Object-Oriented Analysis and Design

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Lecture - 10
Foundations of the Object Model - OOA, OOD and OOP

Welcome to module 7 of object-oriented analysis and design. In the last module, we took a quick look into the evolution of programming languages, the programming paradigm and in the earlier modules we have taken a look into the challenges of software development of modeling complex systems and we analyze to understand a few common properties of complex systems.

From this module, onwards we would try to use both these backgrounds to slowly start defining our object models which is the fundamental concept of staring to analyze and design something in an object-oriented language. So, in this context the current module will provide the foundations that talk about the foundations of the object model and or my main intention would be to introduce the free basic terms that we will frequently use.

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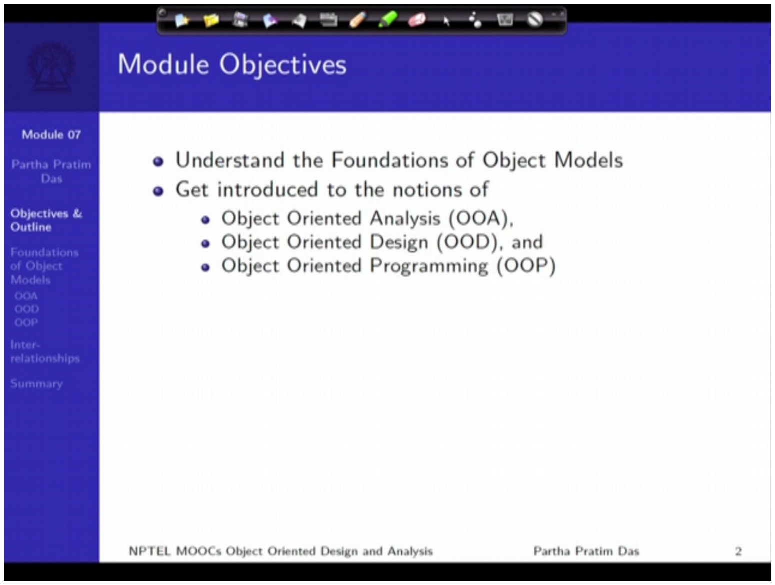

Module Objectives

- Understand the Foundations of Object Models
- Get introduced to the notions of
  - Object Oriented Analysis (OOA),
  - Object Oriented Design (OOD), and
  - Object Oriented Programming (OOP)

The notions of what is object oriented analysis, what is object oriented design often they are so interrelated that they are referred together as object oriented analysis and design as is the title of this course and we will get introduced to what is object oriented programming.

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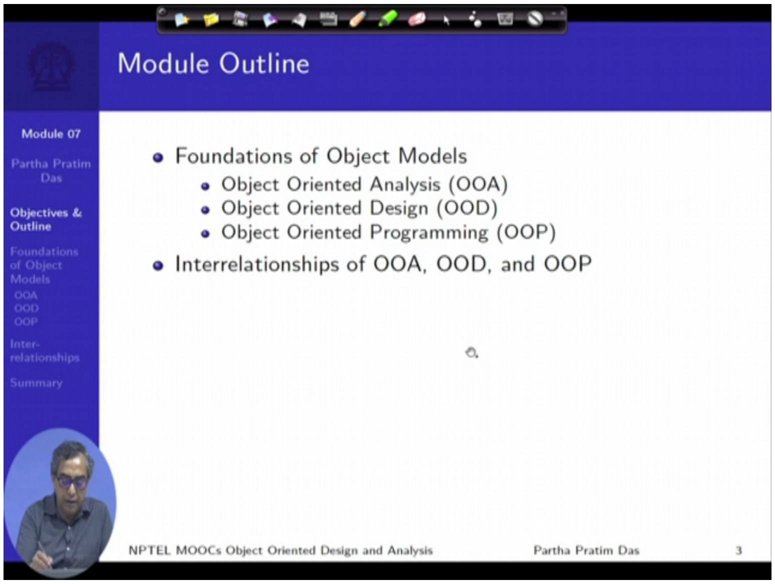

Module Outline

Module 07

Partha Pratim Das

Objectives & Outline

Foundations of Object Models

OOA

OOD

OOP

Inter-relationships

Summary

- Foundations of Object Models
  - Object Oriented Analysis (OOA)
  - Object Oriented Design (OOD)
  - Object Oriented Programming (OOP)
- Interrelationships of OOA, OOD, and OOP

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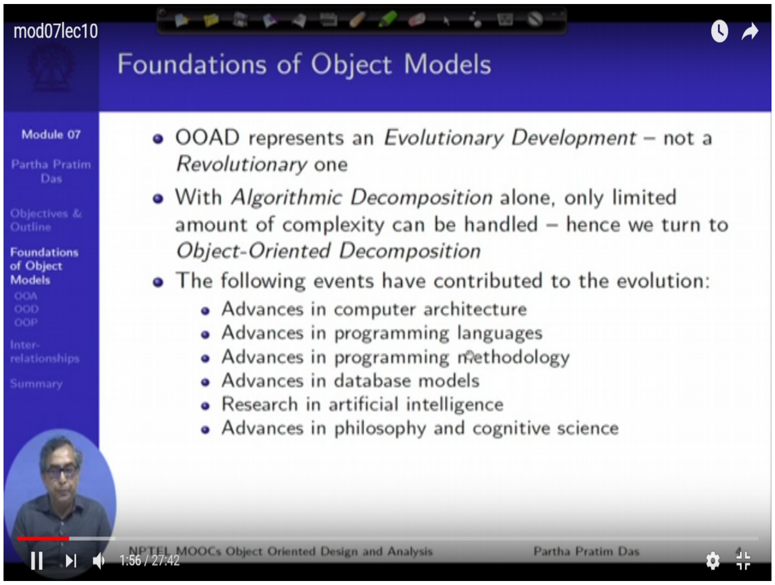

Foundations of Object Models

Module 07

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Objectives & Outline

Foundations of Object Models

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Summary

- OOAD represents an *Evolutionary Development* – not a *Revolutionary* one
- With *Algorithmic Decomposition* alone, only limited amount of complexity can be handled – hence we turn to *Object-Oriented Decomposition*
- The following events have contributed to the evolution:
  - Advances in computer architecture
  - Advances in programming languages
  - Advances in programming methodology
  - Advances in database models
  - Research in artificial intelligence
  - Advances in philosophy and cognitive science

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So, the object models, the foundation of object models certainly is in object oriented in analysis and design. Please note that this whole design, analysis and design paradigm methodology has been a or represents an evolutionary development and not a revolutionary one. What it means is this is not a single part baking part or a part breaking approach by which we will quickly create a completely new solution.

This is not coming and showing you that any set of numbers can be sorted in login time without any extra memory. So, we will solve that problem with a revolutionary solution but object-oriented analysis and design is typically an evolutionary development which means that in the process itself the approach is to start small, start something, start elementary and then evolve the system over a series of transitions into the final target of the system.

We have to keep that in mind and that is for the several different reasons that I have highlighted in the earlier modules, going in an iterative evolutionary refinement form to go from simple to little bit more complex to little more complex to further complex and so on and the final system is the only way to keep things under our control, to keep it within the human capacity of handling and manage the complexity to deliver a good working software.

So obviously with algorithmic decomposition alone, only limited amount of complexity can be handled we have discussed this at the end. So, we turn to object oriented decomposition. If you historically look at, we just took one this course in terms of evolution of programming languages in parallel similar dispose, you could study but the slot of time want of time might want to cover them. All in the historical perspective but if you track in a similar way the object-oriented analysis.

And design is the direct fall out of advances in computer architecture which has made it possible that different object based on object oriented feature can be brought into the computing system, advances in programming languages which we have already discussed. Advances in programming methodologies like framework based programming which also we have discussed, advances in database models which has given us really new powerful ways to model databases.

And this is growing; this is still getting much bigger than where our current course will stop. We have now databases which are called say no, no sql database, unstructured data database. So that is a regular evolutionary process that is going on even research in artificial intelligence which is shown as that how much the reasoning can be structured, how much the reasoning can be automated given advances in philosophy.

And cognitive sciences, understanding of our own thinking process, all contributed towards the emergence of object oriented paradigms.

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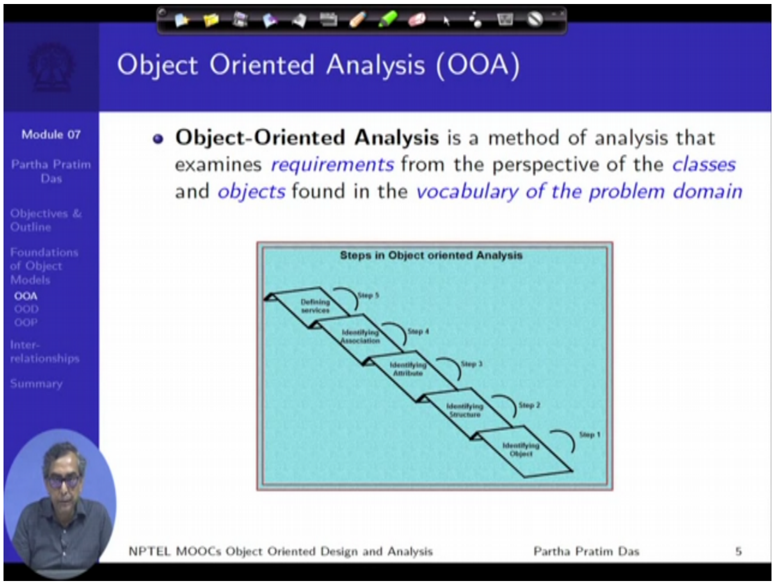

Object Oriented Analysis (OOA)

Module 07

Partha Pratim Das

Objectives & Outline

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Summary

- **Object-Oriented Analysis** is a method of analysis that examines *requirements* from the perspective of the *classes* and *objects* found in the *vocabulary of the problem domain*

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So, in that context we start discussing about the three basic approaches that we need to do. One is the object-oriented analysis. First thing you do is object oriented analysis, the method of analysis that examines requirements, so please this is a very simple statement but please understand it very carefully. It examines requirements from the perspectives of the classes and objects found in the vocabulary of the problem domain.

So first we are doing a process of, we are doing an activity of engineering. So, what is the first question you need to ask? You certainly need to ask is to what is my input and what is my output. Am doing an activity, so what I am given and what I had to deliver. So, if I look into object oriented analysis or the analysis phase then what we are given is the requirement. That is somebody my customer needs the system to be built.

And the customer has expressed that need in terms of possibly natural language descriptions to me. Please consider am sure you have had an opportunity to take a look into the tutorial that we created for the first week. The tutorial on leave management system of an organization where you saw two of our volunteers Srijoni and Tanwi behaving as customers and vendor to discuss about what leave management system is required.

That requirement so kind of you can say that the requirement is to specify in terms of this video. So, this itself could be your input. Of course, we will not get you started with such a vague abstract place. We have also provided you a 2 page, 2, 3-page kind of document which gives you some more statements about further requirements. And but that whole thing whether the video or the diagrams or the text are all kind of different vaguely specified, incompletely specified possibly inconsistent.

Requirements that the customer has not the customer herself may not be clear as to whether 100 percent of the requirements are really needed, whether they are really can be done and so and so. So, object oriented analysis is a process is a practice that you will take up in view of this input to actually create a very basic level of identification for classes and objects.

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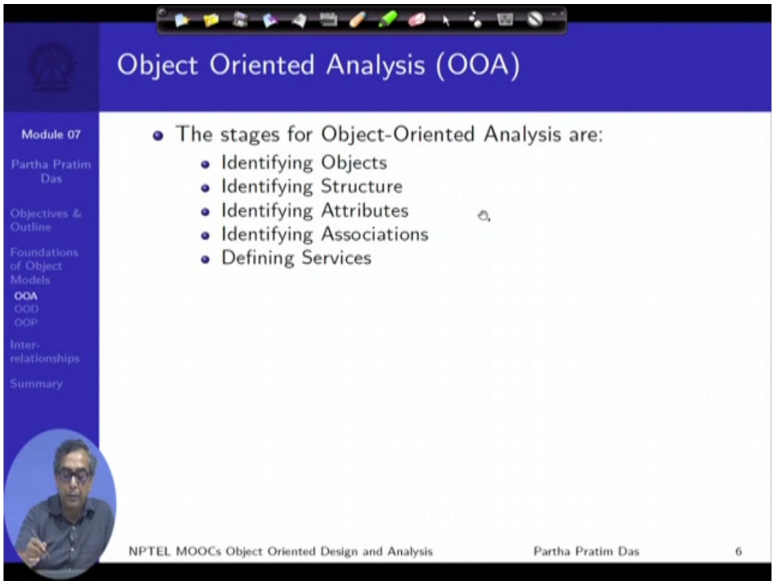

Object Oriented Analysis (OOA)

- The stages for Object-Oriented Analysis are:
  - Identifying Objects
  - Identifying Structure
  - Identifying Attributes
  - Identifying Associations
  - Defining Services

And while you do that, we try to use the vocabulary of the domain that is the vocabulary of the problem domain is whatever is said in terms of the problem that you are given to solve, whatever you said in terms of the requirements documents, the requirement video, diagrams and so on. so, the typical stages could give based on the first thing you would like to do is to identify your objects.

So, your system leave management system we have heard so what we were told. We were told that the organization has employees and they need a system to manage the leave of their employees. We were told that the organization, the employees in the organization are not of the same kind. There are 3 kinds of employees, executives, leads and managers and we were told that the leave is also not of one kind, the variety of leaves, causal leaves, earn leave.

And so, on and the if you if you go through the 2 pages of the document, you will find several different rules of who can how can who and one apply for a leave and how can a leave granted, how much leave you are eligible for, what are the conditions for different leaves and so on are documented. Now the first task that we know that we are looking at an object-oriented decomposition of this problem. So, the first things we need to learn are what are the objects.

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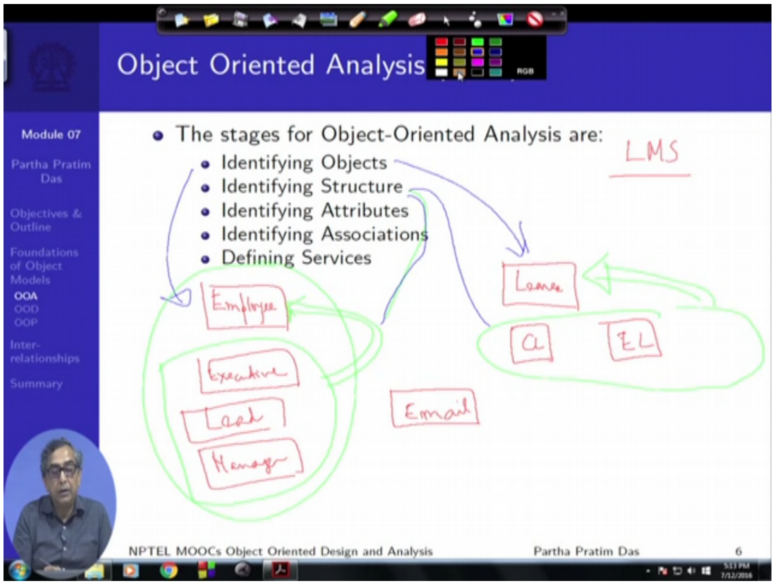

Object Oriented Analysis

- The stages for Object-Oriented Analysis are:
  - Identifying Objects
  - Identifying Structure
  - Identifying Attributes
  - Identifying Associations
  - Defining Services

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So, some of the good cases that we can make is certainly I can say that given this employee is an object. Given this leave could be an object. Like these are good candidates so that when you do identification you saw the employee is an object. You say leave is an object. But what about executive? What about lead? What about manager? These are all possible candidates for objects. Similarly, what about a causal leave, how about an earn leave and so on.

So, this identification process can lead you to identification of objects could lead you to several sides, different possible objects. There could be symmetrically different object also for example if you read in the specification that you learned some places saying that if a leave is approved then an email is sent to whoever has applied. So, email also is a concept, you can say email is an object. So, there could be several objects identified.

And as you identify different objects, keep them try to see if you can have certain structure between them that is object of all these different objects that you have here are they really distinct objects are they are kind of interrelated and we can say that one commonality that we can see that these 3 objects are all of have something in common with the object employee. Again at least say an executive is an employee.

So, anything that applies to an employee in general employee has an employee code, get his salary, has a designation, reports to someone all of these will apply to executive to leave manager and so on. Similarly leave different kinds of leave, there could be several others, or leave anyway that is when you get paid possibly and but you do not come to office or you do not work. So, the next to identifying the objects is picking up a wrong color is identifying structures.

You try to see what structures these objects may have. Subsequent to that certainly you will need to look at what are the how are a concept like an employee or a concept like a leave it is an abstract concept, it is an abstraction right. It has a notion but finally the computing system, your final target is computing system so you will not be able to just keep a nation, you will have to get to that notion through a set of properties that the object can have that that concept can have, that abstraction can have.

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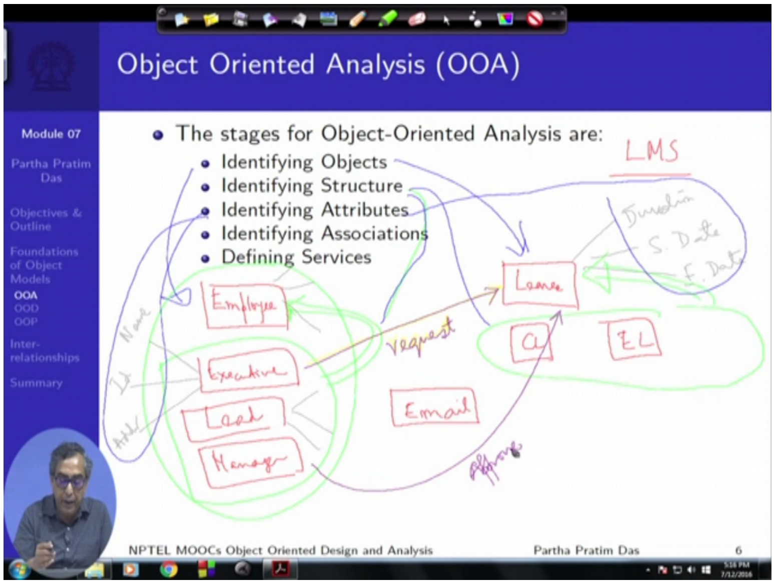

Object Oriented Analysis (OOA)

Module 07

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Objectives & Outline

Foundations of Object Models

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Summary

- The stages for Object-Oriented Analysis are:
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So, will start saying that well this executive has a name, an executive has an id, an executive has an address same for the lead, may be same for the employee, leave has a duration, leave has a start date and so and so forth. It must have an end date, etc. so you start to really understands the objects, you start identifying attributes so these are the different attributes. These are the different attributes that you start identifying.

Then you ask that well I know now I know that there are different objects, I know that there are certain structure between them. I know that there are attributes for these objects, but for a system this object must be interactive, the objects must be doing certain things together, certain things differently, must be sending messages between them and so on. So, you start working on the associations. So, you say that an executive will request this is barely visible so I will use a different color again.

As an executive can request for a leave. I can say that a manager can approve some leave. So, there are different these are different ways that the objects or structures that you have identified can be interrelated, can be associated. So, these will lead to different, these will lead to different associations that we can have. And finally, to put all things together, you will now have to define what are the possible services that the each and every object has to provide.

What are the services that the system as a whole has to provide for making this useful, for making this confirm to the requirement specification that you have been given with? And in this process, see this is not a flat one-way process and while I just took the LMS example and quickly review some dirty I mean back of the envelope kind of reasoning, please do not get scared, we will take through this in a very structured way in the next couple of modules.

Idea here is just to illustrate that this is the process of analysis that you get started with and as a as I mentioned that whole thing is an evaluation evolutionary process, it is not that you will be able to immediately come to all the objects get all the structures identify all the attributes and they have the associations correct, services correctly defined have the whole design. You will do something scratch. Then we will go forward and do certain steps of the object-oriented design.

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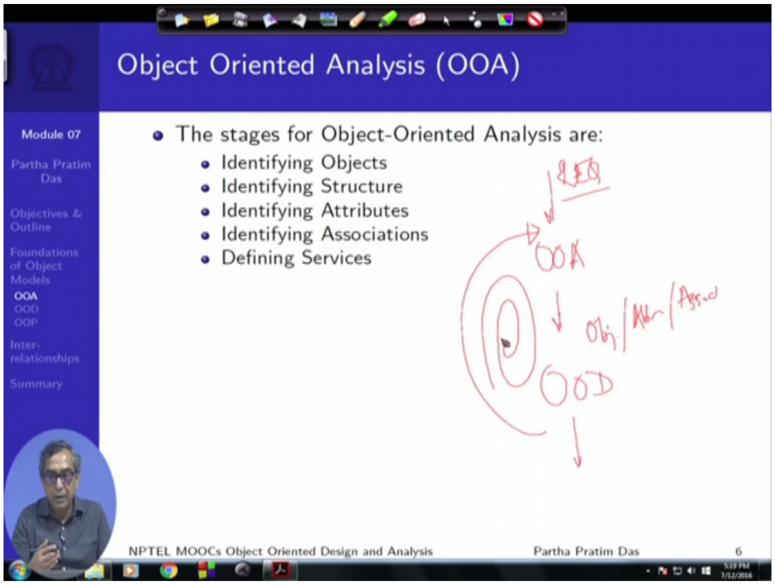

Object Oriented Analysis (OOA)

Module 07

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- The stages for Object-Oriented Analysis are:
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And find that well there are gaps in the design which you cannot fill up so this kind of that is the evolutionary iterative process so you do object oriented analysis. So, you this is where you got the requirement, you have done the analysis. So, we have objects you have attributes, you have associations and so on. And then you do more of design, we will see what design will generate and in the process, we will find that okay things ha have not been completely done, there are contradictions, there are incompleteness.

So, you come back and do the OOA again. You keep on doing this repeatedly and that is the evolutionary iterative process for which you try to perfect your analysis but whenever you are into an analysis what you are trying to do is every time you are into analysis, you either go back to the requirements document or to the requirement video of Tanwi and Srijoni or to the diagrams or even to the things are not clear in those your setup specific meetings with the clients.

With the customers, with the interface and then ask questions. Well this is specified how do I design in the system. That this process is known as an object-oriented analysis or the analysis process of the exercise.

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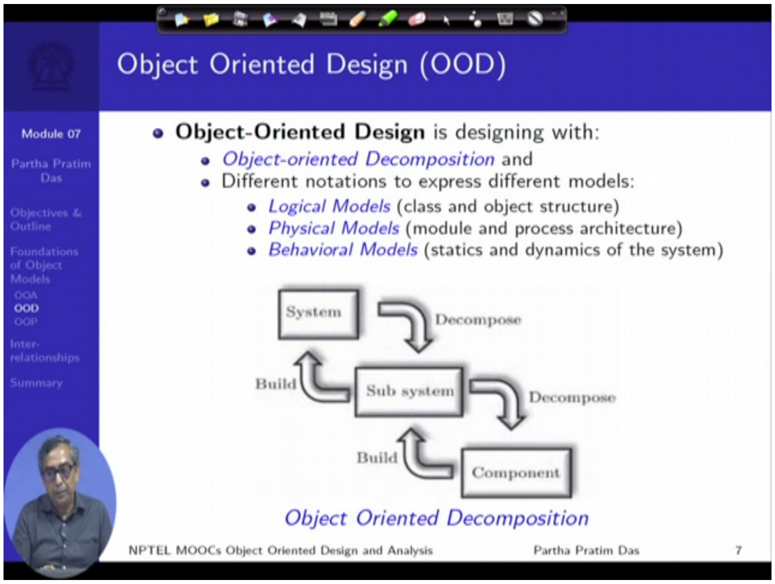

Object Oriented Design (OOD)

Module 07

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Summary

- **Object-Oriented Design** is designing with:
  - *Object-oriented Decomposition* and
  - Different notations to express different models:
    - *Logical Models* (class and object structure)
    - *Physical Models* (module and process architecture)
    - *Behavioral Models* (statics and dynamics of the system)

System

Decompose

Build

Sub system

Decompose

Build

Component

Object Oriented Decomposition

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This is the first step. Next comes the object-oriented design which builds up on the analysis output that you are generating and it is specifically now talks of object oriented decomposition. So, he will find that it is though for the purpose of sake of presentation and understanding am presenting the analysis and design as if as completely separate phases in practice they will often be very closely related.

You do not just keep on identifying objects and identifying attributes or identifying structures and keep them one side and then you come and do object oriented decomposition. It is kind of you do them together. You identify objects, put them in the decomposition model, identify attributes put them in a model, you identify services required, put them in the model, those are the messages that is the whole process of regular process of decomposition that will happen.

The second part of the other characteristic activity of object oriented design is you start generating a whole lot of different models of the system. That is, you start looking at the system from multiple angles through multiple glasses and there is no very specific exhaustive list of models that you will provide, that will specify. some of the models are generic, you will be done for all kinds of system and some of the models are specific to certain types of systems.

But it is typical that you will do logical models. Logical models are the basic fundamental object-oriented model which identify, which represent the class and object structures. The class structure if you recall, the reference to the canonical form, the class structure is which gives us the commonality of the behavior, the hierarchy of specializations, the hierarchy of abstraction. And the object structure is the compositional behavior which show that the how objects are built up, how smaller objects in turn are built of even small objects and small.

So, these are basically the logical models that exist in the problem domain. The reason there could logical models is the fact that these models are completely or significantly dependent only on the problem domain and the requirements that you have given to solve and not so much on the actual target system on which you implemented, actual target system that you built, neither the computer or the architecture on which you are building the system, nor the actual system that you build.

So, the second set of models that we will typically build are called the physical models because they are called physical because that is how your system that you are const or constructing or manifesting that it will show that these are the modules. So, in terms of a typical software system that we are doing, the modules are certainly different. collection of may be source files, headers, libraries together independent compilation

You may be dynamic libraries and so on which together does something meaningful as a subsystem. So, in terms of a physical model, a module could be your email subsystem. in terms of a physical model, your module could be employee management system for the leave part and similarly the process architecture or the software architecture of the whole system which could include the interconnect with the frameworks which could include how your different modules interact between them.

How really your messages are sent? How they responded to? What happens if your situation gets into an exception condition and so on. so, these are the requirements of the physical model and certainly we will talk about several behavioral models which have static and dynamic behaviors that is for example if I talk about the LMS, a dynamic behavior that I need to know is when an employee applies for a leave what happens in terms of the timeline what happens.

How will the manager of the employee who supports to look into the leave and to who regret it, how will that that manager gets to know it. And when the manager gets to know it, what is the timeline through which, within which the manager will respond. And once the manager responded how will the original employee who had requested for the leave will get to know. So that is kind of dynamics of the system which says it is not only enough that you have leave as object.

Or executive as object or not enough to have messages to apply for leave or approve leave as a service but you also need to have a clear idea about the order in which these things will have to happen the many of them have real time constraints, for example I apply for a leave 3 day down the line say today is a certain day x and I apply for a leave I mean Monday let us say, and am applying for a leave on Thursday.

Now certainly whether I get to proceed on leave or it is regretted, I must get to know it before Thursday otherwise I cannot take a decision. The system becomes inconsistent and if you if you this is a quick example of if you go back to discussion we had between Tanwi and Srijoni and the document that they subsequently produced will find that this question is not answered. What is the timeline within which a leave must be reacted to?

These are a part of the behavioral model that needs to be. So, in terms of the object-oriented design, we basically refine on our finding from object oriented analysis and try to start creating these models. The basic difference between these 2 being that the analysis is repeatedly looking into the requirements and bringing out stock in terms of classes, objects, interactions, messages and object-oriented design is trying to put in the terms of or actual paradigm.

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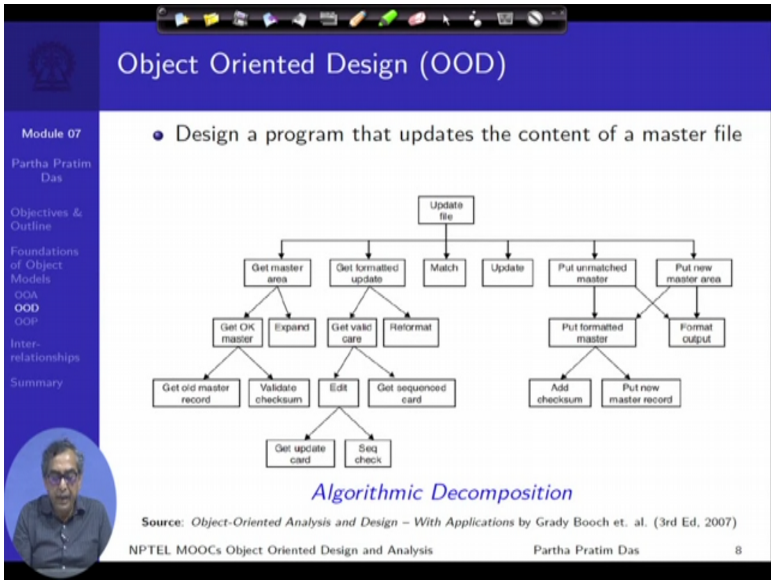

Object Oriented Design (OOD)

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Summary

- Design a program that updates the content of a master file

Algorithmic Decomposition

Source: *Object-Oriented Analysis and Design – With Applications* by Grady Booch et. al. (3rd Ed, 2007)

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So, this is just for a recap, I will not go over this example once again. We had discussed it earlier as well. So am just making a reference to this that we have talked about updating the contents of a master file and this is what you will get to in algorithmic decomposition.

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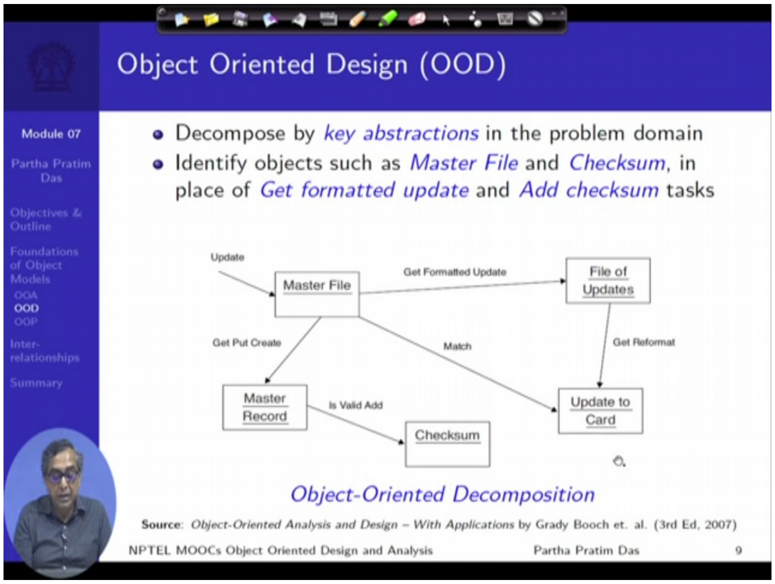

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Summary

- Decompose by *key abstractions* in the problem domain
- Identify objects such as *Master File* and *Checksum*, in place of *Get formatted update* and *Add checksum* tasks

Object-Oriented Decomposition

Source: *Object-Oriented Analysis and Design – With Applications* by Grady Booch et. al. (3rd Ed, 2007)

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And this is what you get to in terms of an object-oriented decomposition and you can see that naturally the process of analysis must have identified these objects, these objects and because it is somewhat vaguely specified in terms of the problem domain but this come from the vocabulary of the problem domain. The problem domain talks about a master file, talks about a file of updates and so on and based on that this kind of a diagram is getting created in terms of how the objects will interact between themselves and that is the core of the object-oriented design process.

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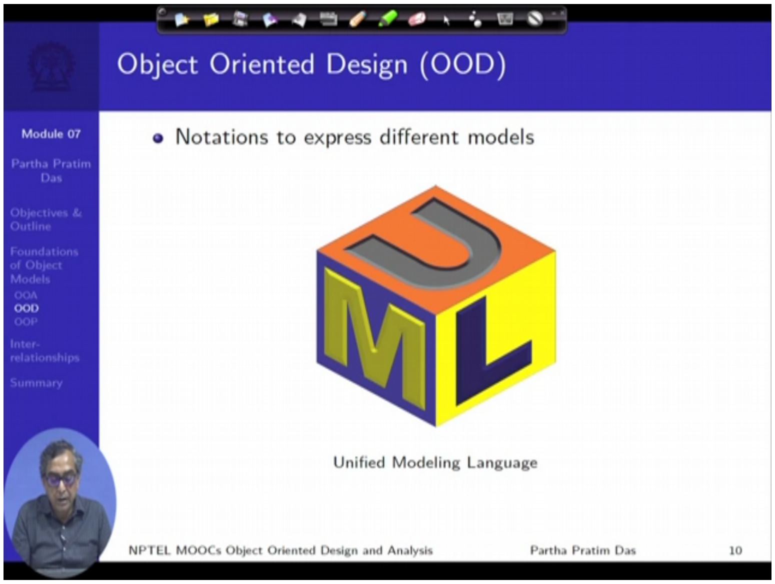

Object Oriented Design (OOD)

- Notations to express different models

Unified Modeling Language

Naturally all those different models that object-oriented design needs to deal with have to be expressed in some concrete terms and we will find that significant part of our course is dedicated to learning for, learning how to express these models which so far even though we are saying that this is a concrete object, this is a concrete attribute, these are messages, services, operations and so on.

We need a mechanism to represent all these logical models, physical models, behavioral models and so on in some well defined, well structured language and we will talk about that language which is called the UML or the unified modeling language. So, with this we will we have taken a look into the object-oriented analysis approach and the basic object-oriented design paradigm. We will now see how these 2 gets engaged into the final system through that object-oriented programming.