computers, revolutionary has led to the birth of a handheld device called as the Tablet PCs. Where, the Tablet PCs was a product that transforming from the minimization of notebook computer. In other words, it can be said as a handheld device that has an 'almost' similar performance as a notebook computer but has a more compact and smaller size dimension than the notebook computers and has a bigger dimension than the smart-phones also. The problem is there were so many variations of Tablet PCs products on the market. Therefore, the question often arises about the Tablet PCs is, "which one the most-suitable product for my purposes"? In this study modeled a simulation process for Tablet PCs selection using the eight domains of weighting criteria. Which from our perspective these eight domains of weighting criteria are an 'objective' measurement for assessing the Tablet PCs products. As a decision support tool that implementing a method of Multi-Attribute Decision Making (MADM) technique using Weighted-Product (WP) algorithm approach, where

WP serves a means to give product recommendations to the users about the most-suitable products for them based on priority ranking mechanism.

Keywords: Weighted-Product algorithm, Tablet PCs selection, Multi Attribute Decision Making (MADM), simulation modeling, weighting criteria, Decision Support Systems

Introduction

According to Li, [16] Tablet PCs or tablet (tablet computer) is a device that has the same basic functionality as computers, but have specific uses depending on who uses and is use for what purpose. Furthermore, Li [16] explains that the tablet in tandem with a smartphone is one of several digital devices which are most popular in Taiwan. The usefulness of the tablet is also quite diverse, such as general-purpose (browsing, running application software, playing games, watching videos), even tablet can use for more specific purposes such as business, teaching and learning activities [10, 6], moreover, it use for supporting medical activities [7, 3]. Currently, tablets are increasingly in demand by its consumers because of its futuristic design, technological sophistication, moreover several tablets have an affordable price to be purchase. Previous studies by Alvarez et al. [6] found that the students preferred tablet than notebook because of the simple design of the device so they are feels free to express their ideas at the time of presentation in front of the class. Belongs to the category of high-involvement product [8], the selection of tablet products are certainly needed careful consideration before deciding to buy it. Careful consideration is required to avoid consumers from unexpected purchasing, which can lead to disappointment in the future [13, 14]. Therefore in this study, we developed a simulation model of the decision-making process in the context of tablet PCs selection. A model used was; one of the several methods based on Multi-Attribute Decision Making (MADM) with Weighted-Product (WP) algorithm approach. The main motivation of this study is a tutorial for using MADM as a method to solving multicriteria problems in the decision-making process. Regarding of this study, expected that will be a growing number of emerging application variations of MADM method as an alternative multi-attribute problem-solving solutions both in case studies or empirical research that can generate best practices in industries.

Literature Review

Decision making is a product of choices. In every purchase of product or service almost certainly motivated by a long thought process before the people deciding to take the execution step (the purchasing). Finally, the end of the journey of thought, produce one decision that will be a factor to buy or not to buy the product [14]. In this study, we will not discuss the factors that were motivate the consumer to make a purchase decision. However, we focused on the implementation of Weighted-Product algorithm as an alternative decision support models to assists user choose the expected product. Products sampled in this study are the Tablet PCs devices. One of the fundamental reasons why tablet are interesting to be the sample objects, because it belongs to high-involvement product category [8]. Or in other words, a high-involvement product is a product that requires effort, sacrifice, and extra consideration from the buyer to get it. We assumed that the characteristic of the Multi-Attribute Decision Making (MADM) in some extent can be helped to solve the case of Tablet PCs selection problem which had a certain number of selection criteria. We utilize one of the fundamental characteristics of MADM to narrow down several criteria into the small number of important recommendations in order of priority weighting by the user [1, 2, 19].

In the case study of industrial operation research, there were a lot of problems regarding the decision-making that can be resolved by the intervention of MADM. Recent studies by Feng and Lai [4] which applying the MADM method based on integrated "aspirations" of the Decision Maker's (DM's) combining altogether with TOPSIS algorithm approach to choosing candidates of flight freight forwarders tells a success story. Feng and Lai [4] put seven weighting criteria consists of: (1) supply quantity, (2) stability of supply, (3) delay time, (4) supply ratio of the low-demand routes, (5) IT support, (6) payment reputation, and (7) switching risk; in the selection of four from the ten candidates of freight forwarders which will be asked as a long-term business partner by Air Cargo Transportation (ACT) Department, on a case study of China's air cargo industry. When constructing the seven weighting criteria of the freight forwarders selection case, Feng and Lai [4] are using the results of brainstorming and in-depth discussion along with the steering committee as a weighting reference.

In another case, the previous study by Yao et al. [15] also utilize the reliability of MADM method using TOPSIS algorithm approach to solving Semiconductor Manufacturing System (SMSs) scheduling problems. Where if there were no good SMSs scheduling process, it would be results in waste of resources on a large scale at each stage of production [15]. In their study Yao et al. [15] emphasize (1) due date criterion, (2) setup cost criterion and (3) a line balance criterion; as the three fundamentals of weighted criteria on SMSs scheduling problems. In this study, the selection of Tablet PCs deliberately focused on the use of Weighted-Product method as the primary method. Because, WP method is rather easy to implement both in a spreadsheet application and on the web-based applications / desktops, intuitive, and a WP method is still rarely used by the researchers to solve the case of decision making.

Method

The constructive methods refer to Feng and Lai [4] used in this study. On the Tablet PCs weighting criteria, we observed several online references such as independent gadget reviewers (tabletpcreview.com, pcadvisor.co.uk, jagatreview.com. gsmarena.com, digital technology solutions [9]), independent gadget bench-marker (HWM Singapore), product marketing white papers, and also online stores that provide technical specifications of Tablet PCs. The Weighted-Product approach in this study refers to Kusumadewi, et al [12].

The Weighted Criteria

Based on our observation towards several technical references, we combine: cost, connectivity, processor, display, memory, storage, camera, and battery as the eight domains of Tablet PCs criteria weighting. To be noticed, we did not categorize screen-size as a basis for weighting consideration because the user needs toward screen-size varies depending on their purpose. We analogize, that was a quite difficult to generalize the needs of a graphic designer who needs Tablet PCs with screen size of 10-inch for product presentation to her/his clients against a student who needs Tablet PCs with 7-inch screen size for the purpose of reading e-books on the train or school bus, but she/he is lazy to carry a larger tote's bag. Then, following were the brief descriptions about the criteria (see **C1**, **C2**, **P1**, **D1**, **M1**, **S1**, **C3**, **B1**):

(C1) *Cost* (*product price*) [-]. There was no doubt that product price is the basic element of a weighted criterion when consumers are considering to purchase products or services. Currently there are a lot of Tablet PCs with various technological specifications, likewise with its brand. Of course with the price as one indicator of the quality of product, consumers are expected not to do a mistake in case of choosing product. The use of product price as one indicator of the purchase consideration of products or services by consumers is also been done on previous study by Enneking et al [18] and Chang [17]. In regards the consumers are not just buying a brand but also consider the quality aspect. We're categorizing product price into negative (-) domain. It means that the lower price is the better. In other words, consumers have rights to get high quality product at a minimum price.

(C2) *Connectivity* [+]. With the use of broadband technology, it allows the data transfer from one host to another can be done quickly, anywhere, and in the various media simultaneously. One of the today's famous data transfer technology is a wireless telecommunication network. Where, the today's generations of wireless technology infrastructure have a possibility for supporting high speed data (audio-video) transfer. In addition Cisco predicts by the end of 2015 mobile data transfer process to be performed by the majority of the world's population will be in video format [11]. Hence not to be surprised if there were various low-middle cost Tablet PCs in the Indonesian market which already supports third generation (3G) wireless technology. To be noticed, currently in Indonesia there was a telecommunication network provider which already provides wireless network connectivity technology with 4G LTE (Long Term Evolution) at affordable prices [5]. Thus the needs of consumers about the tablet PCs that support the latest technology telecommunication networks connectivity (such as: 3G, 4G, and so on) have certainly led us to assume that connectivity can be categorized into the positive (+) domain. It means the higher connectivity bandwidth which is supported by the Tablet PCs is the better, because the technology infrastructure is already established. Then why choose 2G's tablet when consumers can get the 3G's tablet at affordable prices?

(P1) ***Processor*** **[+].** To support the rapid computation process, it was necessary for Tablet PCs to adopt fast processor performance also. This is reasonable because of the very quick mobility and multi-task activities of today's Tablet PCs users. The role of Tablet PCs which can only support for e-book reading was no longer needed. Today's computation trends are: high-definition video and ultra-speed internet access, therefore we categorize processor to the positive (+) domain. We assumed higher processor performance speed is better to serve high requirements of today’s computation.

(D1) ***Display*** **[+].** Besides being used for working or studying purposes, tablet PCs are expected also to be able to indulge users on entertainment needs. The entertainment needs is a screen high-definition display, which can supports user for watching high-definition movies or playing realistic video games. Therefore, the color depth and pixel's density is definitely a quality indicator for Tablet PCs screen display. We categorize the screen display into the positive (+) domain, because the high-definition quality is needed to accompanying high performance processor speed. That means the higher pixels resolution is the better.

(M1) ***Memory*** **[+].** Memory is useful for storing data in a temporary primary instruction before being stored into the permanent data media storage. The main operations of memory are for writing and reading the data spontaneously and sustainably. To support those operations, memory needs a buffer media called a cache. Bigger memory capacity storage can be able to store more caches, and then input-output data loading can be processed quickly. Based on that reason we categorize memory to the positive (+) domain.

(S1) ***Storage*** **[+].** Storing hundreds of music and video files of course requires a storage resource is quite large. Moreover for the installation of widgets and applications data files which are usually consume a big space of storage. Without built-in data storage, users may find it difficult to do the software installation. Where, user must purchase another external storing media (e.g. Micro SD Card) and then "rooting" (e.g. in terms of Android Operating Systems) it, to give more capacity for storing data. Therefore, we assumed the bigger storage capacity (intended storage is built-in storage) is the better. Then, we categorize storage to the positive (+) domain.

(C3) ***Camera*** **[+].** If the technical review of digital technology solutions [9] uses a dual-camera as the weighting criterion, in this study we only include a camera as the weighting criterion. We assume it is similar to the case of Tablet PCs screen-size which it usefulness depends on its purpose. The reasons of the use of dual-camera for video calls or video conferencing purposes are still not strong enough to be generalized because it is still highly subjective. However, high-resolution camera support (higher megapixels) should be implemented on any Tablet PCs devices, considering the trend of amateur photography which always increases. Especially for consumers in Indonesia which are quite keen to publish their photographs on social networking media like: Facebook, Instagram, or Path. Thus we categorize camera (primary or secondary camera which was has a sharper resolution is chosen) to the positive (+) domain. Where, larger megapixel's is better.

(B1) ***Battery*** **[+].** Battery is one important element in any handheld devices. Where, the most crucial role of a battery is for its capability as a main power supply for the devices. Battery performance is usually been measured by how long it can stay life for supplying power to another components. Typically, the battery performance was correlated to the amount of its power capacities. The capacity of a battery was defined using a measurement unit on miliAmpere-hour (mAh). We assume that the bigger capacity of a battery is the better. Because, it was relate to the ability of a battery life for giving a supply power.

Result

In this section, we present a simulation model for the Tablet PCs selection using the eight (8) domains of criteria weighting based on Weighted-Product algorithm approach. In this study, we used numerical samples method to do the simulation. The weighting values between alternative products (Tablet PCs) given a vis-à-vis comparison among their values. While the amount of weighting values from the consumer perspective given randomly. Here is a step by step simulation modeling of Tablet PCs selection using WP approach.

Alternatives Weighting

In this section as the sample model of Tablet PCs products, we chose five the alternative of preferred products; there were: (a) Samsung Galaxy Tab 3, (b) Hewlett-Packard Slate 7, (c) Acer Iconia A1-811, (d) Asus Nexus 7-3G, and (e) Lenovo B6000-Yoga. For specification products comparison, the eight domains of criteria weighting we refer to the existing product specification on Lazada.co.id, Bhinneka.com, Cnet.com, and GSMarena.com.

Step (1). Do the vis-à-vis comparison of each product to gather the weighted values. *See* ***Table 1***.

Table 1. Alternatives vis-à-vis comparison towards biggest denominator in every column

Alternatives	Cost [-]	Connectivity [+]	Processor [+]	Display [+]	Memory [+]	Storage [+]	Camera [+]	Battery [+]
1. Samsung Galaxy Tab 3	4,200,000	4	3	1,024,000	1.5	16	5	4,450
2. HP Slate 7 – 3G	2,599,000	4	4.8	614,400	1	16	5	4,100
3. Acer Iconia A1-811	2,199,000	2	4.8	786,432	1	16	5	4,960
4. Asus Nexus 7-3G	3,399,000	4	4.8	1,024,000	1	32	1.2	4,325
5. Lenovo B6000-Yoga	3,699,000	4	4.8	1,024,000	1	16	5	6,000

The explanation of ***Table 1***:

In the cost's [-] column, values listed are the product prices denominated in Indonesian Rupiah (IDR). In connectivity's [+] column values listed are based on the connectivity features which are supported by the Tablet PCs. Alternative product was given in a value of '4' if it supports several connectivity features like Bluetooth, Wi-Fi, EDGE, 3G, and so on. While the value of '2' was given to the Acer Iconia Tablet A1 - 811 because, that tablet's does not support older connectivity feature like Bluetooth. In the processor [+] column, values given are in GHz (Giga Hertz). In display [+] column, values given are in pixels. In the memory [+] column, values listed are in units of GB (Gigabyte). In the storage's [+] column the values listed are using GB as a scale as same as scale used in memory's. In the camera [+] column, values listed are using MP's (Megapixel) as a unit of measurement. And in the battery [+] column, mAh (Miliampere-hour) was used as a unit of measurement.

Step (2). The largest value in a column is the denominator, do the normalization by making every value in each column as the numerators and do the division towards the denominator.

To get a normalized value, every value that's listed in each column divided to the largest divisor. At the **cost's [-]** column the largest value is IDR4200000 (Samsung Galaxy Tab 3), thus the denominator in the **cost's [-]** column is IDR4200000. So that all values in the **cost's [-]** column should be normalized by comparing it vis-à-vis towards the IDR4200000. Example: HP Slate 7-3G was compared to the Samsung Galaxy Tab 3 then the normalized value obtained will be 2,599,000 / 4,200,000 = 0.62. Another example can be demonstrated at the **battery [+]** column, which is the greatest divisor values is 6,000 mAh (Lenovo B6000-Yoga), then all the values listed in each column should be compared vis-à-vis with the '6000 mAh'. Example: If the battery power of Acer Iconia A1-811 compared to the greatest divisor, it will get a normalized value on 4.960 / 6.000 = 0.82. Complete normalization results can be seen in **Table 2**.

Table 2. The normalization product of weighted alternatives

Alternatives	Cost [-]	Connectivity [+]	Processor [+]	Display [+]	Memory [+]	Storage [+]	Camera [+]	Battery [+]
1. Samsung Galaxy Tab 3	1.00	1.00	0.62	1.00	1.00	0.50	1.00	0.74
2. HP Slate 7 – 3G	0.62	1.00	1.00	0.60	0.66	0.50	1.00	0.68
3. Acer Iconia A1-811	0.52	0.50	1.00	0.76	0.66	0.50	1.00	0.82
4. Asus Nexus 7-3G	0.81	1.00	1.00	1.00	0.66	1.00	0.24	0.72
5. Lenovo B6000-Yoga	0.88	1.00	1.00	1.00	0.66	0.50	1.00	1.00

From the **Table 2,** formed a normalized matrix of alternative weighting called **AW** matrix, which consists of:

$$\boldsymbol{AW} = \begin{bmatrix} 1.00 & \cdots & 0.74 \\ \vdots & \ddots & \vdots \\ 0.88 & \cdots & 1.00 \end{bmatrix}$$

Thus, the pseudo-code for AW matrix normalization can be seen in the **conceptual 1.**

Conceptual 1. Pseudo-code for AW matrix normalization

Pseudo-code:

```
!-- for AW Matrix Normalization
Var Mat(n)
Var AW(n)
Var C1 = Mat(0), Var C2 = Mat(n)
Var counter: double

Begin
For   loop counter to Mat(n)-1 Step+1
      Begin
            If ( mat(counter) > C1 ) Then
                  C1 = mat(counter)
            Else If ( C2 < mat(counter) ) Then
                  C2 = mat(counter)
            End If
      End
            Return C1, C2
End

!-- //

Begin
        For Loop mat(C2) to mat(C1) Step+1
        Begin
                AW(n) = mat(C2)/C1
        End
            Return AW(n)
End
```

Criteria Choices of Weighting and Normalization

In this section we simulate the criteria weighting of Tablet PCs products using random method based on our perspective as users of Tablet PCs. Intervals are preceded by the '1' as the lowest weighting value to the highest is '5'. Meanwhile in context of linguistic variable, the value can be defined as: '1' = 'poor'; '2' = 'low'; '3' = 'fair'; '4' = 'good'; and '5' = 'excellent'. The overall results of criteria weighting can be seen in **Table 3**.

Step (3). Set the values for the weighting criteria using an interval on scale of '1-5'.

Table 3. Weighting matrix for choices criteria (conditioned)

Criteria	Weight
Cost [-]	4
Connectivity [+]	3
Processor [+]	5
Display [+]	4
Memory [+]	4
Storage [+]	3
Camera [+]	2
Battery [+]	5

Then, from **Table 3** can be formed a matrix called **CW** matrix which consists of:

$$\mathbf{CW} = \begin{bmatrix} 4 \\ 3 \\ 5 \\ 4 \\ 4 \\ 3 \\ 2 \\ 5 \end{bmatrix}$$

After the **CW** matrix was formed, the next step is to perform normalization using **Theorem A**, so it is possible to obtain the normalized weights at:

$$\sum CW_j = 1\ (Max).$$

$$CW_j = \frac{CW_j}{\sum CW_j}$$

Theorem A. Criteria weighting normalization

Step (4). Do the normalization on **CW** matrix using **Theorem A**.

$$CW_1 = \frac{\mathbf{4}}{4+3+5+4+4+3+2+5} = 0.13$$

$$CW_2 = \frac{\mathbf{3}}{4+3+5+4+4+3+2+5} = 0.10$$

$$CW_3 = \frac{\mathbf{5}}{4+3+5+4+4+3+2+5} = 0.16$$

$$CW_4 = \frac{\mathbf{4}}{4+3+5+4+4+3+2+5} = 0.13$$

$$CW_5 = \frac{\mathbf{4}}{4+3+5+4+4+3+2+5} = 0.13$$

$$CW_6 = \frac{\mathbf{3}}{4+3+5+4+4+3+2+5} = 0.10$$

$$CW_7 = \frac{\mathbf{2}}{4+3+5+4+4+3+2+5} = 0.06$$

$$CW_8 = \frac{\mathbf{5}}{4+3+5+4+4+3+2+5} = 0.16$$

The Weighted-Product Approach

In this section Weighted-Product algorithm is implemented, where there will be two matrix calculations. The first is alternative weighting towards criteria weighting. And the second is the calculation process about the ranking results of alternative recommendations. As for, both calculations can be seen on **Step (5)** and **Step (6)**.

Step (5). Do the normalization between AW matrix and CW matrix using **Theorem B**. The formulation of **Theorem B** was constructed as is follows:

$$ACW_i = \prod_{j=1}^{n} AW_{ij}^{CWj}\ ; where\ i =\ integers\ (1, 2, \dots, n)$$

Theorem B. Normalization of alternatives weighting

$$ACW_1 = (1^{-0.13}) + (1^{0.1}) + (0.62^{0.16}) + (1^{0.13}) + (1^{0.13}) + (0.5^{0.1}) + (1^{0.06}) + (0.74^{0.16}) = 7.812$$

$$ACW_2 = (0.62^{-0.13}) + (1^{0.1}) + (1^{0.16}) + (0.6^{0.13}) + (0.66^{0.13}) + (0.5^{0.1}) + (1^{0.06}) + (0.68^{0.16}) = 7.820$$

$$ACW_3 = (0.52^{-0.13}) + (0.5^{0.1}) + (1^{0.16}) + (0.76^{0.13}) + (0.66^{0.13}) + (0.5^{0.1}) + (1^{0.06}) + (0.82^{0.16}) = 7.835$$

$$ACW_4 = (0.81^{-0.13}) + (1^{0.1}) + (1^{0.16}) + (1^{0.13}) + (0.66^{0.13}) + (1^{0.1}) + (0.24^{0.06}) + (0.72^{0.16}) = 7.842$$

$$ACW_5 = (0.88^{-0.13}) + (1^{0.1}) + (1^{0.16}) + (1^{0.13}) + (0.66^{0.13}) + (0.5^{0.1}) + (1^{0.06}) + (1^{0.16}) = 7.897$$

*for CW_j which has a negative power, these are categorized as a *cost*. That is mean that cheaper is better

Step (6). After obtaining the normalization result from ACW matrix, the next step is performing final calculations using **Theorem C**. Where, the results of this calculation will be the list of alternative products which sorted by priority rankings. As for, the formulation of **Theorem C** is as follows:

$$AR_i = \frac{\prod_{j=1}^{n} AW_{ij}^{CWj}}{\prod_{j=1}^{n} \left(AW_j^*\right)^{CW_j}} \; ; where\ i = integers\ (1, 2, \dots, n)$$

Theorem C. Alternatives ranking

Where, $\prod_{j=1}^{n} \left(AW_j^*\right)^{CW_j} = 7{,}812 + 7{,}820 + 7{,}835 + 7{,}842 + 7{,}897 = \mathbf{39.206}$

AR_1 = 7.812/39.206 = 0.1990
AR_2 = 7.820/39.206 = 0.1994
AR_3 = 7.835/39.206 = 0.1998
AR_4 = 7.842/39.206 = 0.2000
AR_5 = 7.897/39.206 = 0.2014

Then, the ranking results using **CW** matrix = {4, 3, 5, 4, 4, 3, 2, 5} as a weighting preferences are obtained in **Table 4**.

Table 4. Tablet PCs product suggestion ranks based on Weighted-Product algorithm

AR_i	$^{Priority}/_{Weight}$	**Alternatives**
AR_5	**1st** (0.2014)	Lenovo B6000-Yoga
AR_4	**2nd** (0.2000)	Asus Nexus 7-3G
AR_3	**3rd** (0.1998)	Acer Iconia A1-811
AR_2	**4th** (0.1994)	HP Slate 7 – 3G
AR_1	**5th** (0.1990)	Samsung Galaxy Tab 3

The pseudo-code for **Step (3)** until **Step (6)** can be seen in **Conceptual 2**.

Conceptual 2. Pseudo-code for alternatives ranking

Pseudo-code:

```
!-- for Alternatives ranking

Var Counter1 = 1, Counter2 = 1
Var AW = { {1.00, … , 0.88}, … , {0.74, … , 1.00} }
Var Flag = { 0, 1, 1, 1, 1, 1, 1, 1 } !--   0 is for cost's criterion
Var CW = { 4, 3, 5, 4, 4, 3, 2, 5 }
Var SigmaCW = SUM(CW)

Begin
          CW = CW / SigmaCW
          For Loop Counter1 to AW.Length Step+1
              Begin
                 If Flag(Counter1) == 0 Then
                     CW(Counter1) = -1 * CW(Counter1)
                 End If
              End
          Return CW(Counter1)
End

!-- //

Begin
          For Loop Counter2 to AW.Length Step+1
              Begin
                  ACW(Counter2) = AW(Counter2) ^ CW Then
                  AR = ACW / SUM(ACW)
               End
          Return AR
End
```

Conclusion

This section is the final step of simulation modeling for the selection of Tablet PCs using Weighted-Product algorithm. A limitation in this study is about the construction of selection model based on eight domains of weighting criteria that are still using the assumptions or perspectives from the authors. And not yet through a series of reliability and validity testing. Moreover, the data being used in this study (as a numerical example) was not a real test data. However, the main purpose of this study was to simulate or to portray the process of decision making using MADM approach which specifically focuses on the modeling of the weighting criteria as the 'favor' aspects of consumer problem, when the consumers wanted to buy a Tablet PCs product. With this study expect, the simulation modeling could lead other studies using another variety of MADM approach to solving the multi-attribute problems moreover, for the construction modeling of the domains of weighting criteria also. It is crucial to overview another method from the other perspective to formulate the better solutions. In other words, the more research that addresses the excess and the deficiency from any MADM method is the better. It could be used as benchmarking analysis tools among the subset of MADM methods. And bring us to the larger horizon in case of the multi-attribute decision making problems.

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