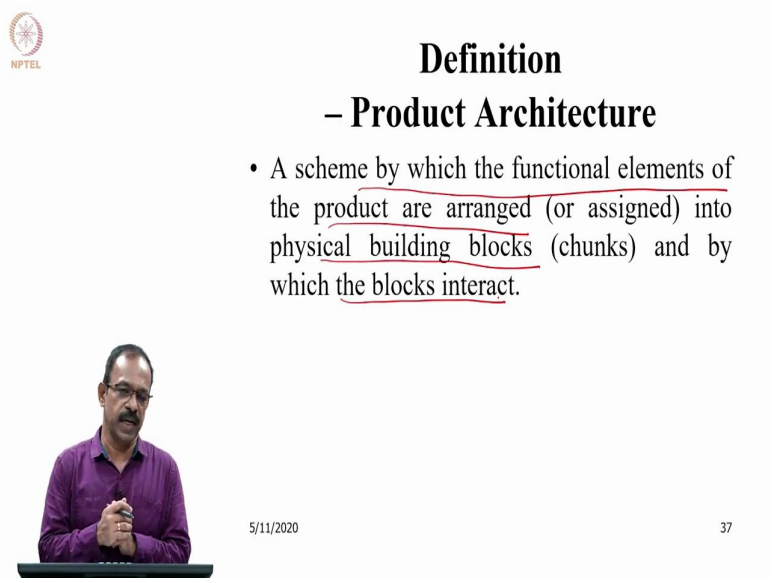
Functional and Conceptual Design
Professor Dr. T. Asokan
Department of Engineering Design
Indian Institute of Technology, Madras
Lecture No. 21
Product Architecture

(Refer Slide Time 0:15)



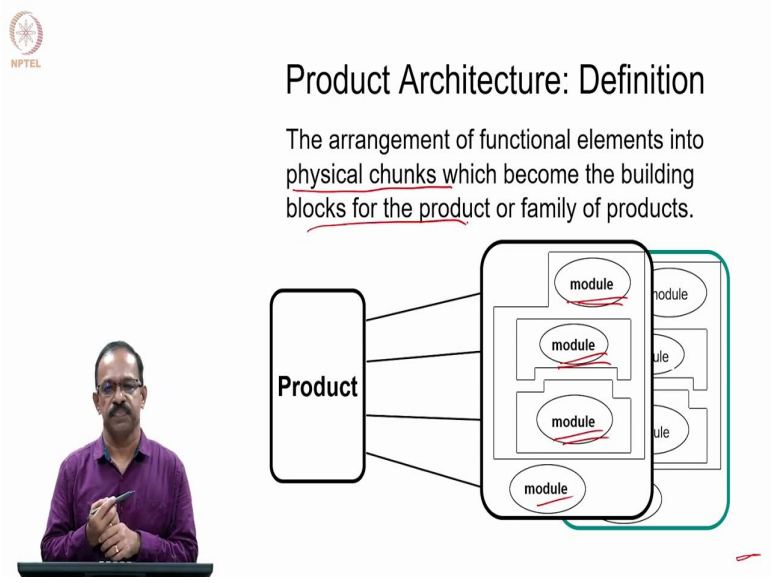
Good morning, welcome back to the discussion on product and portfolio architecture. In the last class we discussed portfolio architecture and what are the different types of architectures in the portfolio, and what is the method by which we can decide the number of products in the family as well as the individual structure of the product. So, that is what we discussed in the last class. Today, we will move to the product architecture.

So, the portfolio talks about the family, but then product architecture talks about individual products, how do we actually identify the architecture of an individual product. We saw that the product architecture is defined as a scheme by which the functional elements of a product are arranged into physical building blocks and by which the blocks interact. So, we need to check how these individual building blocks can be identified and then how we can have a proper interaction between these individual building blocks.

So, as I mentioned earlier, the functional blocks need to be converted to physical blocks. And then these physical blocks need to be identified, what are the functions that can be combined or what functions need to be kept separate. So, that actually decides which are the building

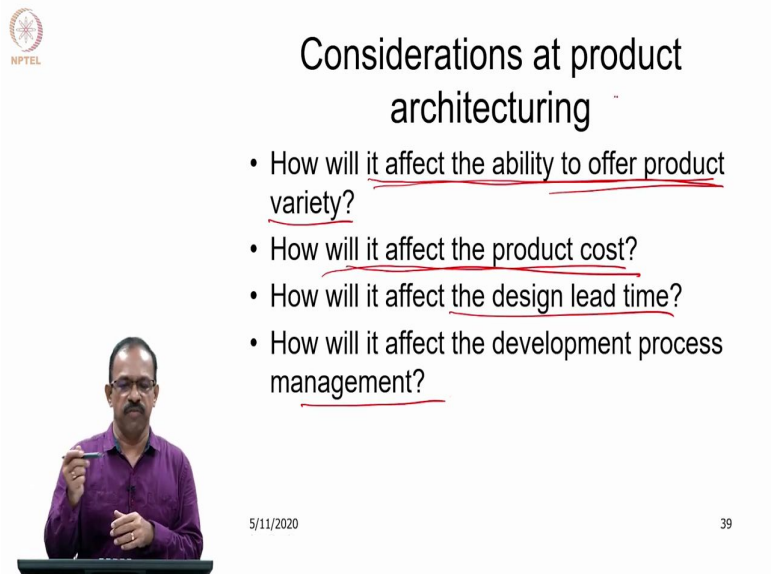
blocks, the physical building blocks, and based on that we will decide the architecture of the product.

(Refer Slide Time 1:40)



Also we saw that we can actually have different modules in a product. If it is the modular one, we can have different modules. So these modules are the chunks which actually provide a set of functions in the product. So it is the, the physical chunks, which become the building blocks for the product.

(Refer Slide Time 2:01)



So the architecture basically depends on the ability to offer product variety. Okay, so, if you want to have multiple products in the family, then the individual product architecture also should satisfy that requirement, though you should be able to provide a family of products without making too many changes in individual products. So, that is why we need to know how this is going to affect the ability to offer a variety of products. Similarly, how is it going to affect the product cost?

So, if you want to make every product as an individual one without much sharing of components, then the cost will go up. So we need to make sure that without increasing the product cost, we should be able to offer the product variety and accordingly we need to have the product architecture. And then the design lead time and the process management. So, these are the factors that will actually affect the product architecturing.

(Refer Slide Time 2:56)

Let us look at these products, what you are seeing on the screen. So, if you look at this product, as an individual product, you can see that there is only one physical chunk in this product. All the functions needed in this product, this spanner is actually provided by one physical element, there are no multiple elements, and there are no parts. So, it has all multiple functions, it has to hold the nut head, it has to apply the torque, someone has to hold it, or we should be able to use this for tightening or loosening different sizes of nuts.

So, we can actually see that all these functions are combined into a single physical block. So, that is one type of architecture we can think of where all the functions can be mapped to a

single physical block or a physical chunk that can actually provide multiple functions in the product. So that, that is one type of architecture you can think of in a product. So all these products, so they are in the family.

Okay, they are actually a family of products but each individual product you take, if an individual product is having only one physical chunk that provides you multiple functions. And then of course, this, the family architecture, you should take the portfolio, then it is actually unshared architecture, there is no sharing of anything in between, in between these parts. Now take the example of this product. It is also doing the same function of a spanner, only thing, this is an adjustable spanner, so we can actually have, and we can use it for tightening or screwing different sizes of screw nuts or the screw heads, bolt heads.

Now, if you look at this product, you can see that it is actually not a single block, there are two-three elements in this one. So there is an adjustment screw here and there is this movable job and then you have a physical block. So you can actually say that it is providing this function using two or three elements. And then if you want to have a, a different size for adjustable size, you can actually use the same screw, the same kind of handle only thing that we need to adjust, this part which actually needs to have a larger size or a smaller size. So, this way, you will be able to provide multiple functionalities, and the functionalities are actually provided using one or more elements.

So, here actually there are more physical chunks which actually helps you to provide the function. And similarly you can actually see this one, so here all the individual products are actually having multiple elements and when you combine these multiple blocks, you will be able to provide the main function in the product. Individual elements will be having their own function, but when you combine these multiple elements, the handle, the head, etcetera, if you combine, then you will be getting different functionality.

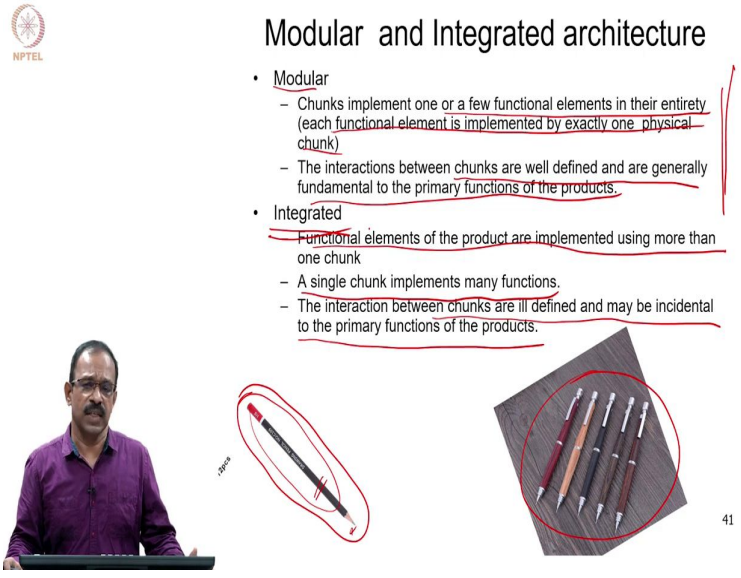
So, that is one way of, the two ways in which you can actually identify, develop individual products. Other examples are aeroplane if you take it, so, you can actually see that this engine, there will be a slot in the main assembly, where you can actually attach the engine. So, engines of various configurations can be connected to this one. Similarly, the fuselage, the wings and other things, each one can be considered as a physical chunk which provides a

particular function, but then if you combine all these physical chunks you will get an overall function of the product.

So, these are the two major architectures you can identify in products. So, we call this as an integral architecture. So, when there is only one physical chunk which actually provides you the function needed in the product, then we call it an integral architecture. When there are no multiple elements, only a physical chunk, mostly one physical chunk is providing all the functions then we call it as an integral architecture. And if there are multiple physical chunks when combined together to give you a product, the product function, then we call it modular architecture.

So, integral and modular are the two important architectures that can be thought of when you have a product architecture. So, these are the main architectures used for designing products. So, integral one will always look at combining all those functions into a single physical chunk and modular, look for different modules which individual functions and then combine them in different ways to get the function of the product update. So, these are the two major architectures for products.

(Refer Slide Time 7:55)



A modular and integrated architecture. So, a modular architecture, the chunks implement one or few functional elements in the entirety, each functional element is the physical chunk that is the modular one. So, you have multiple physical blocks, physical elements implementing the functions to get the overall function of the products. Then the interactions between the

chunks are well defined, and are generally fundamental to the primary function of the product.

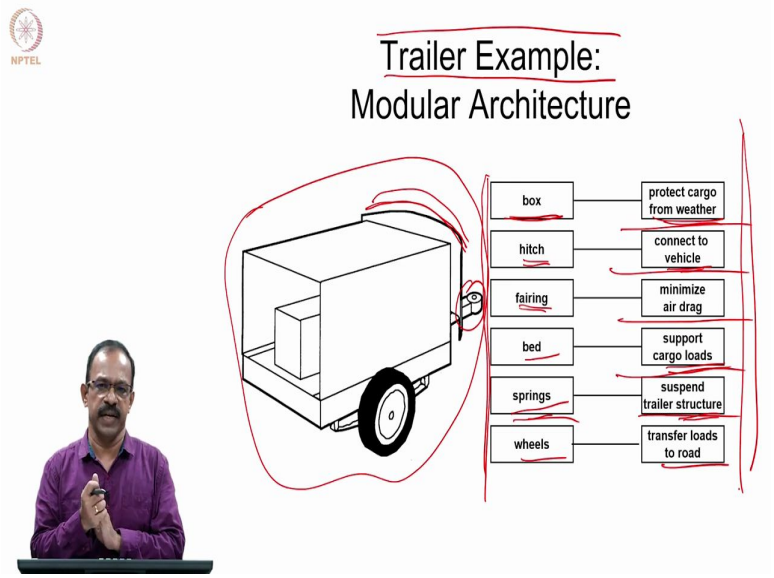
So, if you have multiple physical elements then each, the function of each one is well defined, and you know that how this can actually be integrated to the main building block. For example, if you take this set of pen, so each pen or the mechanical pencil, you know that there are multiple elements, each one has got its own function, the body has got some function, the tip has got its own function and the control, and one has got its own function. So each one has got its own function, so each is, each one is a physical block.

And when you combine these physical blocks, you get the function of the product. So that kind of an architecture is known as modular architecture. But contrary to that, if you have an integrated architecture, the functional elements of the product are implemented using. So in this case, a single chunk implements many functions. So you have one single chunk, which actually implements many functions in the products and the interaction between the chunks are ill defined and maybe incidental to the primary functions of the products.

So that is the way how the integrated architecture is defined. So you can take an example of this pencil. So, you can see in this pencil one chunk, which actually provides many functions in the product. So, almost all the functions of this pencil are provided by the whole chunk though there are multiple elements in this one, but each one is, everything is combined together into a single element and it provides the function. It is very difficult to identify the interaction between them, how each element is interacting is very difficult to identify, for example, this lead, the tip and the wooden block.

So all these are actually integrated, and there is no separate interaction between them, or there is no separate interface between these elements. So, that kind of an architecture is known as an integrated architecture. So, these are the two major types of architectures that you can see in the product. And most of the time as I mentioned earlier also, you will see more products in the modular architecture, because that helps you to very limited products using integral architecture.

(Refer Slide Time 10:29)



So, these are some of the examples for this architecture. I will just take the trailer as an example. You will see these kinds of trailers which are attached to the trucks to carry loads or it can be attached to the truck and then you can take it. Now if you look at this as a product and as its architecture, you can see there is a box which actually is to protect the cargo from weather and there is a hitch which actually connects to the vehicle, so which is the hitch.

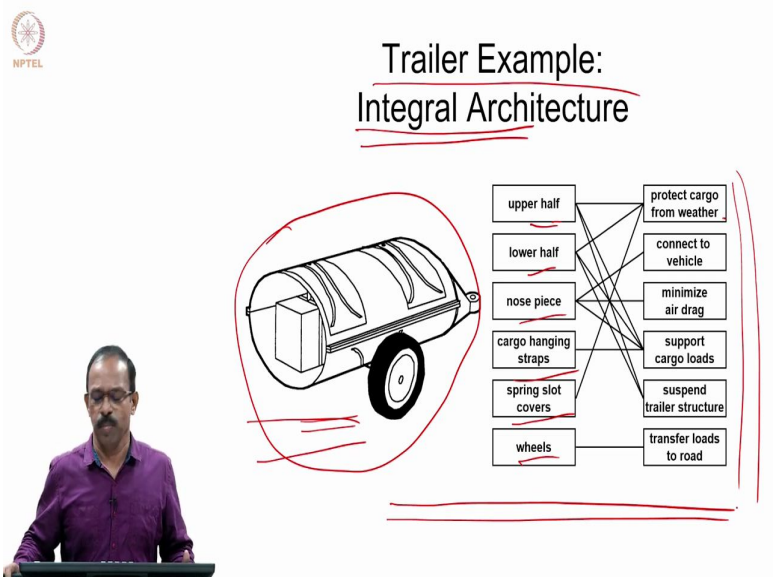
Then there is a fairing which is known as the fairing, which actually provides the air drag reduction, then there is a bed at the bottom, then the supports the cargo loads, then the springs which actually suspend the trailer structure and the wheels transfer loads. Now you can see each physical block has got some function to do and it does that function and when you combine them it provides the overall function of the trailer.

So, that is the typical modular architecture where you have multiple modules. Now, if you want to change the fairing, so you feel that, okay, it is not providing you enough air drag or there is a case where actually that is not any critical factor, then actually you can remove it and then you can put something else there. Similarly, if you feel that the spring, the suspension part is not doing well or it needs to be modified for a different application or another product, you can easily change it and get a new product variety in the market.

So, that is the modular architecture. Now, if you have the same as an integral architecture. Suppose you think that okay the trailer can be made as an integral architecture, because you

have a large requirement for this, so you need not make separate parts or assemble. So, you can actually have it as an integral architecture where you will be having a structure like this.

(Refer Slide Time 12:32)



Now you can see, this is the integral architecture. You have the upper half, lower half, you can actually identify upper half, lower half, nose, cargo hang, straps, spring slot, covers and wheels as the elements, but you cannot really identify them as a separate, each one doing a particular function because all the functions will be actually it will be doing multiple thing and you will not be having any separation between these individual physical chunk. So each physical chunk may be doing multiple things and there is no definite interface between these elements, so that kind of architecture is the integral architecture.

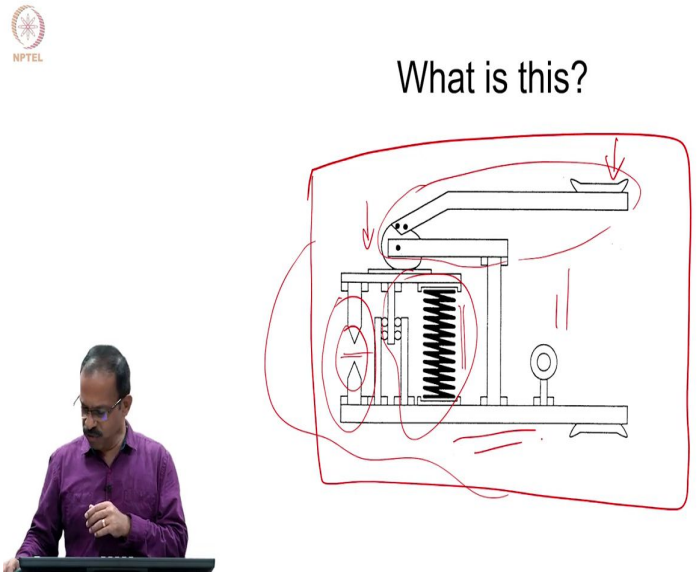
You can see that the upper half is actually to protect cargo, it can actually support cargo loads, it can actually suspend trailer structure also. So, there may be many things which actually this element is doing and very difficult to tell what actually each, each physical chunk is doing in this case, together they provide the function that is the integral architecture that you can see in this case. So, the same product can actually be designed with a modular architecture or an integral architecture, but that depends on what the final outcome that we are looking for.

In this case, if you are not looking for any large variations in the product, and you can actually give the same product to everyone, you do not need to make it into separate assemblies because, or different modules, because you are not going to change any modules

to get a different product. So in that situation, an integral architecture is one of the best options for a product.

But if you are expecting a change in a variety of the product or people are looking for various options in this particular product, then it should be always good to go for a modular structure so that you can actually modify some of the modules to get a new product to meet the customer's requirements. So, the decision whether to go for a modular or integral depends on various market dynamics as we mentioned earlier, but these are the two architectures you can always consider when we are going for a product design.

(Refer Slide Time 14:42)



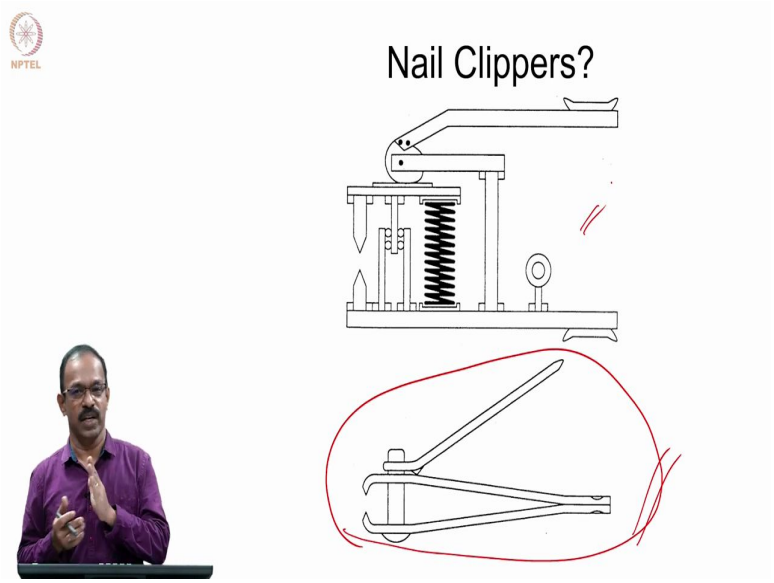
This is another example. If you look at this product, what you are seeing here, can you identify what is this or what actually this represents? You can see there is a tool tip, there is a mechanism to apply some force and there is a mechanism to increase the force here, and it can do some cutting operation here and there is a spring which can actually bring it back also.

So, if you look at your nail clipper as a product, then you will see that this nail clipper is actually having, if you take that as a modular structure, then you can see these are the elements that you can actually have in a nail clipper. Because you can have an element, function blocks which actually can use the apply force, a block which can actually increase the force and then get the spring back and then say block which can actually provide the

cutting tips, the tooltip and this way, and there is a base which can actually be used for applying the force, using a, applying the finger force.

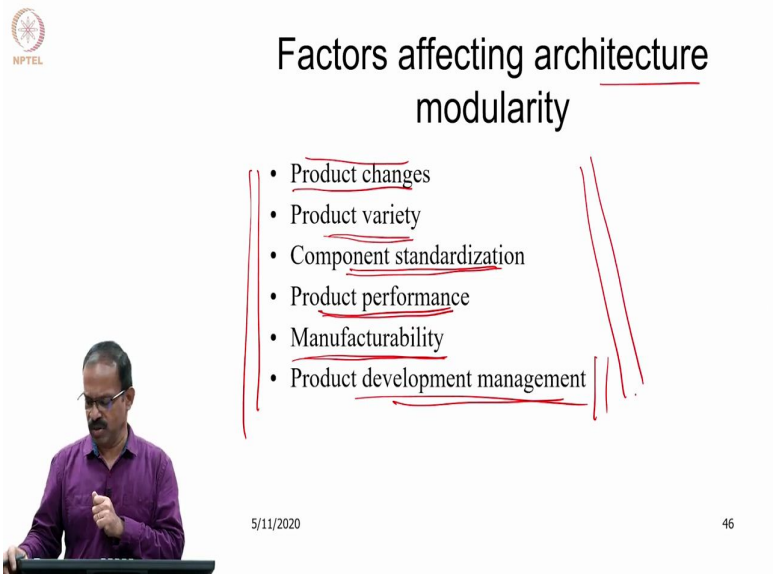
If you look, a nail clipper as a modular structure, then actually you can, you will be able to get this many modules. But most of the nail clippers are not designed in modular architecture, they are actually made an integral architecture where you do not need to, you cannot really change each one of these, because the functions are actually shared between the physical sense and you will not be able to get a clear differentiation between the physical chunks which provide the, the functions, okay.

(Refer Slide Time 16:30)



If you look at the same as a clipper, you can actually see this is the nail clipper in an integral architecture. So, this is an integral architecture where actually the physical block provides all the functions and it is very difficult to distinguish between the different physical blocks and their individual functions because there will be a lot of sharing of functions between the elements and then you will not be able to see it as an individual module. So that is the integral architecture and this is the modular architecture. And as I mentioned, the modular one is most preferred, because the modular modules allow us to provide a variety of products. So, depending on the portfolio architecture, you can actually take a call on whether to go for an integral or a modular architecture.

(Refer Slide Time 17:21)



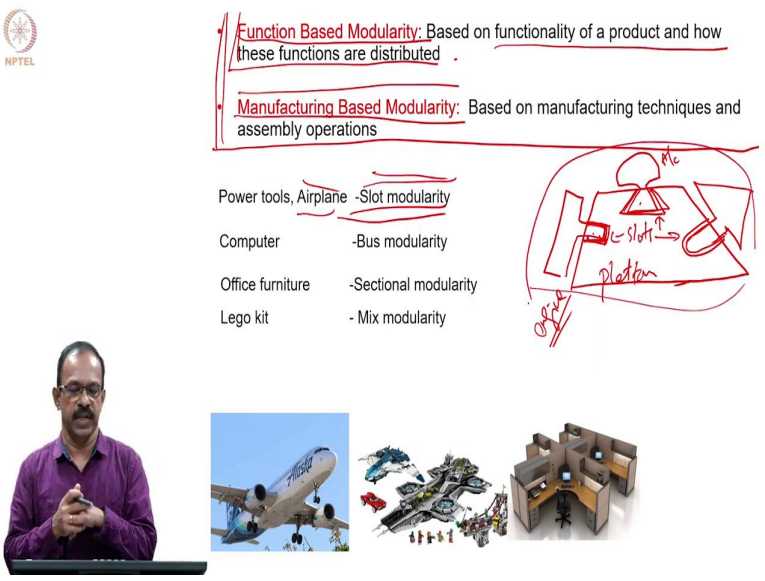
This briefly mentions what are the factors that are affecting the architecture modularity; so the product changes. So, if you think that the product may change after some time, then you may have to go for a modular one and if you are expecting a number of varieties to be brought into the market. Similarly, the standardization of components. Suppose there are some standard components available for a particular function, then you can actually buy those standard elements or you can develop the standardized components and then use it.

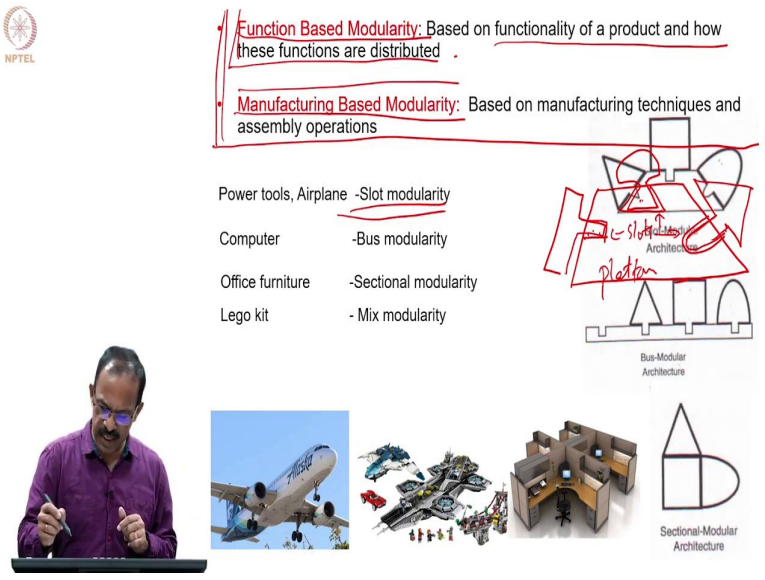
In that case, you do not have much of an option, you have to use those standards and then develop the products. And then, the performance of integral architecture and the modular architecture may not be the same depending on the number of modules and the interfaces that you need to provide, the performance may degrade in some of the modular architectures and some performance cannot be achieved in the integral architecture.

Looking at the product performance again you need to take a call on, to have that architecture and then, the manufacturability and product development management. And if you make everything as integral then the manufacturing will be a problem. So, you may not be able to manufacture it in the form of an integral architecture, you may have to make it multiple elements and then combine them. That also needs to be taken into account when we have to decide the architecture of the product and of course, how long it will take, how much, how many people may be needed in, if you go from one architecture to the other architecture so

that actually comes from the management aspect. So looking at all these, you need to take a call on the architecture development or deciding the architecture.

(Refer Slide Time 19:15)





Now, there are two ways to look at the modular architecture. Since we found that modular is the most common, popular one, we look into the modular architecture and then see what are the different types of modularity that are normally provided in the product, or normally adopted in the product development. So, one is known as the function based modularity, that is, based on the functionality of a product and how these functions are distributed, you can identify the modules.

So, for each function you can identify a module and accordingly we can develop modules and then make the product that is basically known as the function based modularity. But the other modularity is basically on the manufacturing base modularity. So, some of the products may require a lot of manufacturing and there will be different manufacturing techniques that can be used for this.

So, depending on the manufacturing easiness we can decide okay this particular module is easy to manufacture so let us make this as a particular module and some part can actually be manufactured using a particular process, then there, all those, which requires that kind of a process can be put into together as a module. So, this way depending on the manufacturing requirement, we can identify modularity.

So, these are the two kinds of modularities, normally employed in the product architecture, that is the function based modularity and manufacturing based modularity. Now, this modularity if you look at the modular architectures, so these are, there are different ways in which this modularity can be achieved in the product. Now, assuming that we are going for a modular architecture, we can actually think of four types of modularity that can be brought into the product based on the, mostly on the function based modularities.

So what we do is to look at how these modules can actually be combined together. And based on that, we will identify the modularity. So, one of the most common modularities is known as the slot modularity. In slot modularity, what we do is that we will have a basic assumption, we have a basic platform available onto which we want to add modules. So, that kind of modularity where we provide some kind of slots in the product.

So we provide a slot, this kind of a slot or we provide a slot like this and then we can actually add components whichever component actually meets this slot, we can add to this. Similarly, we have a product, a module, which actually has got this slot or a component with this slot. So, this base platform, so we call this as the platform, based platform and these are the slots available.

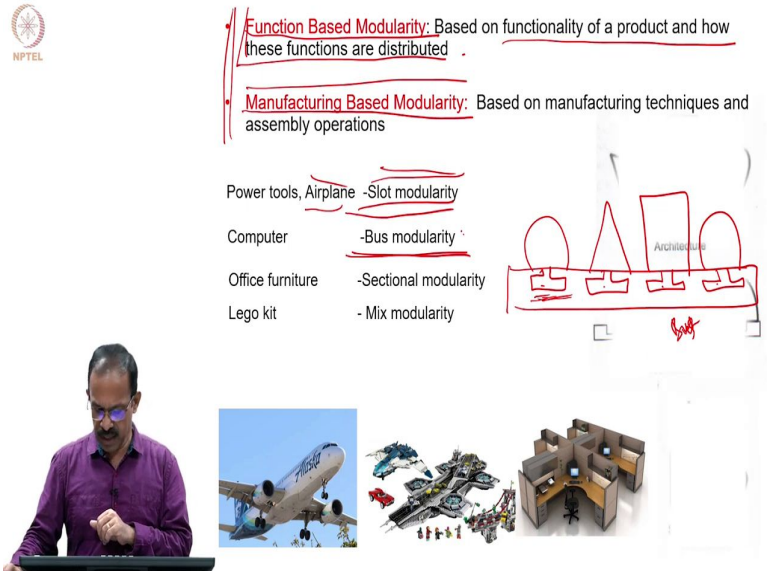
Any module with a slot like this can be attached to this product that is the slot modularity. So, if you take an example of an aircraft, you will see that there will be a slot for an engine. So, any engine which actually has this kind of slot can be fitted to this particular aircraft.

Similarly, you have an air conditioning system and any air conditioning system which has got a slot like this to suit this product can be fit into this.

It does not matter whether who is manufacturing it, what is the other specification and all as long as this actually matches the slot that is available, you will be able to fit into this product. So, that kind of modularity is known as slot modularity. So, you can actually see many products in this format. If you take your power tools, electrical drills, hand drills or any other electrical drills, there will be a slot for an electric motor.

As long as the motor has got a slot or interface suitable to this machine, you will be able to connect any motor. So it does not really matter what kind of motor so as long as it is actually having the same slot, you will be able to connect. So that kind of products are having this slot modularity. So this is one of the commonly used modularities in the products. Especially in the modular architecture, you will be having this slot modularity.

(Refer Slide Time 24:11)

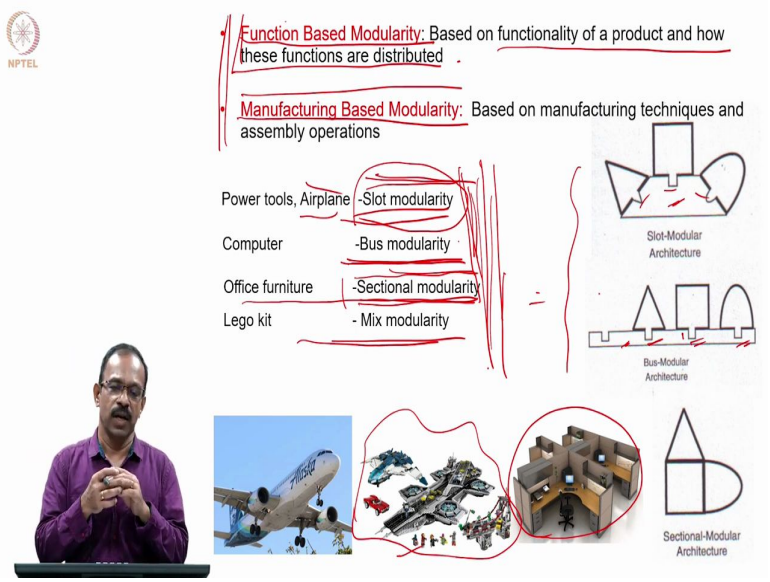


Another one which is commonly used in computers and other electronic products is known as bus modularity. So, bus modularity is that you have a platform. So, you have a platform and in this platform you have one slot. So, this slot is having a common, a common slot in this, so this is known as the bus, okay. So, the basic connecting element is known as the bus. Now, any element which has got a slot, I mean interface slot like this can actually come into here.

It can be anyone can be like this, or it can be like this or it can be like this or anything can actually come into this as long as the modularity is, sorry the slot is safe. So, for example in a computer, it will be a bus which connects, so you can actually connect a RAM, you can connect a hard disk, and you can connect a communication device. So, anything can be connected to this bus as long as the slot is like this, so that is the bus modularity.

So, in bus modularity your interface is the same and any module with that interface can actually come into this. In the previous slot modularities there are multiple interfaces possible, so you can actually have multiple components with that kind of interface can actually go into the product. So, that is the slot modularity and bus modularity in products.

(Refer Slide Time 25:59)



And so the best architecture, so you have the same interface, okay bus modular architecture, here you have multiple interfaces. Now, another one architecture is known as the sectional modularity. Sectional modularity is that in these two architectures, you have a base platform, you have a base platform or a base structure to which you add the modules, that is the bus modularity and slot modularity.

But in the case of sectional modularity, there is no basic structure so everything you have, what you have is a module. So, you have multiple modules, and then when you combine all these modules, you get a structure, okay? There is no basic structure to which you add

modules, but every module can actually become part of a structure. So that kind of an architecture is known as sectional modularity.

So sectional modularity you can see that each one is an individual module, but then they have the interfaces and you connect these interfaces, I mean these modules to perform a structure so that you can actually have different structures identified, or you can develop different products based on this kind of architecture. So, this is a typical example of furniture, office furniture. So, you can see office furniture there will be basic platforms, you have basic modules, the top plate, the legs and then the support plates, etcetera.

And then you start assembling them in different ways, you get different products that are basically the sectional modularity. So, you have sectional modularity where there are no basic elements or basic platform, but every module contributes to make a structure or a product that is the sectional modularity. And the last one is the mix modularity, where you can have a combination of all these things.

There is no specific modular structure here, you can have a slot modularity, bus modularity, or sectional modularity and then when you combine all these, you will be getting a product. So most of them, these Lego kits, if you might have seen the Lego kits. So, you will see that you can actually combine the different modules or different blocks and get a structure. And each one will be having either a slot modularity or a bus modularity or a sectional modularity and then you take each one of these and then assemble them properly, you will be getting a product.

So that kind of thing is known as the mixed modularity. So, in any individual product architecture, you can see these kinds of modules or the modular structure that is either a slot modularity, or a bus modularity or a sectional modularity or a mix modularity happening. And what kind of modularity you want to provide in the product depends again on the product and other, all other factors that we discussed. So, the designer can actually take a call, what should be the modularity they want to provide.

And there are many cases there will be both slot and bus modularity because if you take even computer, you will see there it is a combination of slot and bus modularity, because all those processors and other things will come under with the bus modularity or the connection to the

processors and the RAM and things like that will be using a bus modularity, but then the other elements like your USB drives or your power supply units, these can come under the slot modularity.

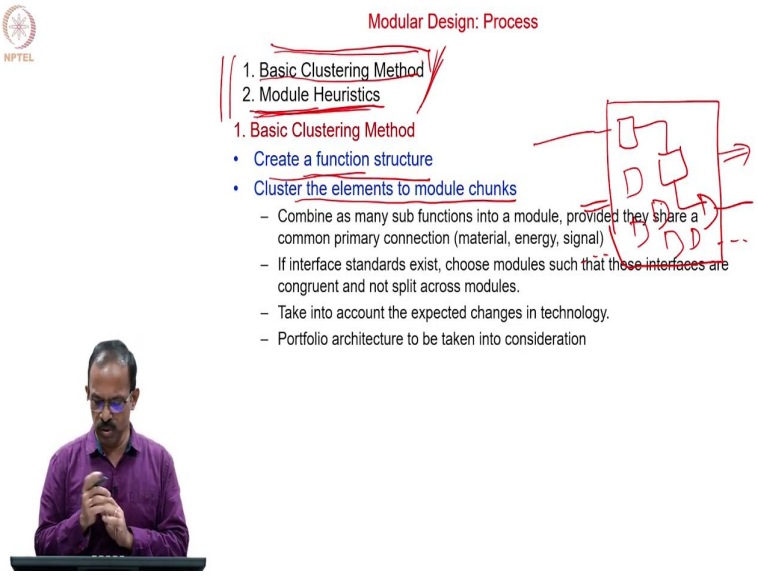
So not that you can use only a particular one. So you will be always having a mix of these slot or bus modularity depending on the product and the other aspect where actually what kind of modules you want to offer in the family. So that is about the product architecture, the two types of product architecture. The first one is an integral architecture where you have one physical chunk providing the overall function and multiple functions in the product.

And in the modular architecture you will have different physical chunks each one providing a function and then when you combine all these chunks you will be getting the total function of the product. So, and again you will be having within the modular architecture you can have either a function based or a manufacturing based modularity. So, that completes the discussion on what are the different types of architectures you can have.

Now, the question is that, how do we actually decide the module? Suppose we want to go for a modular architecture based on requirements of the product and the customer's needs, you decide to go for a modular architecture for a product. The question is, how do you decide the module within the product? Yes, it can have, you will be having a lot of functions required in the product and then you need to know how these functions can be grouped together to have physical blocks.

And if you are actually combining all those functions into a single physical block it becomes an integral architecture. And if you are actually trying to make them into different physical channels then it becomes modular. But then how do we actually combine these functions to make them individual blocks or how do we actually decide the number of modules and the elements within the module? So, that is the next question.

(Refer Slide Time 31:28)



Here we use two methods to get the modules. The first one is known as a basic clustering method and the second one is known as module heuristics. So, the basic clustering method, what we will do, we look into the functional block of the product and then based on our own understanding, we try to group them together, some of the blocks we will see over this, blocks are, blocks seems to be common or it has got many things common and therefore, we put them together and then make it as a module and that is basically known as the basic clustering method.

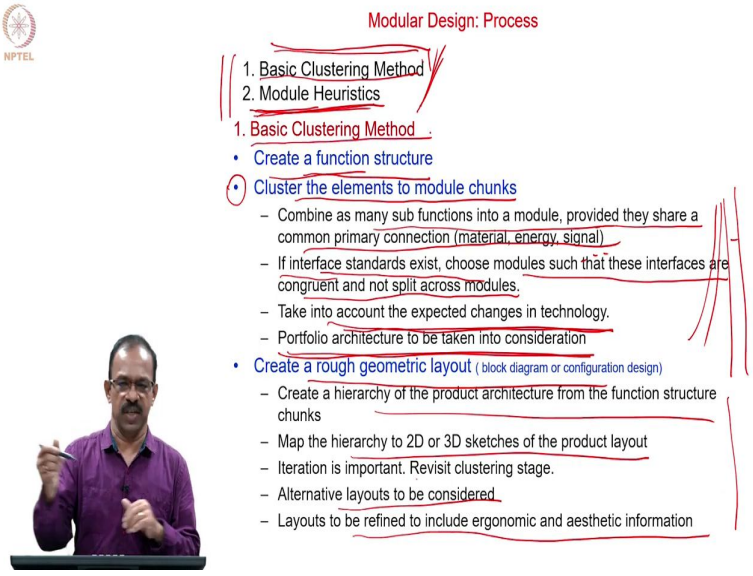
Without any logic or any particular rule, we try to start clustering them and identify the modules that are known as basic clustering methods. And the second one is the module heuristics, where we try to use some kind of a logic or heuristic method to get the module, so that is the module heuristic. So there we use some kind of a rule to say that okay if these things are there, then you made them together, so that is the module heuristics. First let us look at the basic clustering methods and then we will see the module heuristics.

So, in the basic clustering methods, the steps involved in getting the module are the first method is to create a function structure. So, we know what a functional structure is. So using the flow methods we can create a function structure that is the first step. So, any product, you try to identify the functions using the flow method. So we will identify all those products, the functions and then see how it is going.

Of course, there will be energy material and flow going. And similarly, we will be getting energy, material and flow coming out. So, using this you identify all those functions needed

in the product. So that is the function structure, then cluster the elements into module chunks. Now, based on this, you cluster these, the functions into modules, provided they share a common primary connection.

(Refer Slide Time 33:55)



So combine as many sub functions into a module, provided they share a common primary connection material, energy or signal. So, you look at this function and then see, is there something common in all these functions. So, if you can identify a few functions which actually share something, either a material or energy or flows, you try to see whether you can combine them that is the first step.

Combine as many functions into a module provided they share a common primary connection. And then if standard interfaces exist choose modules such that these interfaces are congruent, they are not split across modules. Standard interfaces are either the communication interface or mechanical interfaces, where you need to have a transmission or mechanical conversion, electrical to mechanical or mechanical transmission of mechanical power. So, such things require some kind of a physical interface.

If you can see such interfaces, then you put them together so that all those things require a particular interface to be put together, so that it can be easily interfaced with the other modules. That is the thing if interface standards exist, choose modules such that these interfaces are congruent, they are not split across modules. And take into account the

expected changes in technology. Suppose you think that the technology is going to change or a particular technology you are used for some function in the product.

And then if there is a possibility that this technology is going to change in the future, try to make it as a module so that when the technology changes, you can change the function of the module also. So that is what actually says, take into account the expected changes in technology. And then take into account the portfolio architecture also, suppose, you already decided with the portfolio and you identified that there should be four products, and there is a requirement of a low cost and high quality or high capacity, then keep that in mind.

Suppose, you need to change the capacity then you can make that the capacity part can be a module so that you can have different capacity so that you can have different products that is the way how you can think of the portfolio architecture in the product architecture decision. So, the second step is clustering the elements into module chunks based on these criteria, any of these criteria or multiple criteria.

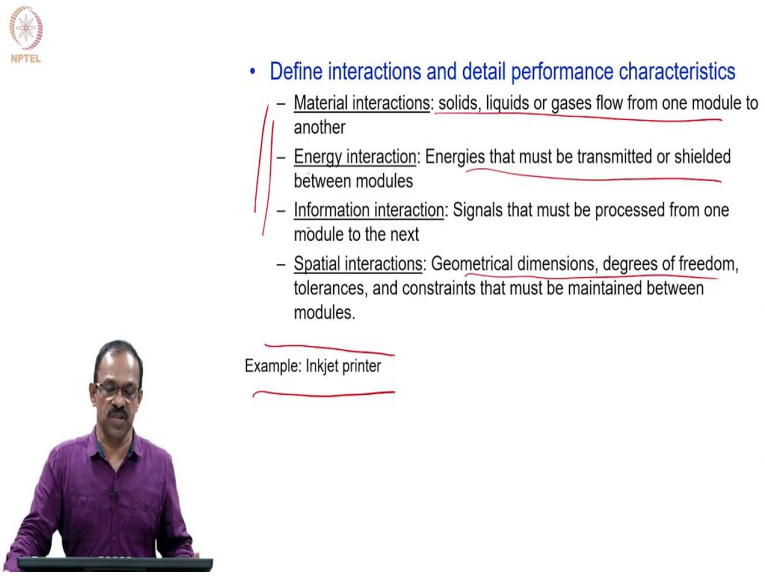
So, you may have to do it two-three times because you will be doing it first time, first based on the sub function, then you look at the standards, then you look at the changes in technology and then you finally decide, oh okay, this can be module, this can be module and whichever cannot be converted into modules, that we will make it as the base platform or a part of the base platform. So you will have a base platform to which other modules can be added.

And this module, again can have it as a slot modularity or a bus modularity or a mixed modularity. Okay, so that is the way to create a rough geometric layout. So once you do this module, then you create a rough geometric layout. Okay, you can say this is the paper handling module and this is the power supply module and this is the control module and this becomes the chassis. So, like that you can have the rough geometric layouts and hierarchy of the product architecture from the functional structure.

Map the hierarchy to 3D, 2D, 3D sketches and alternate layouts can be considered, and layouts to be refined including ergonomic and aesthetic information. So, that is the, the stage where actually you identify these modules and then try to give them some shape, create 2D, 3D models and then try to see whether that actually matches the requirement or matches your

expectation, revisit it and refine it as you feel as necessary and then complete the architecture. So, that is the first method of the basic clustering method. Hope you understood this. And let us take a simple example and then see how to do the basic clustering methods.

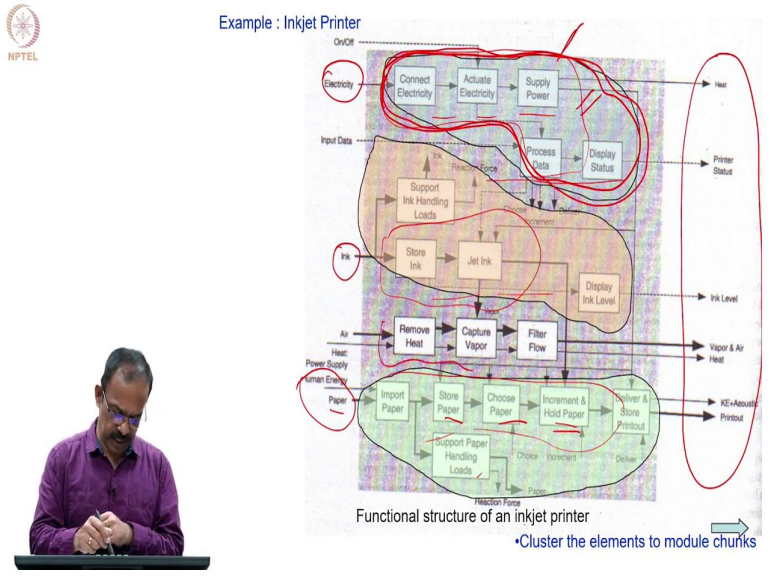
(Refer Slide Time 37:56)

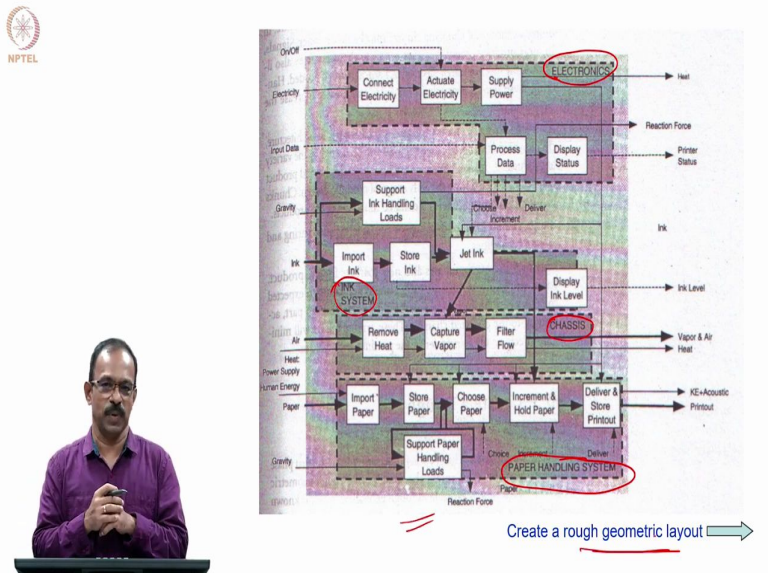


As I told you, the material interaction, energy interaction and information interaction are the one which need to be, can be considered while we are trying to identify the modules, and based on the functional architecture. So, if you have materials flowing then you consider that as a module, there is energy which actually is transmitted or shielded then basically looks at that aspect? Similarly, information and spatial interaction, spatial interaction is basically the dimensions, degrees of freedom etcetera, etcetera.

Okay, so let us take the example of this inkjet printer, we already saw this inkjet printer earlier and we discussed the functional decomposition. So, here we will see, I mean we saw the function structure also. So, let us see how can, how we can use this function structure to identify the modules within the product.

(Refer Slide Time 38:51)





Now, this is the example for the inkjet printer function, function structure. So, we saw that the, the input electricity, then ink, then human energy and paper, these are the main inputs. And of course, the input data, air and the power supply, are the other, power supply is already taken into this. So, these are the main inputs and these are the outputs okay. Now and we have these blocks here, these are the different functional blocks.

Now as an individual and again basic clustering method, as I told you that we do not follow any particular rule per se, but we will follow the guidelines where actually we will try to follow the, the material or energy or flow the signal in flows and see whether something is common between all these functions, then you try to make it as a group. For example, you

take paper and you see that okay paper is doing here, here, here and then this one and handling. So, there is something common between these blocks.

Similarly, there is something common between these energy parts and there is something in these ink parts. So like this, we can identify, we can look at this individual thing, and then see whether we can group them together as a module. But we will do, we will look at this electricity first. So as I told you the electricity part, you can see, you have this electricity, connect electricity, actually electricity, supply power, and then this display status and then they process the data. So this all becomes part of something called the electrical or electronics module.

So we can think that okay, since they are all common to this electrical and electronics, which is very much distinct from the other functions of the product, probably we will be able to make this as a module. So that is the way we try to see. So this can actually be considered as an electrical or electronics module. And then we will try to see whether something else can be identified. So we can see this as store ink, jet ink, and display ink level and support ink handling modules.

So this again, you have the common flow in this ink as a material which actually is common to all these functions, we will try to see whether we can put this as a module. And as I told you, this is only the beginning of the identification of modules. So, it need not be necessary that all these modules will be there in the final product, we are trying to see potential modules that can be identified. And so you will be having another one as the paper module.

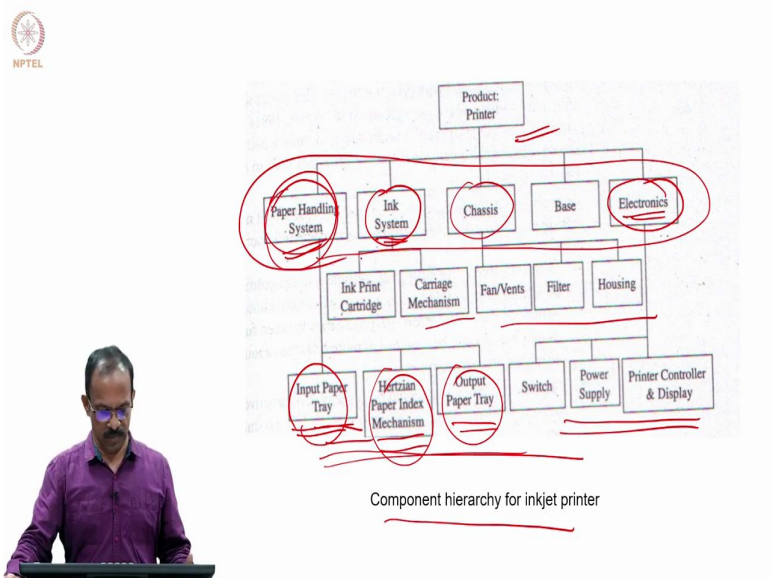
So, you will have to import paper, store paper, choose paper, increment paper, etcetera as another potential module. And we have another one like removing heat, capturing vapour, filter flow and these things air take, intake air and other things. So that can actually be, either can be made as a separate module or we can say that is part of the basic structure. So that it need not be a module, it can be an integral with this one also. Anyway, in any case, we can actually say that okay, this is another thing which can actually be thought of as a combined function which has got common things with them.

So these are the potential modules that you can identify in this product. Now, so you can see that okay, this is the electronics module or electrical and electronics module. So this can be

the ink system in the product, and this is the paper handling system and this is the chassis. But this is basically the structure of the printer, we do not need to make it as a separate module. So it can actually be part of the chassis or the body of the printer. So, this way we will be able to identify the modules.

And again, as I told you, it is the designer's job to properly identify the modules based on the common flows in these functions. So, that is the first method. Now once you have this, then you can think of making a geometric, rough geometric layout to see whether that actually meets your expectations or your requirement. So now you have a paper handling module, you have an electronics module and you have an ink module. So, these three modules need to be assembled in the product as modules.

(Refer Slide Time 43:13)

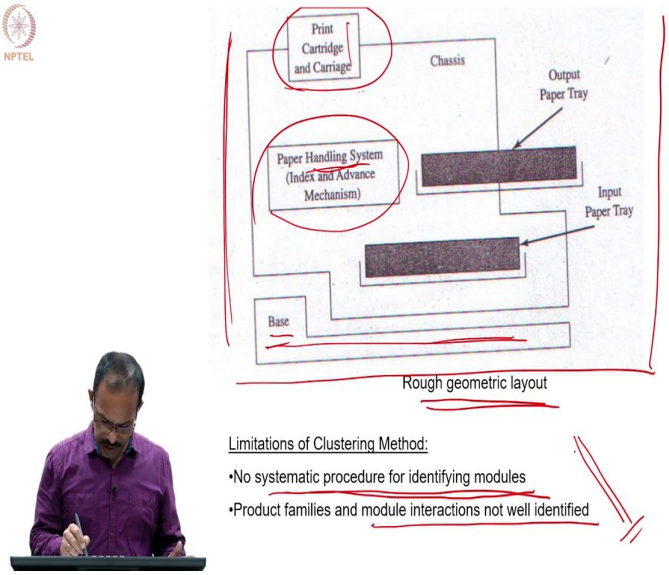


And again of course, this is the component hierarchy. So, if you have, look at that, when you can get a paper handling system, ink system, then chassis and then the electronics. So, these are the modules that you can identify and in addition to that, you need to have a base and edges. Base is to connect all these modules and the chassis is to provide a cover or a supporting structure for that. And each system you will be having these elements, ink system and then you have the chassis.

Now you can see the functions have been converted to physical elements, so it is no longer a function here. The product is actually trying to identify the, the physical chunks or the, the components of the product. So, slowly we are moving to the, from the functional elements to the physical elements. So, we are trying to identify the physical elements or we are trying to give names to the physical elements which provide the function in the products.

The paper handling system takes care of all these then, the functions needed, all functions needed for the paper to be handled. And individual parts take care of the individual function that we identified in the functional decomposition. So, that is the way we can convert the functional blocks into the physical blocks of the product. So, now we have a product hierarchy. So, this is the hierarchy of the product that you can see. And now, we know that okay these are the modules to be there in the product, so we can consider these are the modules and these are the components that actually form the module.

(Refer Slide Time 44:57)



Now, we can say, you have a print, cartridge carriage, a paper handling mechanism and then you have an input tray and output tray for paper acceptance and this is the base, and this forms the chassis. So, this is the way again a very rough geometric layout we can say. This is for the designer to understand okay how it will be, how it can be actually assembled or how it can be organized within the product, so you have a rough geometric layout of the product.

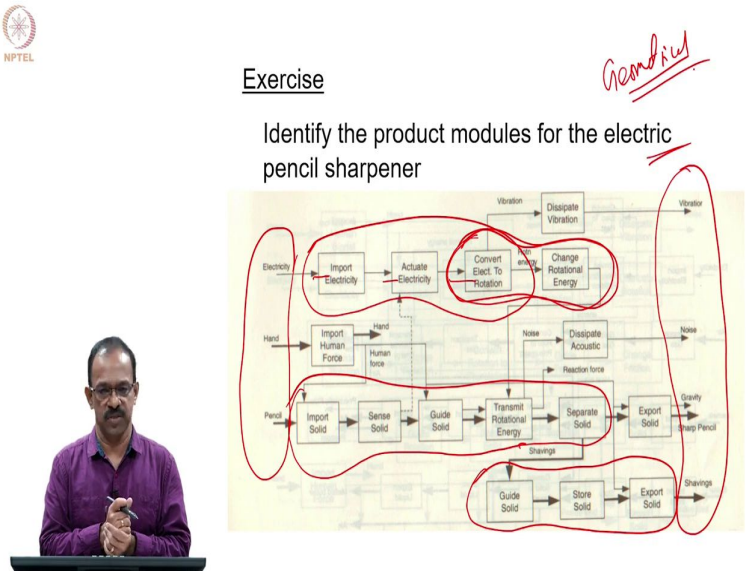
This is the way we actually move from now, if you look at the design process, so we had the functional blocks. And now, based on the functional blocks, we identified the modules and

based on the modules we identified the components. And now based on this we have a rough geometric layout of the product also. Of course, we still do not know how the, what kind of a base to be provided, what kind of handling mechanism to be provided, we are trying to identify the physical elements that can, that need to be there in the product to meet the requirements.

Okay, so this is the first method of, first method where we try to identify the modules, based on some basic clustering methods. So, but the limitations are that there is no systematic procedure for identifying modules. So, we left it to the designer to say that okay you identify a module, and he based on his own understanding and his own way of identifying modules, he identified the module. So, there is nothing to say whether it was correct or not and because there is no rule to follow.

So that is the problem here no systematic procedure for identifying modules and families and module interactions are not well defined. So, here we cannot really define the interaction between the paper module and the electricity module or electronic model what kind of interactions need to be there, so that is not really identified. So there is a, the, to overcome these issues we are going for the next method. So, the module heuristics actually try to overcome these issues in the product, in the, in the clustering methods. So, before going to that, let us take a simple example and then see again how to identify the module.

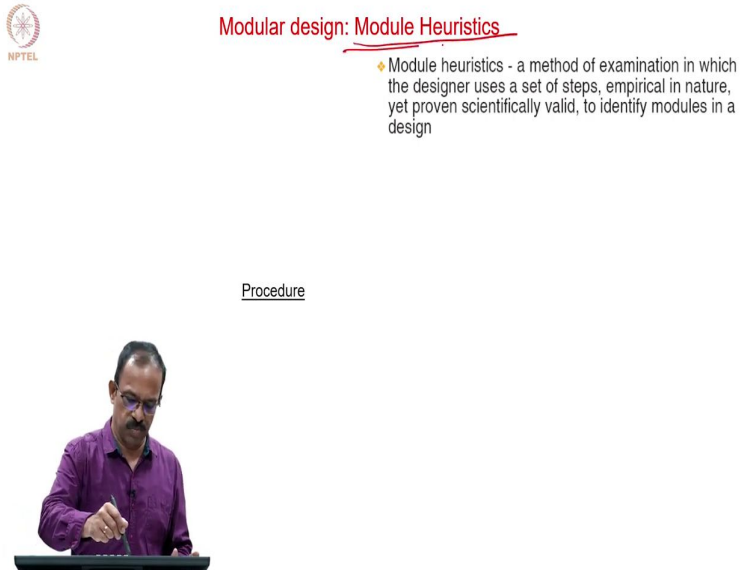
(Refer Slide Time 47:21)



So, here you can see this is the pencil sharpener as we discussed, electrical pencil sharpener. Again you can identify the inputs and the output flows here. And if you go for the basic method of clustering, we look at the flow so you can see there is electricity flowing, so you have this electricity common to all these blocks. So, we can say that this can actually be made into a module that can be made into a module that is one way. Then you can look at the pencil okay, all the pencil, all the functions which actually connect can actually be made into a pencil module or this can actually be separate because this actually talks about the shaved up pieces coming out. That can be considered as a module. So, and the other things can be considered as the chassis. Again you can have, either you can think this also, also as a separate module because you have an electrical to mechanical conversion and then mechanical energy transmission also.

So, if possible we can consider this also as a module. So, this is the way we can identify various modules in the product, right? So, this one you can do it as exercise, you can try it yourself and then check whether this is working well and then you can think of how to identify the architecture. So, a geometrical architecture you can think of, how a geometrical architecture can be decided based on this, and what are the modules and the components that can be thought of in this case.

(Refer Slide Time 49:09)



Okay so we will stop here, we will discuss the module heuristics or the heuristics based modular decomposition in the next class. Okay. Thank you.