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Utilization of Design for Modularity Approach to Identify Product Platform

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Abstract

The aim of this paper is to propose a methodology to identify platform from a product variants based on modularity approach. The modules are identified by utilizing two well-established approaches. Two case studies of two types of consumer products have been carried to clarify the methodology .i.e. product which can be categorized from different family and same family. The result shows that the platform can be identified systematically.

Keywords: Modularity approach, Platform, Product family

1. Introduction

Companies are striving to produce products at low cost at shorter time. One of the best and preferred approaches is design for modularity approach. There are a lot of advantages and one of the main focus is the capability to formulate the common part that can be shared among the product variants namely product platform. The application of product platform has been suggested as a key component of a well-targeted development strategy for companies that aim better utilization from limited resources. Manufacturers and customers sometimes do not realize that most of the product in the market shares common parts or assemblies, namely platform. Platform architecture is a set of selection and configuration choices shared among products (Gonzalez-Zugasti, Baker and Otto, 2000, pp. 61-72). Product platform can be formulated as a general optimization problem in which the advantages of designing a common base must be balanced against the constraints of the individual product variants and of the whole family. Zugasti et al., (Gonzalez-Zugasti, J., Otto and Baker, 2000, pp. 61–72) defines product platform as a set of shared functionality across multiple products from similar or different family. Each different product supported by the platform is called a variant, while a set of all variants derived from a platform formed a product family. Product platform can be classified into four based on product brand and family (Abdullah and Ripin, 2003, pp. 333-345);

(a) Products from same brand and family

(b) Products from same brand but different family

(c) Products from different brand and family

(d) Products from different brand but same family

There are several approaches used in platform development, whether during, before or after product is designed. Some of the examples in developing platform are Sudjianto and Otto (Sudjianto and Otto, 2001) from multiple brand product using brand architecting rules for product modularization, i.e. dominant theme of product functions and aesthetic forms, brand signature and platform rules. Zugasti et al. (Gonzalez-Zugasti, Baker and Otto, 2000, pp. 61-72) used models of several spacecraft to identify possible subsystem that could be made common to all or some of the missions. Similarly Ripin and Abdullah (Ripin and Abdullah, 2001, pp. 190-199) developed modular UAV based on the multi-mission requirements optimization. The advantages of product platform are that by using proven modules that are known to operate effectively at their designated sub-tasks can minimize design risk. Further, reuse of previously designed modules can bring saving at least in part, the cost of redeveloping those sub-system. Product platform also could reduce design risk and also deduct time and cost to market (Martin and Ishii, 2002, pp. 213–235).

The concept of product platforms and design variants has been successfully applied to wide range of product especially consumer and industrial product. For example Sony used three platforms to support hundreds of different personal portable stereo product in its Walkman family and as shown in Figure 1 seven variants are developed i.e. cordless delta sander, cordless reciprocating saw, cordless jig saw, cordless circular saw, cordless hedge trimmer and cordless grass trimmer by using common main housing and battery mounter. Lately several names from automotive company such as

Volkswagen also takes the advantages of platforming and components commonality by sharing between its four major brands such as VW, Audi, Skoda and Seat (Bremner, 1999, pp. 30-38). (See Figure 1)

This paper emphasis on development of methodology to identify platform from variants of product based on modularity approach. The methodology involves three steps; product variant listing, module identification and platform identification. Two cases are present from same and different product family.

2. Methodology

This approach starts by listing of variants from product family. Then products are decomposed into the lowest level of components for better understanding of the physical configuration of the product. Then modularization takes place, where two established modular approaches are utilized in determining the modules and finally platforms identification. The idea of platform development can be generally visualized as shown in Figure 2. For example there are three variants that have three modules each. Module 1 from variant A consist of components 1, 2 and 3, while module 1 from variant B consist of components 1, 2 and 4 and finally for variant C consist of components 1, 2 and 3. As a result after applying algorithm in Figure 3, platform that consists of components 1, 2 and 3 can be developed. This is similar to module 2 and 3. (See Figure 2)

Based on that idea, an algorithm is developed to systematically identify the platform. Consider a variant of products with i number of models, $V = \{1.....i\}$ and C_{Vi} is list of components in the variant i. After the module identification methods have been applied, there are p_i numbers of modules in each variant. The interaction between modules or similarity between modules in terms of components consisting in the modules of variant i and i+1 is consider as platform i, $m_{1V1} = m_{1Vi}$, the process is continue till there are no more platform can be identify. The algorithm can be formulated as follow;

Step 1: List down the variants, V_i ($i = 1, 2, \ldots n$)

Where n = number of variants

Step 2: List down the components in each variants, $C_{Vi} = \{\quad\}$

Step 3: Applying the conventional module identifications methods.

Step 4: Set $j = 1$ ($j = 1, 2 \ldots p$)

Where p = number of modules

IF, $m_{1V1} = m_{1V\,i}$,

m_{1Vi} = {Components in module 1 of Variants i}

THEN, $P_1 = \{m_1\}$

P_1 = Platform 1, m_1 = {Similar components in the module from the variants}

ELSE, rearrange the module

END IF.

Step 5: Set $j = p + 1$ and m_{p+1} GO TO step 4

Step 6: IF, $m_{p+1V1} \cap m_{p+1V\,i} = \{m_r\}$

$m_{p+1V\,i}$ = {Components in module p of variants i}

m_r = {Components in module p of variants 1 that intersect with components in module p of variants i}

THEN $P_q = m_r = \{m_{p+1V1} \cap m_{p+1V\,i}\}$

IF, $m_{p+1V1} \cup m_{p+1V\,i}$

THEN $P_q = m_r = \{m_{p+1V1} \cup m_{p+1V\,i}\}$

IF, $m_{p+1V1} \neq m_{p+1V\,i}$

THEN $P_q = \varnothing$

END IF

Step 7: Delete all modules associated with Platform, P_p from the module, GO TO step 4

Step 8: IF $M_A = \varnothing$, STOP

An approach developed by Huang and Kusiak (Huang and Kusiak, 1998, pp. 66-77) and Stone et al, (Stone, Wood and Crawford, 2000, pp. 215-31) are applied in identifying modules. This approach is then extended to be complying for a list of variants in the family. After the platform is developed, the necessary action need to be done in order to fulfill shared requirements. Finally the potential candidate is further proceeding for redesign.

3. Implementation

3.1 Product from Different Family

In this case study, 3 types of consumer product have been used. Products from different family can be described as product which is physically having no similarity (Dobrescu and Reich, 2003, pp. 791-806). The selected products are flour mixer, blender and juice extractor as shown in Figure 3. Figure 4 show the physical decomposition and Figure 5 list the components in the products. (See Figure 3, Figure 4 and Figure 5)

Next step is to examine flow and functional chains for each of the products to construct the function structure. Modules containing in the mixer, blender and juice extractor can easily be identified after the function structure has been fully built using dominant flow, branching flow and conversion-transmission rule methods developed by Stone et al. (2000). In order to identify platform, the algorithm is applied As a result, from Table 1 four platforms can be developed;

(1) Transmit electricity module

(2) Transmit rotation module

(3) Actuating module

(4) Convert electricity module

The platforms are represented in shaded blocks. From the identified platforms, it can be concluded that the motor and switch modules are the most potential module that can be platformed. (See Table 1)

3.2 Products from Same Family

For the products from same family, also three products have been selected i.e. the table fan, wall fan and stand fan. Here products from same family can be explained as a list of products, which have some similarity either in terms of functionality or physical configuration. The steps taken are similar to the previous case study, where it begins with decomposition of the product to identify all components in the products. The decomposition can be demonstrated in the form of hierarchy structure. There are five sub-system and mechanism of fan as decomposed in the Figure 6, with total of 22 components for all three variants of fan family as listed in the Figure 7. Here switch panel and motor assembly are considered as a single component. (See Figure 6 and Figure 7)

As are result after applying the module identification approach developed by Huang and Kusiak (1998), 5 modules are identified as shown in Table 2. (See Table 2)

The algorithm is applied to identify the platform and as a result five platforms are identified as summarized in Table 3. For platform A, B and C there is clear decision in platform selection, where all three variants own the same components. But for platform D, conflict occurs where for module **δ**, components 20 and 22 contain in variants 3 only, not in the other variants, whereas component 14 only in variant 2 and not the other variant. But by considering the physical structure of the components, only components 12 and 13 can be combined to become a platform. The components not in the platform could be the specials features where dissimilar comes in. (See Table 3)

4. Discussion

This paper has presented the methodology to identify platform from the group of product variants from same and different family. Two conventional module identification methods are applied. The paper is not intent to compared between the approaches, but want to prove that the developed algorithm is able to easily identify platform even the approach used is different. The extended algorithm is proposed in order to ensure that the identified platform own features that can be shared among the variants. In the algorithm, the platform is developed based on the similarity of the module identified among the product variants in terms of functionality and physical configurations of the components. From the case studies, out for each fan family and products from different family shown that there are several potential platforms but with a minor modification needed to accommodate components sharing among product variants.

5. Conclusion and future works

This paper has looked into main objectives, which is developed product platform by using modular approach. After the modules are identified, an extended approach has been developed to form platform. From the case studies indicate that the platform form several variants of same family and different family can be identifying systematically. This approach also can be further extended to other module or parts in order to increase the commonality of the product.

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www.allproducts.com.tw/prc/toomly/p05.html

Table 1. Platform identified from the approach.

	Module		
Product Family	*Dominant flow*	*Branching flow*	*Conversion-Trans*
Mixer	1. Hand Interface	1.Coupling/ decoupling	1. Convert electricity to
	2. Coupling	2. Decoupling	rotation
	3. Mounting	3. Actuating	
	4. Mixture Containment		
	5.Transmit rotation		
	6. Transmit electricity		
Blender	1. Soft food containment	1. Soft food containment	1. Convert electricity to
	2. Hard food containment	2. Hard food containment	rotation
	3. Coupling	3. Weight Transmission	
	4. Transmit electricity	4. Actuating	
	5. Transmit rotation	5. Food removing	
Juice Extractor	1. Transmit electricity	1. Actuating	1. Convert electricity to
	2. Fruit Guide	2. Fruit Guide	rotation
	3. Transmit rotation		
	4. Waste storing		
	5. Juice storing		

Table 2. Module identified from the algorithm

Module	Variant 1	Variant 2	Variant 3
ά	1, 2, 3, 8	1, 2, 3, 8	1, 2, 3, 8
β	4, 5, 6, 7	4, 5, 6, 7	4, 5, 6, 7
γ	9,11	9, 10, 11	9, 11
δ	12, 13	12, 13, 14	12, 13, 20, 22
ε	14	-	14
λ	-	17, 18, 19, 20	-

Table 3. Platform identified from the approach

Platform	Variant 1	Variant 2	Variant 3
A	1, 2, 3, 8	1, 2, 3, 8	1, 2, 3, 8
B	4, 5, 6, 7	4, 5, 6, 7	4, 5, 6, 7
C	9, 11	9, 11	9, 11
D	14	14	14
E	12, 13	12, 13	12, 13

Figure 1. A series of products variants that share battery and main housing
(www.allproducts.com.tw/prc/toomly/p05.html)

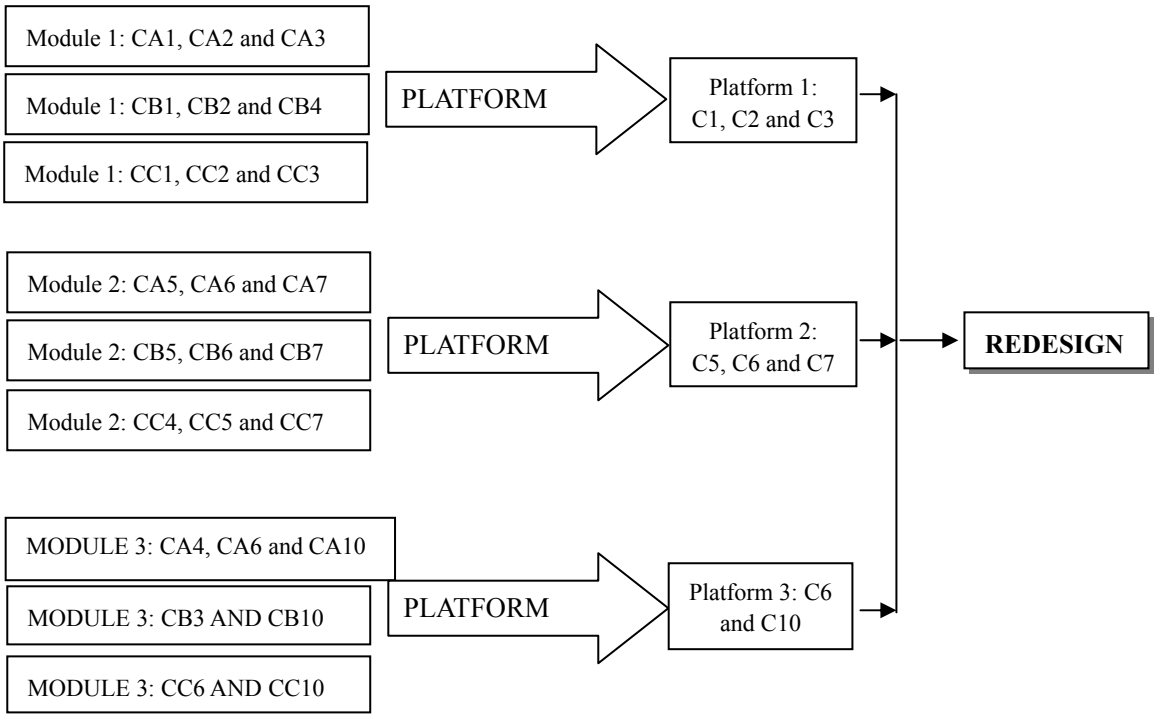
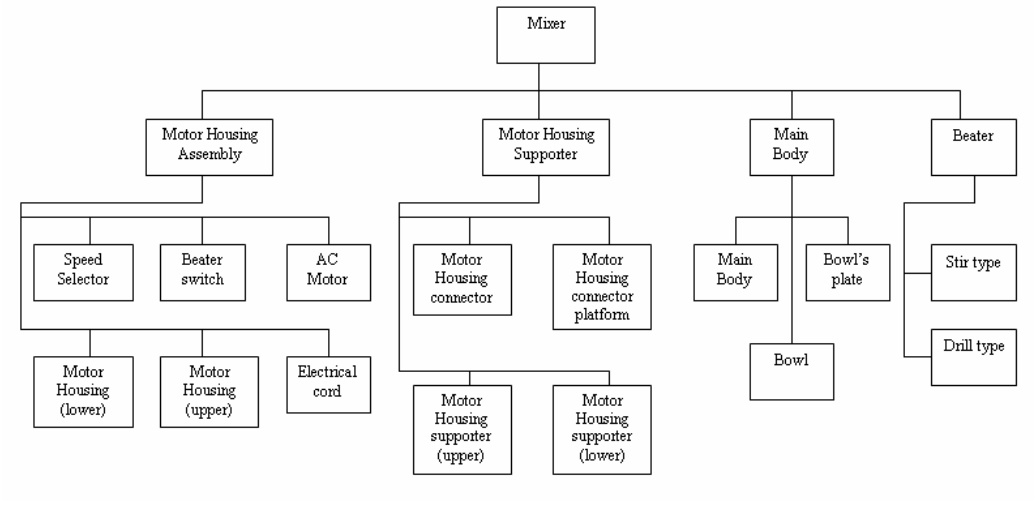


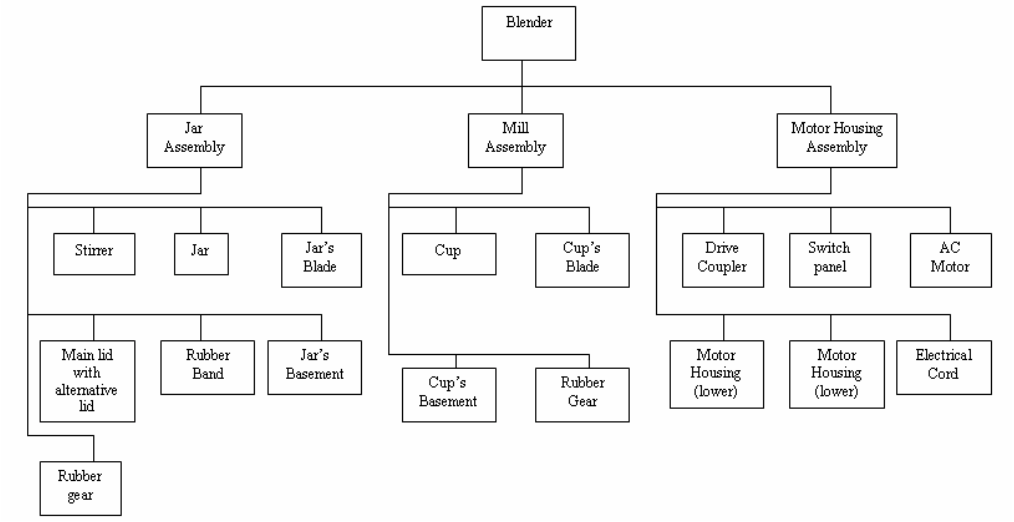
Figure 2. A generalize platform identification flow process

(a) (b) (c)

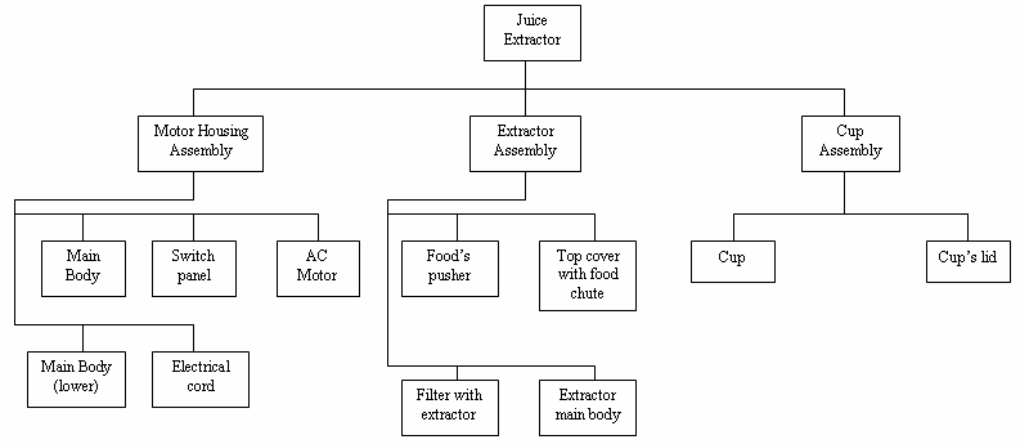
Figure 3. Customer products from different family



(a)



(b)



(c)

Figure 4. Physical decomposition of product (a) mixer, (b) blender and (c) juice extractor

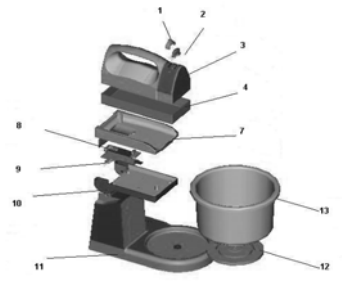
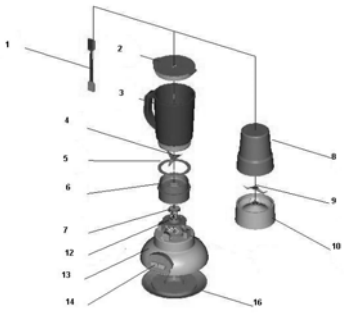
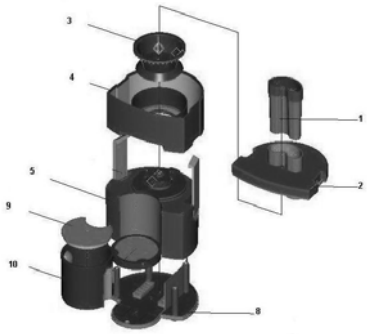
					
1	Speed Selector	1	Stirrer	1	Pusher
2	Beater Switch	2	Main lid with alternative lid	2	Top cover with food chute
3	Motor Housing(upper)	3	Jar	3	Filter with extractor
4	Motor Housing(lower)	4	Blade	4	Extractor Main Body
5	AC Motor	5	Rubber Band	5	Main Body
6	Electrical cord	6	basement	6	Switch panel
7	Motor Housing Supporter (upper case)	7	Rubber Gear	7	AC Motor
8	Motor Housing Connector	8	Cup	8	Main Body (lower casing)
9	Motor Housing connector (platform)	9	Blade	9	Electrical cord
10	Motor Housing Supporter (lower case)	10	Basement	10	Cup
11	Main Body	11	Rubber Gear	11	Lid
12	Plate	12	Drive Coupler		
13	Bowl	13	Motor housing (upper case)		
14	Stir type	14	Switch panel		
15	Drill type	15	AC Motor		
		16	Motor Housing (lower case)		
		17	Electrical cord		

Figure 5. Part listing of (a) mixer, (b) blender and (c) juice extractor

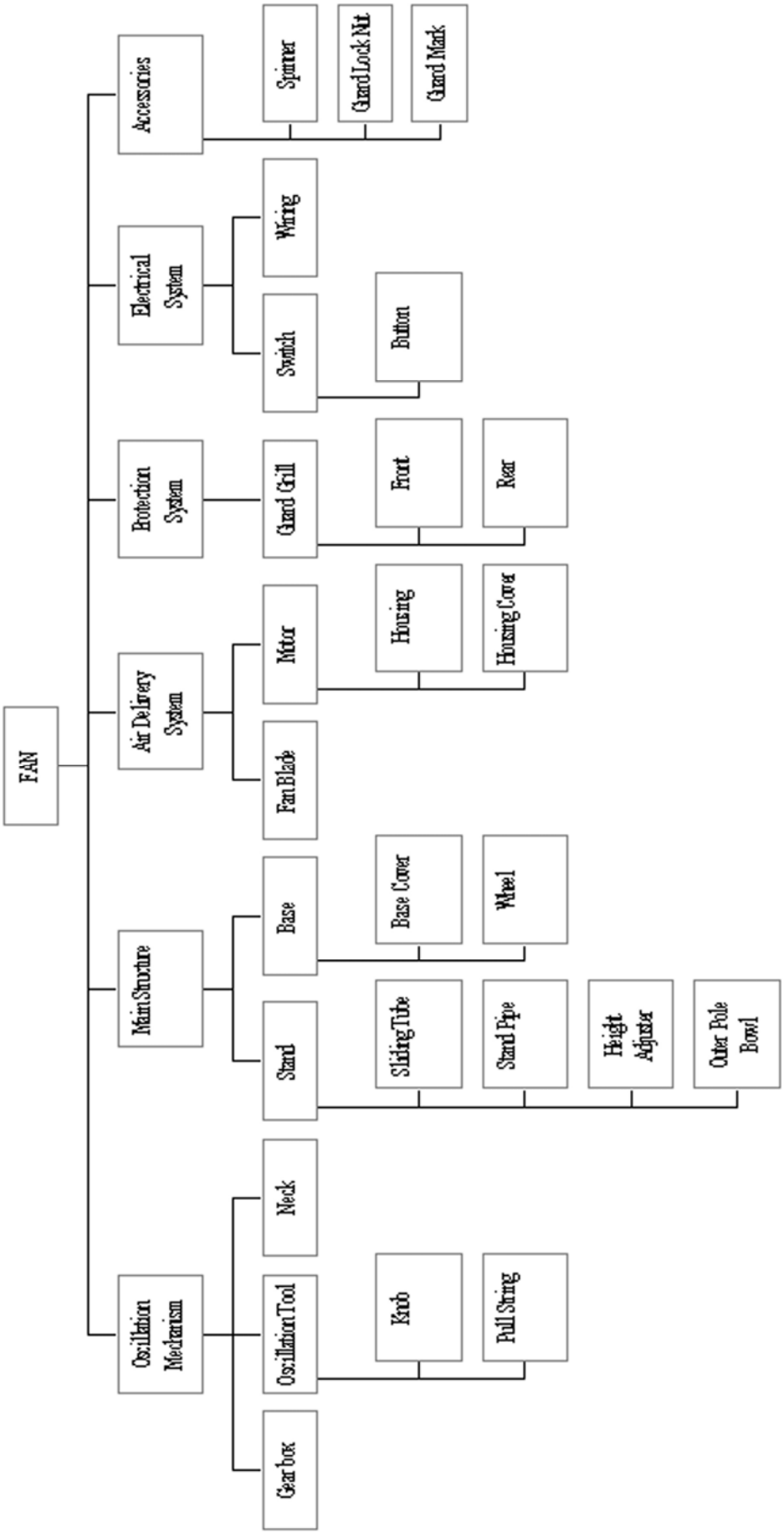
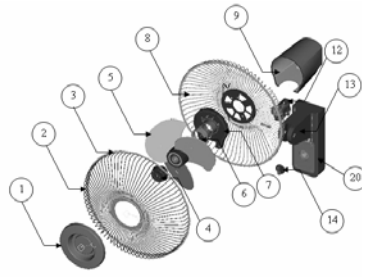
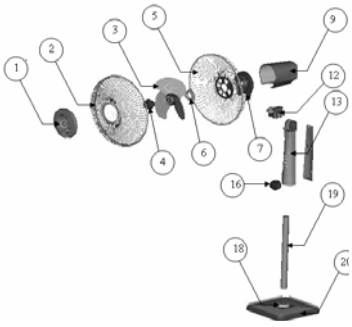


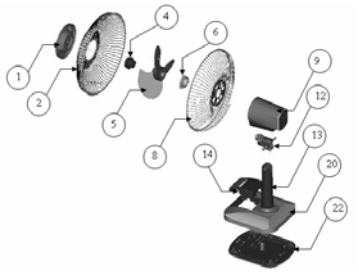
Figure 6. Physical decomposition of table fan



1	Guard Mark
2	Front Guard
3	Guard Ring
4	Spinner
5	Fan Blade
6	Guard Lock Nut
7	Housing Cover
8	Rear Guard
9	Motor Housing
11	Motor
12	Neck
13	Stand
14	Switch Panel
15	Pull String



1	Guard Mark
2	Front Guard
3	Guard Ring
4	Spinner
5	Fan Blade
6	Guard Lock Nut
7	Housing Cover
8	Rear Guard
9	Motor Housing
10	Oscillation Knob
11	Motor
12	Neck
13	Stand
14	Switch Panel
16	Height Adjuster
17	Sliding Tube
18	Outer Pole Bowl
19	Stand Pipe
20	Base
21	Wheel



1	Guard Mark
2	Front Guard
3	Guard Ring
4	Spinner
5	Fan Blade
6	Guard Lock Nut
7	Housing Cover
8	Rear Guard
9	Motor Housing
10	Oscillation Knob
11	Motor
12	Neck
13	Stand
14	Switch Panel
20	Base
22	Base Cover

Figure 7. Part listing of product (a) wall fan, (b) stand fan and (c) table fan