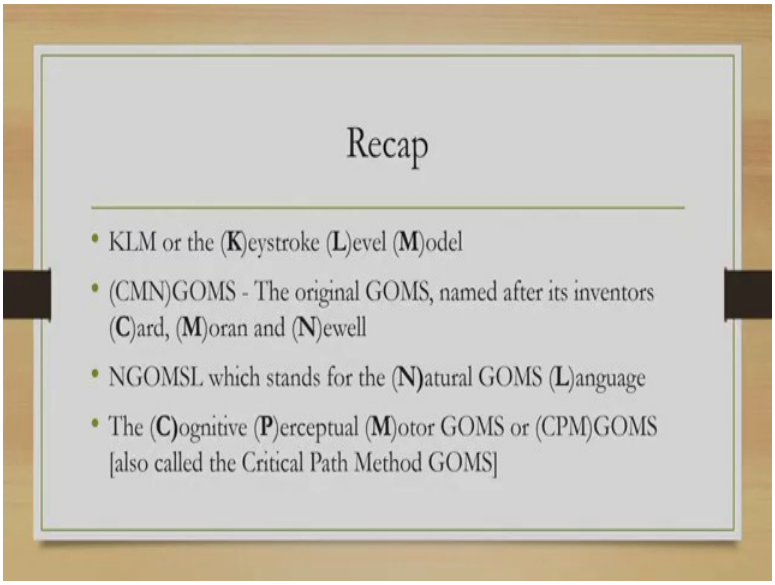
User-Centric Computing for Human-Computer Interaction
Prof. Samit Bhattacharya
Department of Computer Science & Engineering
Indian Institute of Technology, Guwahati

Lecture - 15
(CMN) GOMS Model

Hello and welcome to the lecture number 15 of the course User-Centric Computing for Human-Computer Interaction. So, before we start let us recollect what we have learned so far. In the previous lecture, we got introduced to one of the user centric models that is the KLM or Keystroke Level Model, This model belongs to the GOMS family of models.

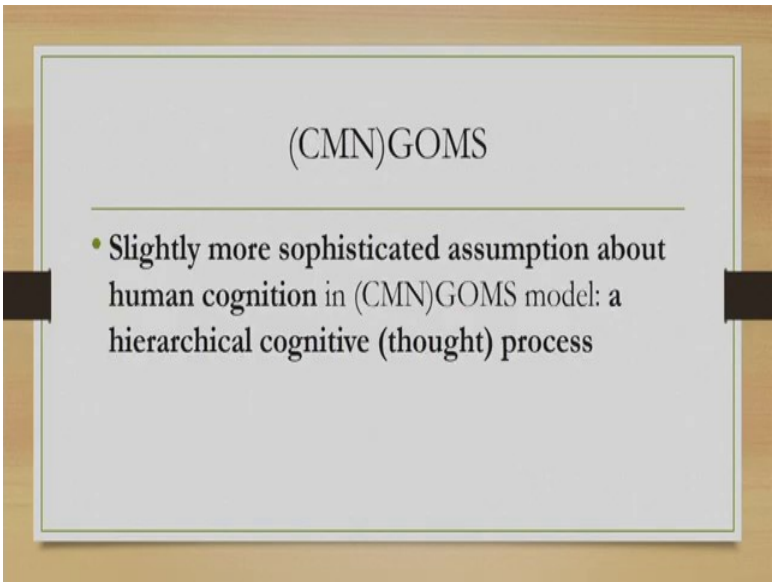
(Refer Slide Time: 01:05)



Now, in the GOMS family of models if you may recollect, there are four models which we have discussed earlier. So, the first one is which is the oldest one is the KLM or Keystroke Level Model which we have already discussed in the last lecture. The second model is the CMN GOMS model which stands for Card Moran Newell GOMS; the three names represent the name of the inventors of this model. The third model is the NGOMSL or Natural GOMS Language model and the fourth one is the CPM GOMS which stands for either Cognitive Perceptual Motor GOMS or Critical Path Method GOMS.

And as we mentioned earlier, among these four except the fourth one all the three assumes that the human cognitive process is a very simple process which can be represented as a sequence of basic cognitive activities or low level cognitive activities, so that is the simplifying assumptions behind all these models belong to this family.

(Refer Slide Time: 02:31)



Now, earlier we have talked about KLM or Keystroke Level Model. Today we are going to talk about the second model belonging to this family that is the CMN GOMS or Card Moran Newell GOMS, other two models we will not discuss in this lecture or in this course; if you are interested, you may refer to the material that will be mentioned at the end of this lecture.

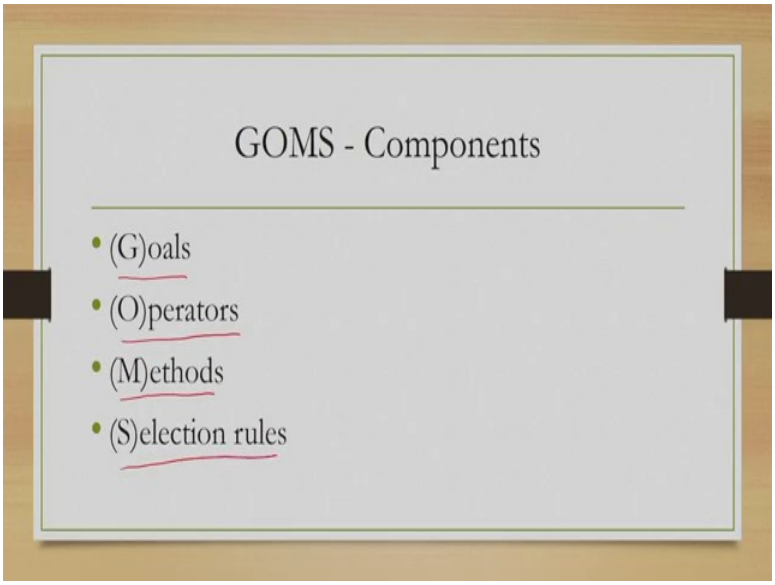
Now, CMN GOMS is slightly more complicated compared to KLM. If you may recollect KLM or Keystroke Level Model actually models interaction tasks or it models the behavior of the user during an interaction task, and this behavior essentially refers to the cognitive behavior the things that goes on in the mind of the user. And the model as such refers to a sequence of operators, where operators are low level cognitive activities.

So, whenever we talk off a KLM or Keystroke Level Model we basically refer to a sequence of such operator and those operators have predetermined values predetermined times and the objective of the model is to compute total task execution time. The time it takes for a user to decide and actually execute a task, and this time is obtained by adding up the individual operator times that are present in the KLM sequence.

Now, in KLM the model is simply a sequence of operators. CMN GOMS is slightly more complicated here the model is not a simple linear sequence of low level operator instead we can have a hierarchical sequence. Essentially it refers to a representation of our thought process, which considers the thought process as hierarchical thought process.

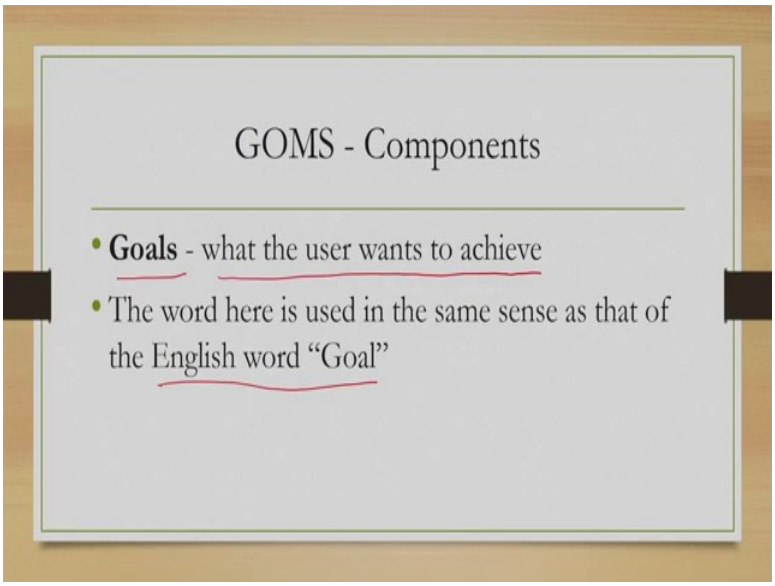
So, the basic assumption behind CMN GOMS is that our thought process can be organized in the form of a hierarchy, hierarchy of what that will learn in subsequent in subsequent part of the lecture.

(Refer Slide Time: 04:55)



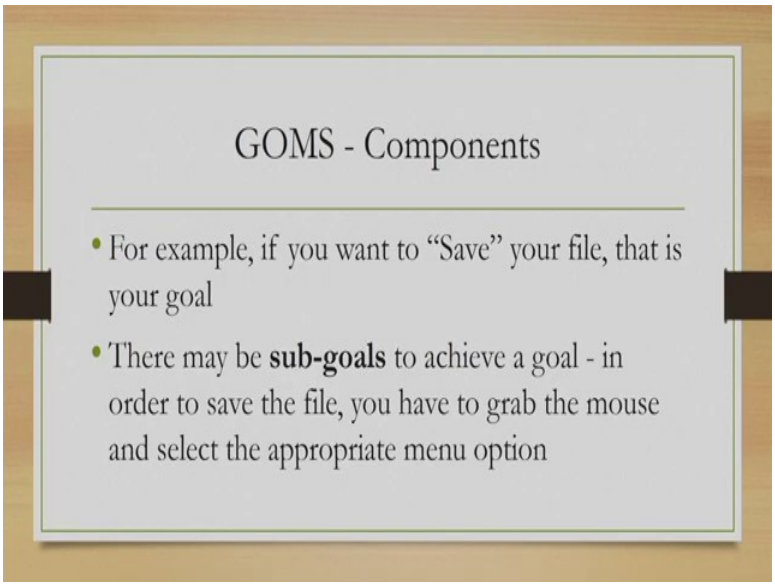
Now, before we try to understand this hierarchy let us first know about the full meaning of the term GOMS. So, GOMS is an acronym what it means, so there are four components in this acronym G O M S; now G stands for Goal, O stands for Operator, M stands for Method and S stands for Selection rule. So, when you talk of CMN GOMS or any model in these GOMS family. So, we are using the acronym GOMS which is a collection of four letters G O M S; now G stands for Goals, O stands for Operator, M stands for Methods and S stands for Selection rules. Let us try to understand these four concepts one by one.

(Refer Slide Time: 05:47)



So, we will start with the idea of goal. So, essentially these goal is the same as the English word goal that we often use in our text. So, it essentially represents what the user wants to achieve, what is our objective in carrying out a task.

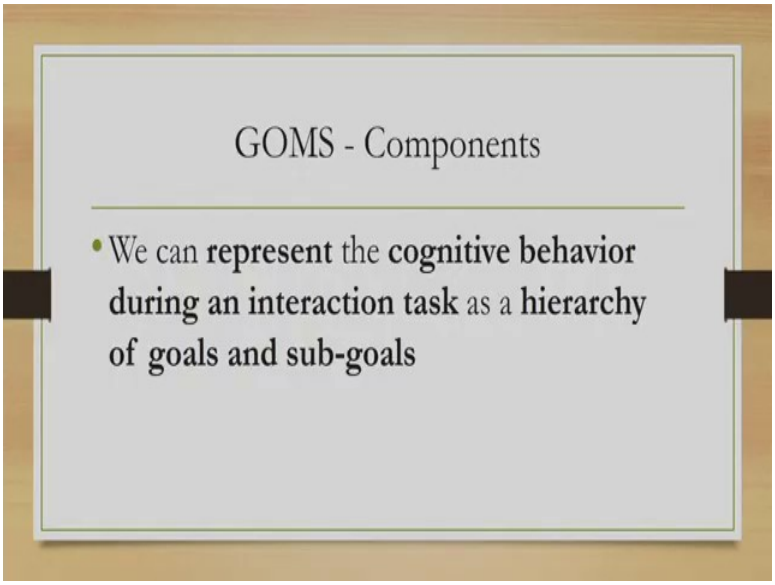
(Refer Slide Time: 06:08)



As an example, let us assume that we want to save a file you are typing something and you want to save it. So, the goal in this case is saving the file, so when you want to save a file that is your goal; now in order to do that you may have to have many sub-goals.

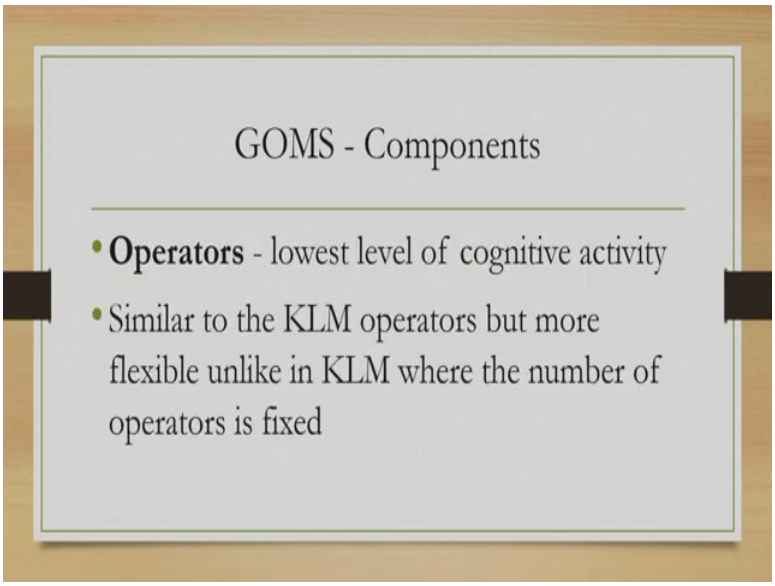
For example, to save a file you may have to grab the mouse and select the appropriate menu option if you want to do it through menu based options. So, if you are asked to save a file using a menu, then you have to grab mouse go to the menu options, select the particular menu option to do this, so these are your sub-goals. So, your overall goal is save a file and there are many sub-goals to achieve the goal.

(Refer Slide Time: 07:09)



Now, this entire thinking process that I want to save a file and the sub-goals that are required to do this, this we can represent as an hierarchy of goals and sub-goals, so that is the basic idea that our cognitive behavior during an interaction or during an interaction task can be represented as a hierarchy of goals and sub-goals, so that is the idea of the hierarchy.

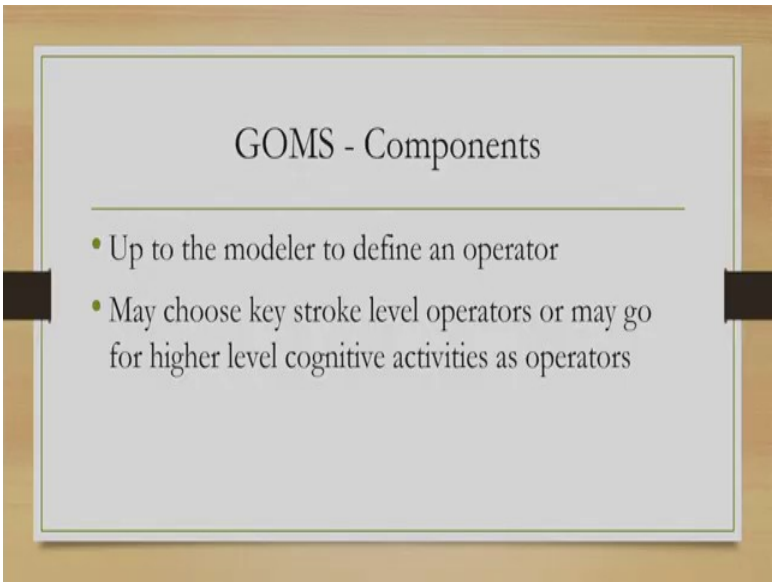
(Refer Slide Time: 07:38)



Next comes the idea of operators, so it is essentially representing the lowest level of cognitive activity. The idea is similar to KLM remember that in KLM also we got introduced to this idea of operators, so there we mentioned 7 operators and here also the idea of operator is same these are low level cognitive activities.

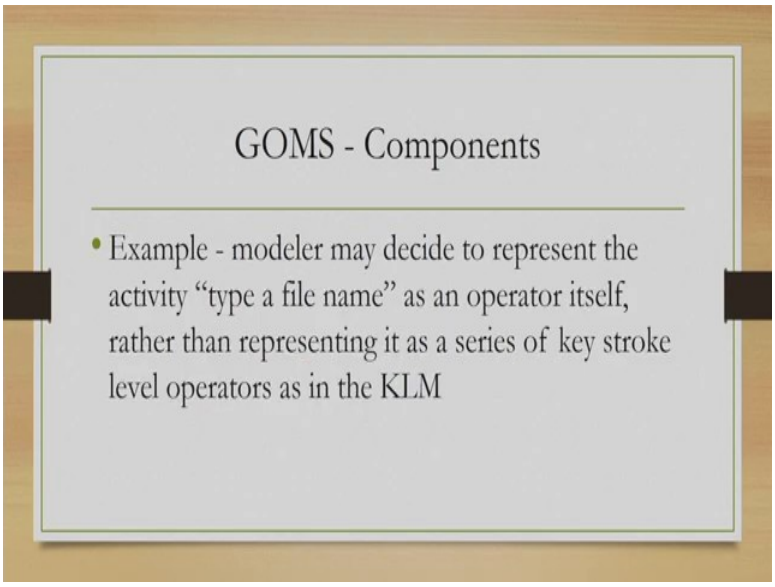
However, the idea here is more flexible in KLM we have fixed the set of operators. We said that there can be only 7 operators, out of which 2 are no longer used and 5 we can used for contemporary interaction modeling. However, in CMN GOMS that is not the case we do not fix the setup operators instead it is left to the modeler which operator or which set up operator to be used during modeling.

(Refer Slide Time: 08:37)



The modeler may choose the lowest level operators such as keystroke level operator or may go for higher level cognitive activities as operator. So, both are possible with this modeling approach.

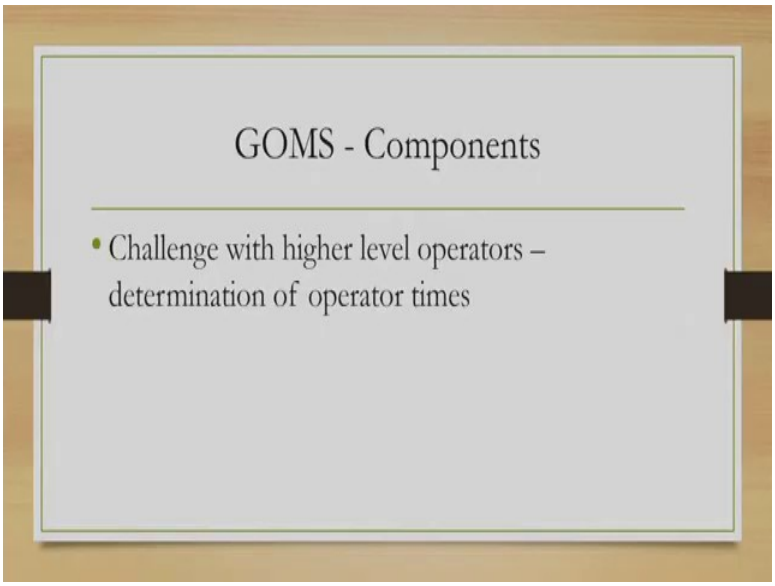
(Refer Slide Time: 08:55)



For example, if we want to save a file sometimes we need to type the file name; now typing the file name is an activity which can be set as an operator itself, so that is a high level operator. Alternatively the modular may decide to use keystroke level operators, whatever operators we got to know of during our discussion on KLM, we can use those

to model this activity type a file name. So, either we can have a single operator type a file name or we can have keystroke level operator, where this entire activity can be modeled as a sequence of keystroke level operator. So, both options are present to the modeler.

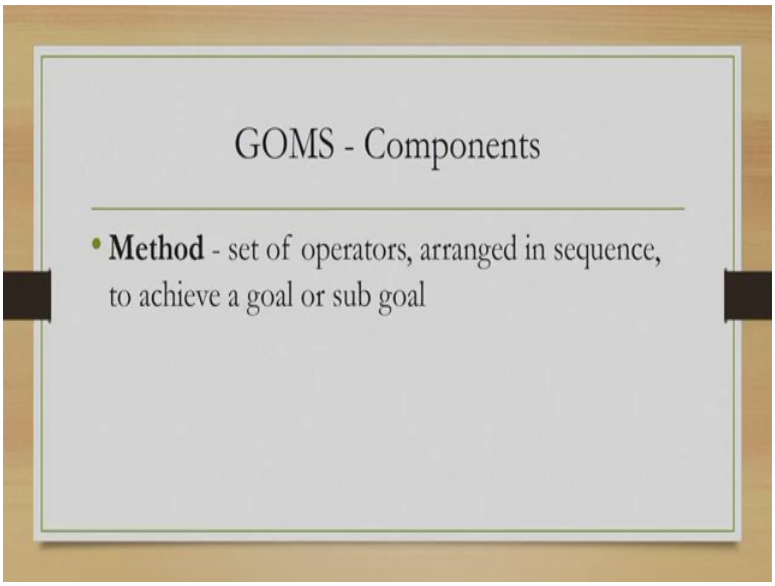
(Refer Slide Time: 09:37)



But there is of course, one problem. So, we mentioned that in KLM operators the times are already determined. So, you already know what are the time; so given an interactive task if we can represent it using keystroke level operator, then we do not need to bother about finding out the operator times instead we can simply adapt a times to compute the overall task execution time. However, if we are not using those operator if we are defining our own operator, then it is our responsibility to find out the time for that operator.

In the previous example, if we are defining the entire activity of typing a file name as an operator itself, then it is again our responsibility to find out the time required to carry out this task, the time required for this operator which of course implies that we have to go for extensive empirical studies to find out this time. But once the time is known, then of course, we can use it for modeling activities in similar or other situations. So, the main challenge is to determine the operator times if we are defining our own operators, so that is the idea of operator.

(Refer Slide Time: 11:00)



Next comes the idea of methods. So, when we talk of a method what we refer to is basically a sequence of operator. Set of operators, arranged in a sequence to achieve a goal or sub-goal that is the definition of this term method. So, when you talk of method, we are basically referring to the sequence of operator that we are formulated to achieve a goal or sub-goal.

(Refer Slide Time: 11:44)

Finally, comes the idea of selection rules. Now, this idea refers to this concept refers to the fact that sometimes, there can be more than one methods to achieve a goal and both

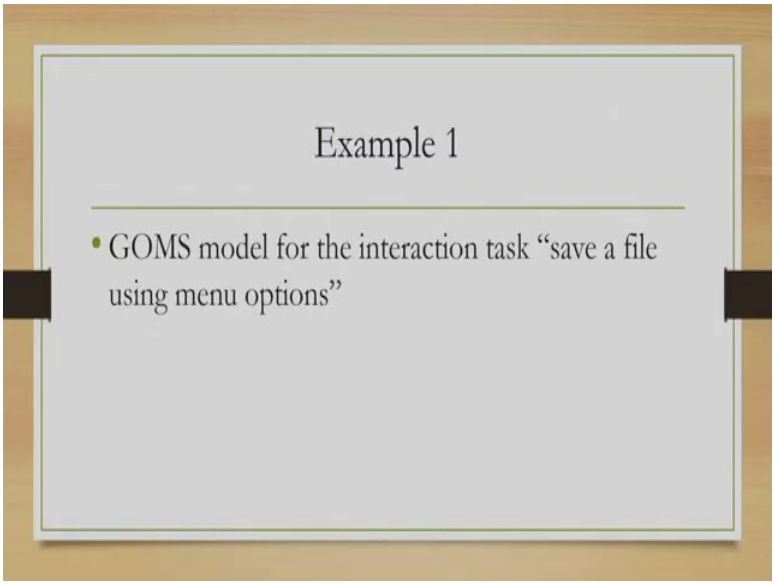
the methods we have to define in the model. But the question is which method to choose and under what circumstance, what are the criteria's for choosing a method; those can be specified, those criteria's can be specified by selection rules.

So, why we are using selection rule, we are essentially specifying some conditions under which a specific method has to be used for a given task; where there can be more than one methods to perform the task that is the idea of selection rules. So, to recap there are four components goals, operators, methods and selection rules. Goals are essentially what we want to achieve, operator idea is similar to the KLM operator we have learned before.

However, here the idea of operator is more flexible here you can define your own operator instead of sticking to only the 5 or 7 operators defined for KLM, but those are low level operators with predetermined values. If you are defining your own operators, it will be your responsibility to come up with the operator times.

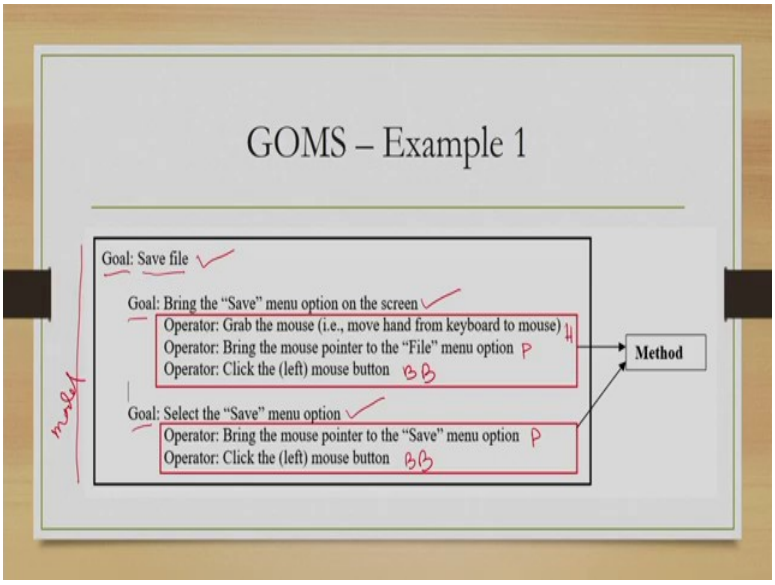
Then method refers to a sequence of operators, which is used to model some activity and selection rules refer to some conditions that are used to choose a particular method for a particular task under a given condition, when the same task can be done or performed by more than one methods. Now, let us try to understand these concepts in terms of few examples, so we will explain the concepts with two example.

(Refer Slide Time: 14:08)



Let us start with the example of saving a file using menu options. So, we want to save a file, so we are essentially typing a document and we want to save a file using the save menu options that are present under the file menu option.

(Refer Slide Time: 14:24)



Now, in order to do that we can actually come up with a CMN GOMS model of file save interaction task as shown here. This is the syntax of the model, so typically this syntax is used to represent the model. First we start with goal top level goal that is save file, so our goal is to save the file.

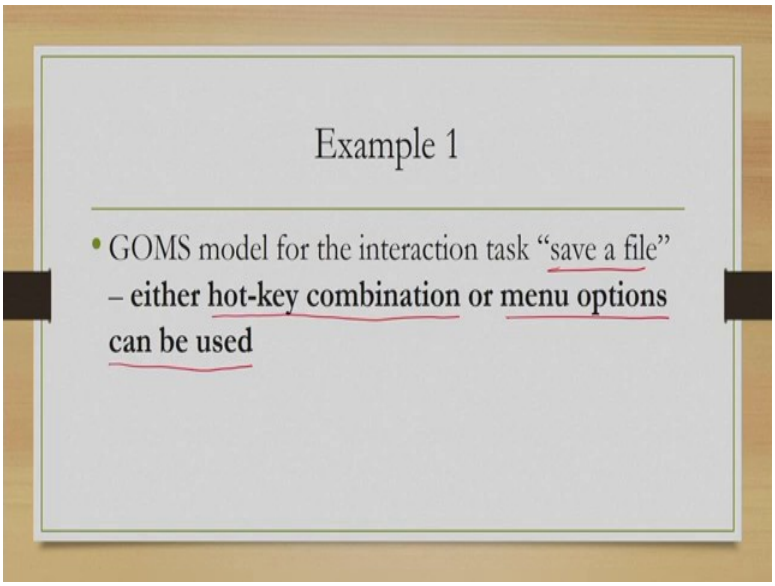
Now, in order to achieve this goal we may have to achieve two sub-goals; bring the save menu option on the screen this is one sub-goal, the second sub-goal is select the save menu option. Now, note that here using this indentation we tried to represent the hierarchy. So, top level goal is this second level goal is this if there is some other sub-goal, then we can have it here with further indentation.

Now, once this sub-goal is defined we can use operators there is an interesting point here that I will discuss after I explained the operators. So, first sub-goal is bring the save menu option on the screen. So, here we can define three operators; the first one is grab the mouse or in other words move hand from keyboard to mouse, second operator is bring the mouse pointer to the file menu option and third operator is click the left mouse button.

Now, here as you can see these we can model as keystroke level operators. So, grab the mouse essentially can be equated to H, operator that we have learned in our earlier lecture. Then pointing can be modeled with P and click the left mouse button can be modeled with B B or a sequence of 2 Bs, B operators these are keystroke level operator. Similarly, under the sub-goal select the save menu option; we can use the operator P which refers to bring the mouse pointer to the save menu option and the operator B B which again refers to click the left mouse button.

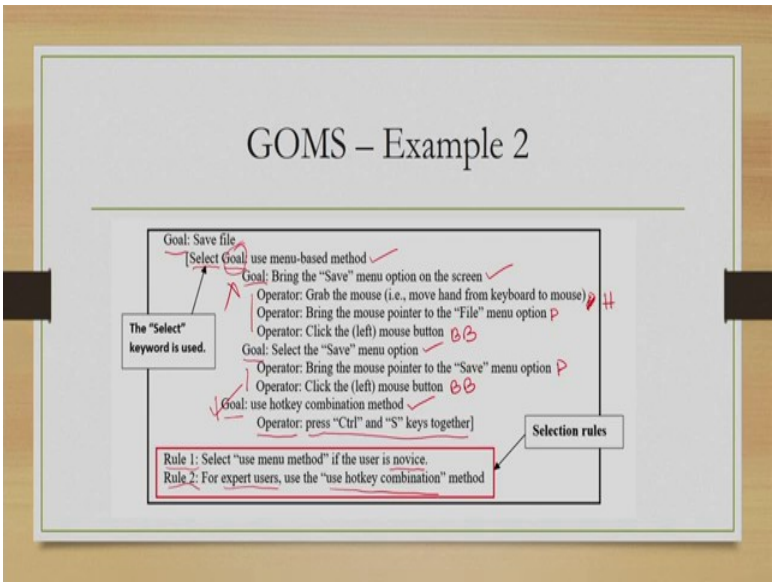
Now, the sequence of operators used in this case H P BB to achieve the sub-goal bring the save menu option on the screen is one method. Similarly, the sequence of operators used to achieve the sub-goals select the save menu option is another method. And so this entire thing this entire hierarchy, where there is first level goal then second level goal and under each goal there is a sequence of operators which refers to a method, this entire thing represents the model; model of what, model of our cognitive behavior during the interaction task of saving a file.

(Refer Slide Time: 17:34)



Let us see another example, this is related to the same task save a file. However, here we will use two different ways to do that one is hot-key combination that is control s, control plus S key combination and other one is the menu options that we have already modeled before. So, if such situations are there where same tasks can be carried out with the help of multiple methods, then let us see how the GOMS model looks like.

(Refer Slide Time: 18:13)



As you can see here, it looks slightly more complicated as compared to the previous model. The hierarchy is similar, so we have a top level goal that is saved file under this hierarchy there are sub-hierarchies which refers to the sub-goals. So, one sub-goal is use menu based method, other sub-goal is use hotkey combination method.

Now, under menu based method there can be further sub-goals like bring the save menu option on the screen and select the save menu option. So, under hotkey combination method there need not be any further sub-goal we can define operator directly. And these methods under the sub-goals bring the save menu option and select the save menu option is similar to the previous one which we can refer to as a sequence of operators which are low level, keystroke level as we have seen in the previous model.

So, essentially we can represent it as the keystroke level operator H followed by P followed by B B; similarly here P followed by B B. Now, the operator required for this other sub-goal that is used hotkey combination that is slightly complicated. So, here no keystroke level operator is sufficient to model this task of placing these together, earlier our K operator used to refer to placing of a single key. So, when we are talking of placing these keys together. So, we are defining our own operator which is at a higher level than the keystroke level operator K.

Now, we can think of it in different ways one is we can directly call it an operator and then accordingly for such operators we have to determine the value. Other thing is we

can actually represent it as a goal of placing these keys together or a sub-goal, and then under the sub-goal we can use keystroke level operators to achieve these tasks. Of course, here we have to make an assumption that this control plus S keys together this activity where the both the keys are to be placed together can be represented as a sequence of low level keystroke level tasks.

But the basic idea is that either we can use a goal notion and then under the goal we can use keystroke level operator or we can directly use the term operator to represent a high level activity. So, with the indentation you may notice the hierarchy the way this activity is modeled that activity of saving a file with multiple ways is modeled. So, in this activity to achieve the top level goal there are multiple methods as you can see. Now, in order to specify which method to use at which situation so we use the keyword select which essentially refers to the use of selection rules whenever this keyword is encounter, so this is one syntax of representing this situation.

And the selection rule is there are two rules; rule 1 and rule 2; these are simple example so and we stick to simplicity, so both the rules are very simple. So, rule 1 states that select user menu method if the user is novice and rule 2 states that for expert users, use the hotkey combination method. So, essentially we have to understand who the user is an accordingly have to apply this model with the specific method to model the behavior of the user.

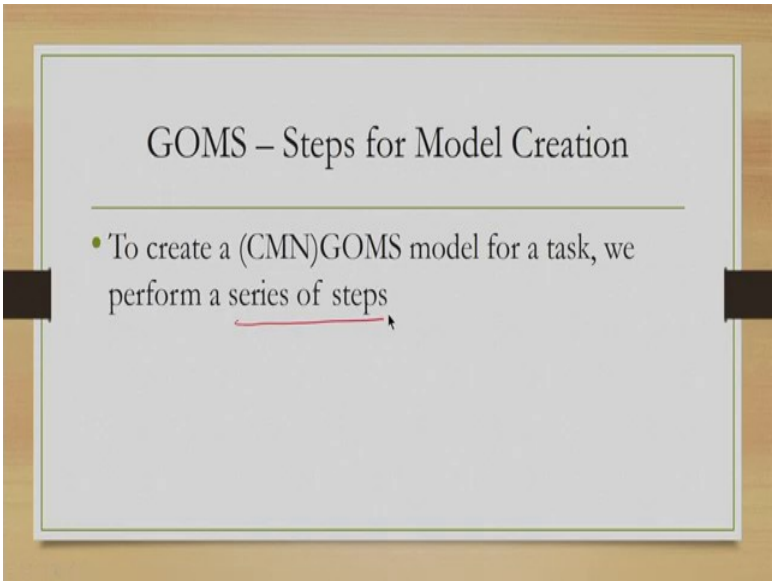
So, if the user is novice, will not bother about these goal we will assume that the goal is achieved through these sub-goals; if the user is expert, then we will not bother about this goal and we will assume that so this goal will not be considered and instead we will consider this goal and then accordingly we will consider the time.

So, with these two examples it may have become clear to you what we meant by hierarchical representation of cognition. And with the ultimate objective of modeling this cognitive behavior during interaction and with this model our objective is to compute the total task execution time, which again depends on the predetermined operator times.

So, if we are using keystroke level operators we already know those times, we already have some idea of those times and we can simply use those. If we are defining our own operators, then we have to identify we have to determine those times through empirical

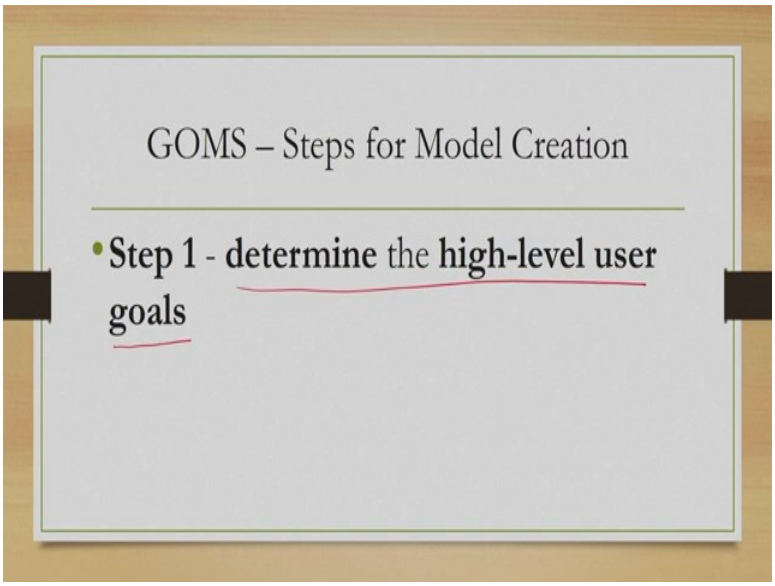
studies and then we can use those with the overall objective of calculating or computing the task execution time.

(Refer Slide Time: 23:58)



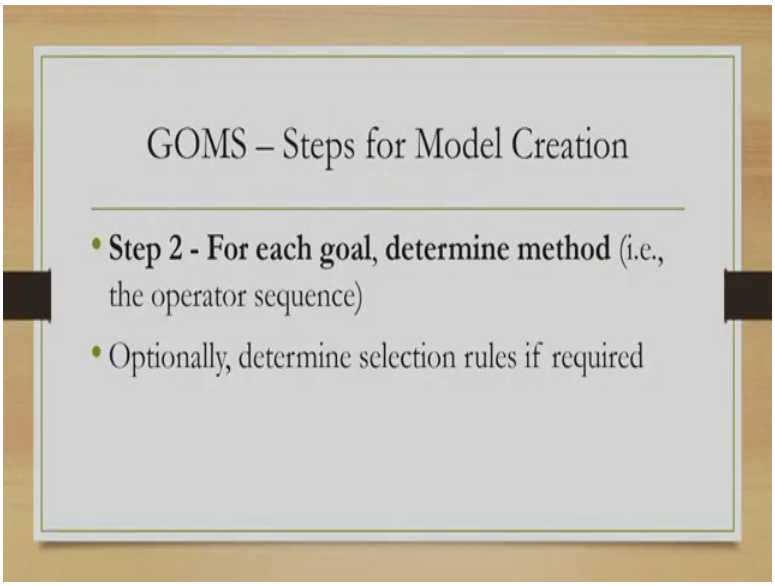
Now, let us see how to build these GOMS models as before we need to perform a series of steps to build a model for a particular task.

(Refer Slide Time: 24:08)



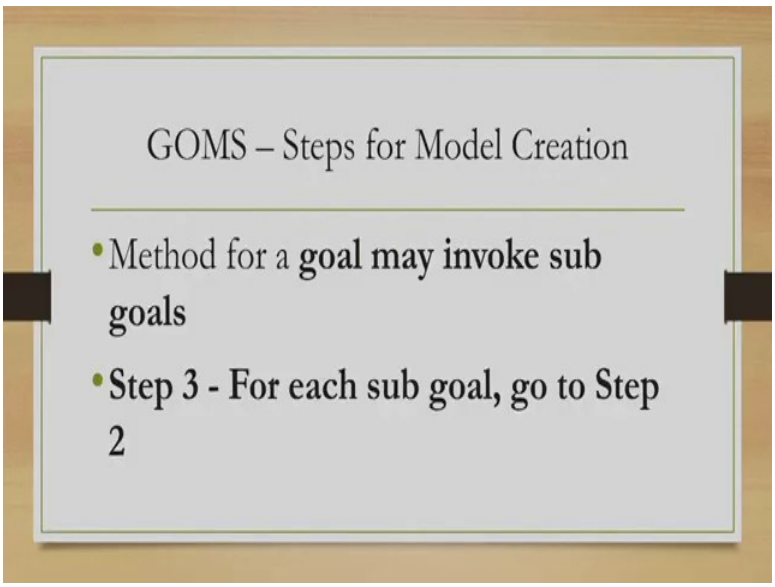
First step is determine the high-level user goals. So, at the very beginning we have to determine the high-level goals that the user wants to achieve.

(Refer Slide Time: 24:26)



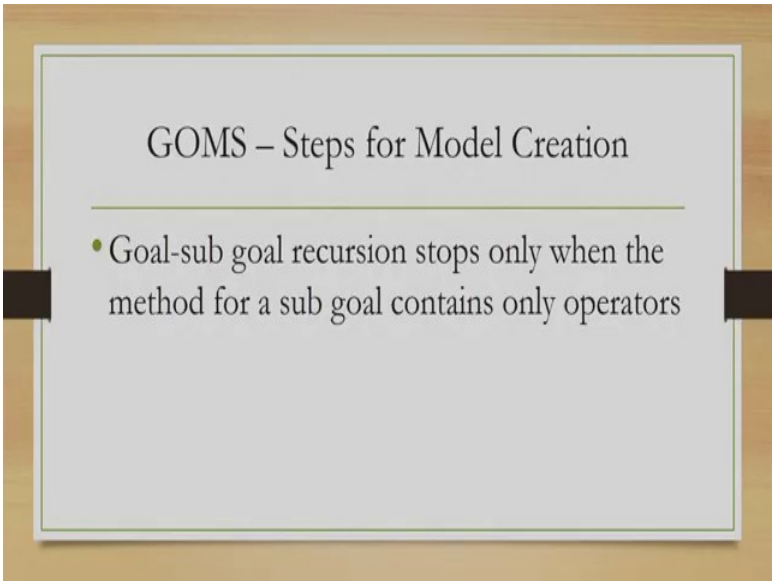
And step 2, so we have to create the method. So, for each goal determine the method or the operator sequence and if for one goal there are more than one methods, then optionally you may have to determine the selection rules. So, step 1 tells you to come up with the goal sub-goal hierarchy, step 2 tells you to come up with the method for each goal or sub-goal including optionally specification of selection rules if there are more than one methods for any of the goals or sub-goals. Now, this hierarchy essentially can be created using an iterative process.

(Refer Slide Time: 25:22)



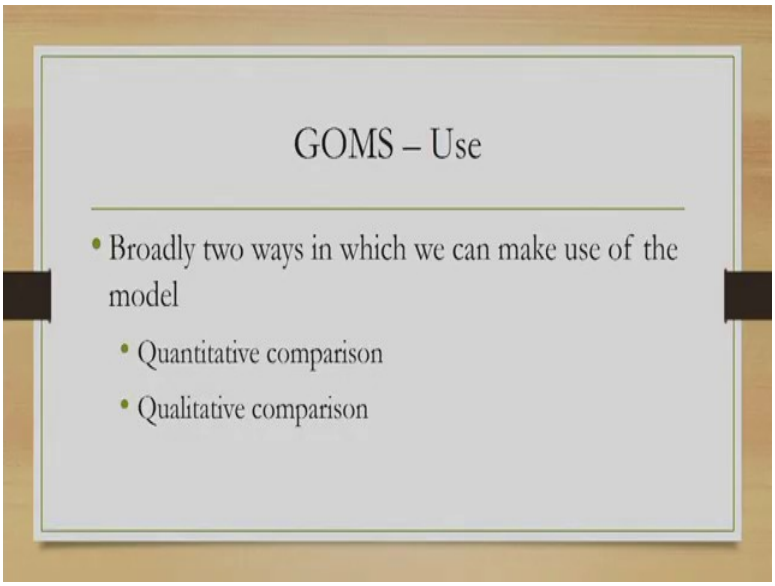
So, in step 1 what you do is essentially come up with higher level goals; in step 2 you try to come up with the method for that those goals. Now, while defining those methods it may happen that some goals come up, those are sub-goals to achieve that higher level goal. And then at this stage you define that goal and in the next stage, stage 3 or step 3 you define the method for it which again may result in specifying another sub-goal at that level, so you go back to step 2. So, in this iterative process eventually what you get is a hierarchy of goals and sub-goals with methods and selection rules.

(Refer Slide Time: 26:12)



So, we stop this iteration we stop this iterative process of creating the hierarchy only when we reach the operator level either keystroke level operator or your own operator which you defined. So, if at any stage we have a set of goals each of which is represented only with operators and there is no further sub-goal, then at that stage we stop building the model and our hierarchy is complete.

(Refer Slide Time: 26:48)

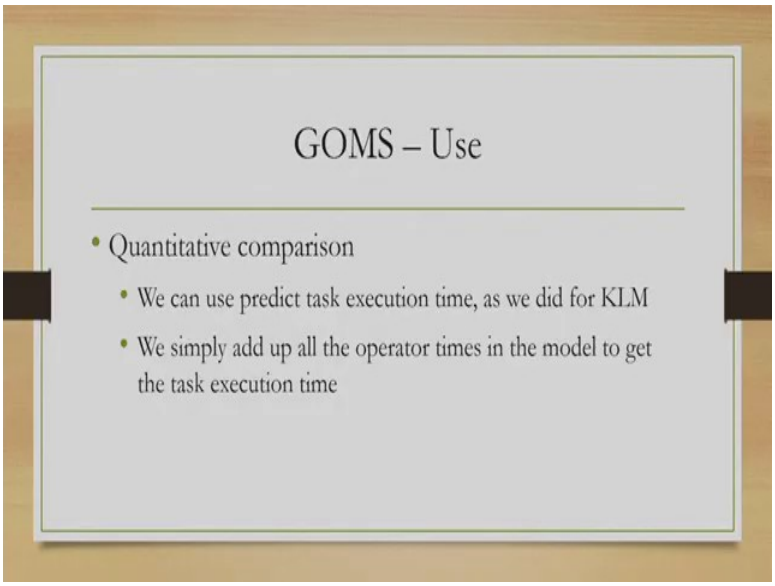


So, the question is how we can use it as I have already mentioned one use is very straight forward and that is our primary objective to use it as a computational user model. To compute the user behavior, in this case the behavior is essentially task execution time. So, by using predetermined operators with values we can actually come up with a model that allows us to compute the time to carry out the task to achieve the highest level goal.

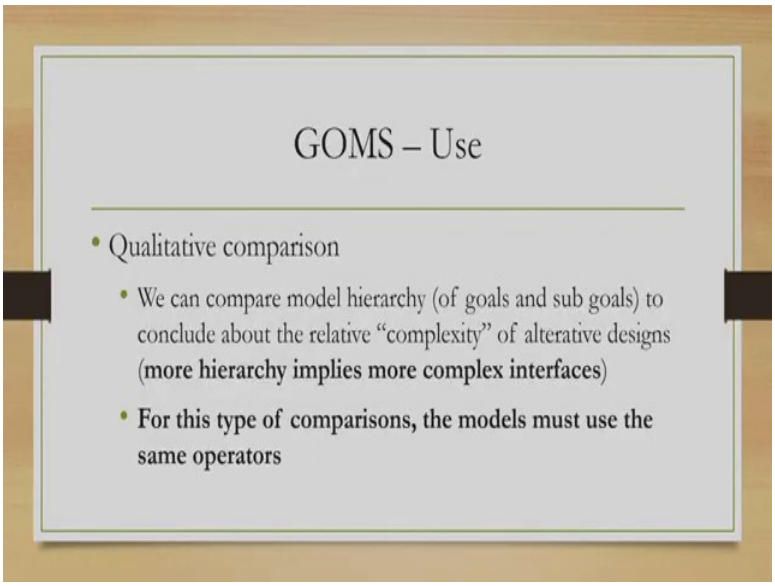
Now, that is one and the primary use of the GOMS model and with that value like KLM we can compare different designs, so that is a quantitative comparison. So, for same task different designs we will are likely to give you different models. And we can compute the time total execution time from each of these models, and then compare and find out which model gives me the least time and then the corresponding design is likely to be better compared to the other designs, like we did in KLM. The other use is qualitative comparison, again like in KLM, but here it is expected to give better results than KLM.

In KLM, we assumed linear sequence of operators. So, there the scope of qualitative comparison was limited, here we have hierarchical sequence. So, the scope of qualitative comparison is much more broader compared to KLM.

(Refer Slide Time: 28:26)



(Refer Slide Time: 28:27)



What we can do here is essentially for different designs we can come up with the models of individual tasks, then we can compare the depth of the hierarchy, the nature of the hierarchy. The more deep the hierarchy is that indicates that we need to think more to perform the task, more thinking essentially refers to more cognitive load which indicates that the overall usability is likely to be less.

However, you have to keep in mind here that when you are comparing alternative designs based on the nature of the hierarchy. The operators that you use at the end stage

or the last level of the hierarchy must be the same. So, it should not be the case that for one design you are using keystroke level operator, for another design you are using higher level operator; then definitely the two designs will be different, it is bound to happen. And in that case if you compare, then you will end up with a wrong conclusion. So, your operators should be the same in both the cases.

To recap, so we have learned about the basic idea of CMN GOMS. What this GOMS, acronym stands for it stands for Goals Operators Methods and Selection rules. We have gone through two examples to understand these concepts and the stages required to create a GOMS model. There are three steps you need to perform, in the first step you identify the top level goals and the second step for each goal you have tried to come up with the methods during defining a method for a goal, it may happen that you come up with sub-goal rather than an operator.

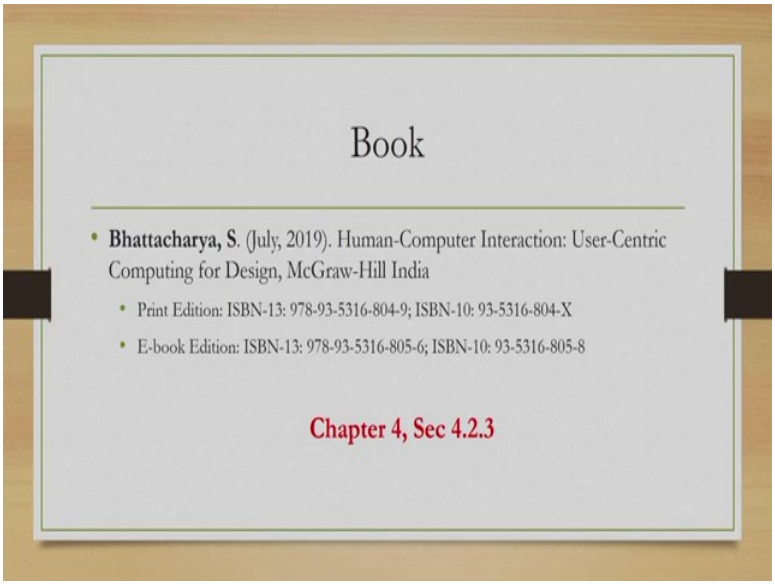
Then you go to step 3, where you try to define the method for that sub-goal and if it again involves another sub-goal, then go back to step 2 and this process continues in a loop an iterative manner. In step 2 additionally with method, in both step 2 and step 3, additionally with the methods you can define selection rules as well if there are more than one methods for each sub-goal for a goal or sub-goal. And this iteration stops only when we arrive at a stage, where a method for a goal is defined completely in terms of operators rather than any other sub-goal. So, at that stage we stop the creation of the model and the model can be used in two ways, quantitative prediction and qualitative prediction.

Quantitative prediction refers to the fact that with the model with the predetermined operator values, we can compute the total execution time for a task which refers to the cognitive time, the time it takes for the user to think and execute the task. Now, we can use this value to compare alternative designs and choose a design that has the least time. Other way of using GOMS is to use the qualitative method, where we compare the goal hierarchy between different designs.

The more deep the hierarchy is the design is expected to be watched than the other designs, because the deeper hierarchy refers to more cognitive load which indirectly indicates less usability, so that is the overall idea of GOMS. And we discussed two models KLM, which is a linear sequence of operators and GOMS which gives you a

hierarchical way of organizing our thought process; both have found wide use in design and analysis of interactive systems.

(Refer Slide Time: 32:32)



Whatever we have covered in today's lecture can be found from this book from chapter 4, section 4.2.3. So, all those were interested for further studies, I requested to refer to this book.

Thank you and good bye.