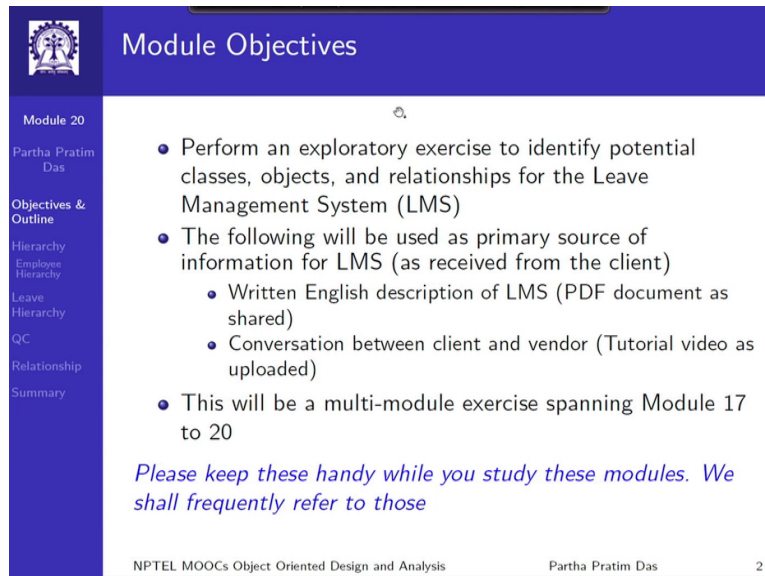


Object-Oriented Analysis and Design
Prof. Partha Pratim Das
Department of Computer Science and Engineering
Indian Institute of Technology - Kharagpur

Lecture - 32
Identification of Classes, Objects and Relationship in LMS (Contd.)

Welcome to module 20 of Object Oriented Analysis and Design, we have been pursuing the exercise of doing a basic design of the Leave Management System.

(Refer Slide Time: 00:43)



The slide is titled "Module Objectives" and is part of Module 20. It lists three main objectives for the Leave Management System (LMS) design exercise. The first objective is to perform an exploratory exercise to identify potential classes, objects, and relationships. The second objective is to use specific information sources: a written English description of LMS (PDF) and a conversation between client and vendor (Tutorial video). The third objective is that this will be a multi-module exercise spanning from Module 17 to Module 20. A note at the bottom asks students to keep these resources handy for frequent reference. The footer includes the NPTEL MOOCs title, the professor's name, and the slide number 2.

Module Objectives

- Perform an exploratory exercise to identify potential classes, objects, and relationships for the Leave Management System (LMS)
- The following will be used as primary source of information for LMS (as received from the client)
 - Written English description of LMS (PDF document as shared)
 - Conversation between client and vendor (Tutorial video as uploaded)
- This will be a multi-module exercise spanning Module 17 to 20


Please keep these handy while you study these modules. We shall frequently refer to those

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And this will be the last module on that exercise, so I will just reiterate that please keep the PDF description of the leave management system handy with you, you will need to refer to it very frequently if you have not already very carefully listen to the interactive video of the client-vendor interaction for LMS, please do listen to that carefully.

And while you go through this module please considered to stop and work out things for yourself when we have outlined any new action on the design aspect that way it'll be able to learn the design process much better.

(Refer Slide Time: 01:30)



Module Outline

Module 20

Partha Pratim Das

Objectives & Outline

Hierarchy

Employee Hierarchy

Leave Hierarchy

QC

Relationship

Summary

- Refinement of Hierarchy
 - Employee Hierarchy
 - Leave Hierarchy
- Relationships


NPTEL MOOCs Object Oriented Design and Analysis

Partha Pratim Das

In this specific module, we- we will particularly focus at refinement of hierarchy and will try to show that in addition to the identification of responsibilities is which we did earlier and the identification of collaborators which also we did earlier while we recognize where we extract a hierarchy it is quite possible that a lot still can be done on top of it by going back to the specification and trying to look for a lot more of possibly intangible information that are hidden all over the document to improve on the hierarchy and get to a better design.

And we will just also outline in this a little bit of a relationship between classes.

(Refer Slide Time: 02:26)



Employee Hierarchy: RECAP (Module 19)

Module 20

Partha Pratim Das

Objectives & Outline

Hierarchy

Employee Hierarchy

Leave Hierarchy

QC

Relationship

Summary

Class: Employee	
Attributes:	<ul style="list-style-type: none"> Name ID DoB
Responsibilities:	<ul style="list-style-type: none"> Record Daily Attendance Request for Leave Cancel an Approved Leave Avail Leave, if approved

IS-A

Class: Executive	
Attributes:	<ul style="list-style-type: none"> Reporting_Lead ...
Additional Responsibilities:	<ul style="list-style-type: none"> Report to Lead

Class: Lead	
Attributes:	<ul style="list-style-type: none"> Reporting_Manager List of Reporting Executives
Additional Responsibilities:	<ul style="list-style-type: none"> Approve Leave (Executive) Regret Leave (Executive) Revoke Leave (Executive) Report to Manager Take Reporting (Executive)

Class: Manager	
Attributes:	<ul style="list-style-type: none"> List of Reporting Leads ...
Additional Responsibilities:	<ul style="list-style-type: none"> Approve Leave (Lead) Regret Leave (Lead) Revoke Leave (Lead) Take Reporting (Lead)

- For brevity, all characteristics and all responsibilities are not shown
- Suggest refinements to Employee hierarchy

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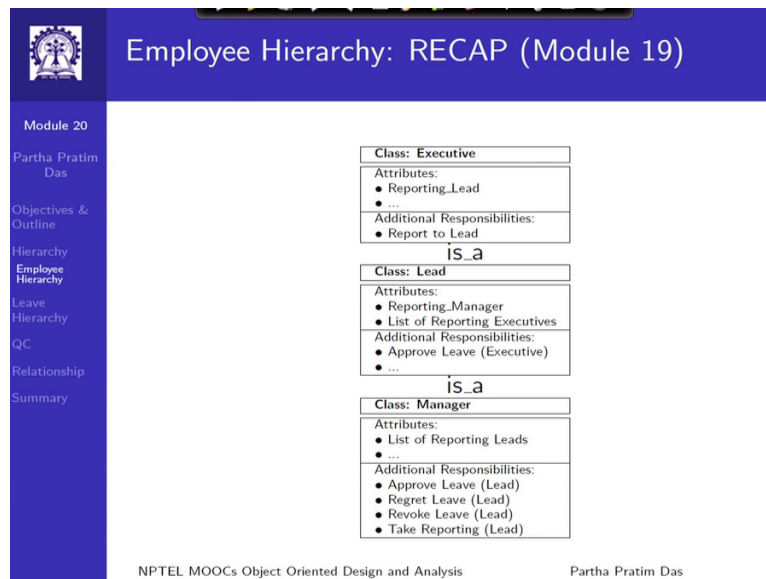
Partha Pratim Das

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A quick recap of the recent stuff that we have done and employee hierarchy design that we did in the last module we did first did a flat design of one level which is just by kind of factoring of responsibilities finding the common responsibilities between the employee and

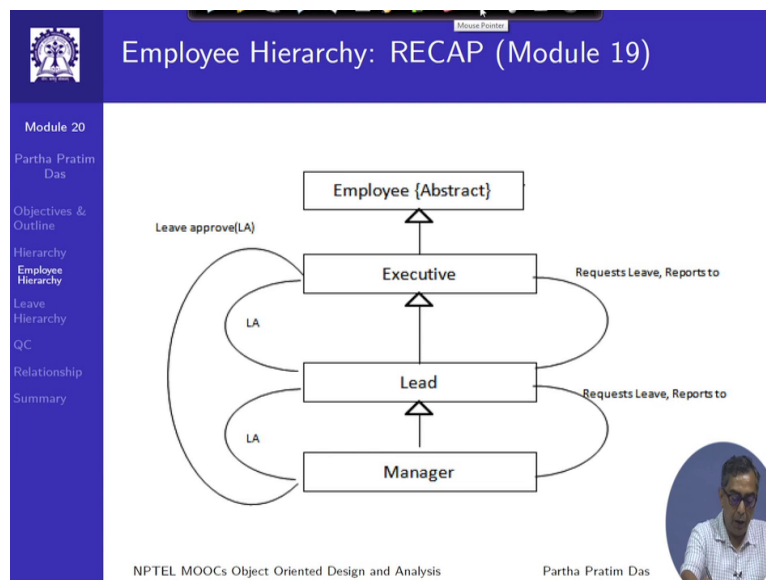
the other classes we made Executive, Lead and Manager all specializations of the employee class.

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And then will look into refined that further by seeing that it is not only a common subset of responsibilities between employee and others there is a hierarchy of subset of responsibilities between these four classes and therefore they form a linear chain naturally they form a linear chain of hierarchy and which is designated as per here.

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Now would like to just a take this further an apply that to leave.

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Leave Hierarchy

Module 20

Partha Pratim Das

Objectives & Outline

Hierarchy

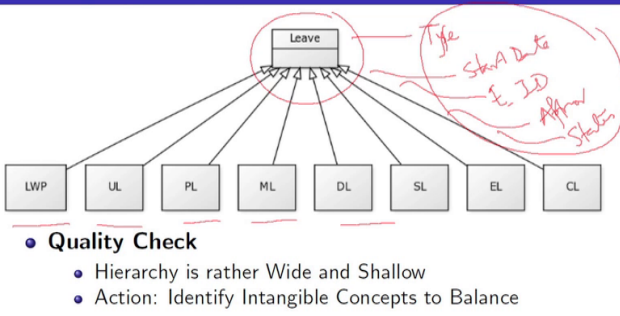
Employee Hierarchy

Leave Hierarchy

QC


Relationship

Summary



• Quality Check

- Hierarchy is rather Wide and Shallow
- Action: Identify Intangible Concepts to Balance



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So you have already read the specification document several times so I am sure you will not have to go back to its to conclude that all kinds of leave that we are talking about our fundamental leave so if it - if it try to say this in terms of attributes sets then we can say that this will need to have a type which we have already received it needs to have a start date.

Certainly it needs an employee ID as to who is taking the leave certainly it needs to have an approver it needs a status and so on. So these are things that a leave will have their maybe lot more, and each one of this special kinds of leave all of them will also have this these properties these attributes but depending on a specific type of leave - leave there will be more specific attributes more that will exist.

For example, a medical leave will have certificate a longer duration and so on am - on leave will have the associated encashment benefits and so on so forth, so doing this hierarchy does not take much effort is not take much time so if you just put it back to our quality check I would refer you to the quality of design discussion we had particularly in terms of choosing the relationships and so on.

Then we will see that this is what is considered to be a certainly a very wide and shallow hierarchy is very wide everything is and very shallow, so which means they are potentially could be lot more of in a communality of a behaviour lot more of possible natural coupling that you're missing out here, so you want to discover that and so the action would be to identify intangible concepts to make this a more balanced hierarchy, okay.

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Requirement Specification

A Company wants to manage the attendance and leave of its employees through LMS. The requirement specifications are:

1. The company has three categories of employees:
 - *Executive*: Employees who work as individual contributors and report to a Lead.
 - *Lead*: Every Executive reports to a Lead who approves / regrets her / his leave. A Lead reports to the Manager.
 - *Manager*: Every Lead reports to the Manager who approves / regrets her / his leave. There is *only one* Manager.
2. The company has provisions for the following categories of leave associated with the respective leave rules:
 - *Casual Leave (CL)*:
 - 10 CL's are available in a calendar year. All CL's are credited to an employee on 01-Jan. For employees joining in the middle of the year, the number of CL's are prorated. CL's cannot be carried over to the next calendar year.
 - More than 2 CL's cannot be availed at a time. CL's cannot be clubbed with other types of leave. Total period of absence including holidays cannot be more than 4 days. Holidays intervening the absence are not counted as leave.
 - CL's do not need pre-approval; but must be approved within 2 days of its availing.
 - *Earned Leave (EL)*:
 - 15 EL's are available in a calendar year. 1.25 EL is credited on the completion of a full month's service. EL's can be carried over to the next calendar year and accumulated up to 45 days. Once it crosses 45 days then on the completion of the current quarter, 30 days are en-cashed and paid to the employee. Remaining EL's continue in the account. All EL's are en-cashed when an employee leaves the company.
 - EL's can be availed at a stretch and up to the existing balance. It can be clubbed with other leaves (except CL). All holidays within the leave of absence of EL are counted as EL.
 - In exceptional cases Manager can approve more EL's than what exists in one's account. Maximum of 15 days' negative balance is allowed.
 - All EL's must be pre-approved (at least by a week).
 - *Duty Leave (DL)*:
 - When an employee is sent out of station or on leave on work, a DL is created.
 - Every DL is approval basis and has no specific accounting. It is considered as being "On Duty".
 - *Sick Leave (SL)*:
 - 12 SL's are available in a calendar year. All SL's are credited to an employee on 01-Jan. For employees joining in the middle of the year, the number of SL's are prorated. SL's can be carried over to the next calendar year and accumulated up to 60 days.
 - SL's can be availed at a stretch and up to the existing balance. It can be clubbed with other leaves (except CL). All holidays within the leave of absence of SL are counted as SL.
 - In exceptional cases Manager can approve more SL's than what exists in one's account. Maximum of 12 days' negative balance is allowed.
 - Medical certificates are needed to proceed for and join back from SL's. SL's can be approved post-facto in cases of emergency.
 - *Maternity Leave (ML)*:
 - Every female employee is eligible for 4 months' ML when pregnant. It can be clubbed with other leaves (except CL).
 - All holidays within the leave of absence of ML are counted as ML.
 - Medical certificates are needed to proceed for and join back from ML's.

So if we want to do this then let us see what are the things that we can look at what can we get those intangible ones, so this needs little bit more careful reading of the specification so please bear with me for one to leave I am going to read out for your benefit the what is stated for the leave.

So it is a ten CL's are available in a calendar year first sentence, all CL's are credited to the employee on such and such date, employee joining in the time - middle of the year the number of CL's are prorated therefore the sentence being said. CL's cannot be carried over to the next calendar year more than two CL's cannot be availed at a time, they cannot be clubbed the total period of options including holidays cannot be more than four days.

But the holidays intervening are not counted, these are the different sentences that are coming up so our - our mental process is as you go to study about the next type of leaves Earned Leave we read it and we tried to see, okay if 15 EL's are available in a calendar year we mentally make a - a kind of map that available is something which mere relate the different kinds of leave so available.


Then we can say that we see that we already seen the was the credited so we know that available is some factor credit is certain factor we say the carried over is talks about carried over now I do not know EL's can be carried over EL's can also be carried over so carry over is an other aspect.

Then there is some encashment encash is an other aspect right, these are the different things we are seeing here, then it says it must be pre-approved and the we say CL's does not need to be pre-approved so we can say pre-approved. So all that I am doing I am trying to go through this different kinds of leave.

And for example I could - I could scroll up of course this set of markings will go here where on that but we can - I can use a different colour, I can use a different colour and try to do some more marking like this here is again talks of available, talks of credit it does for SL it does talk of what else carry - carried over this is the basic concepts that we have been we have been seeing here. So what - for example it talks about something new it talks about a Medical Certificate.

So what I am trying to point to is if you try to go through each one of these leave categories and try to see what are other than the factor that it is a leave what are the different kind of conditions constraints properties that this system is talking about and then kind of try to make a representation for that you could represented in whatever way you please so what I will present you here is certain representation that I tried to extract from this description so that we can use it in terms of the design.

So I have represented in terms of it table so if you look into the left hand side.
(Refer Slide Time: 10:24)



Leave Hierarchy: Analysis of Pre- and Post- Conditions

Module 20

Partha Pratim Das

Objectives & Outline

Hierarchy

Employee Hierarchy

Leave Hierarchy

QC

Relationship

Summary

Property	CL	EL	SL	DL	ML	PL	LWP	UL
Entitlement	Y	Y	Y	NA	Y ^a	Y	Y	N ^b
Duration of Leave	Y	Y	Y	NA	Y	Y	Y	N ^c
Is Leave Clubbable?	N	Y	Y	NA	Y	Y	Y	N
Is Holiday exempt in Leave?	Y	N	N	NA	N	N	N	N
Must Leave be Pre-Approved?	N	Y	N ^d	NA	Y	N ^e	Y	N
Does Leave Carry-over & Accumulate?	N	Y	Y	NA	N	N	N	N
Can Leave be En-cashed?	N	Y	N	NA	N	N	N	N
Does Leave need Certification?	N	N	Y	NA	Y	Y	N	N
Is Leave paid?	Y	Y	Y	NA	Y	Y	N	N


^a: Only for female, when pregnant, twice in career

^b: Deemed entitlement for a week before actions start

^c: Allowed for up to a 7 days

^d: Exception condition for sickness

^e: Exception condition for parenthood



NPTEL MOOCs Object Oriented Design and Analysis

Partha Pratim Das

For example, we - we did see the question of whether let me use red that is better whether a leave needs to be pre-approved we saw that CL said that it does not be pre approval where is

EL said that it needs pre approval, we saw the issue of carry over, we saw some leaves can be clubbed we saw ML leave need certification, so every time you come across cert - certain tangible or intangible properties and constraint you try to put them as the system property and that is why I got this list.

And there can we make a chart of these are the properties and these are the different classes I already know that classes and I know why do I just do this for these classes why do not I take employees why do not I take an admin and why do not I take for that matter calendar year into this because I am trying to refine a hierarchy so my containment is within the hierarchy I have already done those analysis my basic modularization is there within that I have actually created a entity hierarchy so if I am just focusing on that.

So well on those to access of property and the classes so this - these are the properties so this basically is not written its obvious these are the classes, I tried to fill up this is the compliance to what is the compliance of different class to these properties so this kind of gives me a very compact representation for what is intangibly described over two pages or one and half pages of different leave conditions.

if you want to read it through say - you say is leave clubbable so we have read that it says that CL cannot be clubbed but naturally if its unauthorized leave then it cannot be clubbed anyway but and if it is the duty leave there is no question of clubbing it because you are on duty anyway, but all of this now you can go back and actually reads to the document you will find that all of these are actually clubbable.

Similarly, say can the leave be encashed while doing the reading about EL we studied that leave EL can be encashed so you put yes here and rest of them are basically not applicable are known, and of course this this will not give you very uniform design always

For example, in case of entitlement, entitlement is basically what - what I write here is entitlement is what we noted as credit do you remember that we say that every year in 1st January 10 CL's are credited then for every month 1.25 EL's credited and so on, so that cred is what I am calling that entitlement as to what are you entitled to get if you look into the entitlement these are all different types of leave.

But certainly you will have special qualification here when you're talking about maternity leave the qualification is and that is what this suffix represent at this leave is available only for females when if female employee is pregnant and also at most twice in the career so this kind of you will also try to keep track of some of the special conditions which might exist in terms of this general broad illustration of the intangible properties that you'll get to see.

For example, you could look at some of the others for example here which is d or does it mean must leave me pre-approved and we are talking about so this must pre-approved for sick leave that is d so it says that exception condition for sickness that is the if we- if we go back and see what we are encoding if we look at that then let us - let us specifically focus on the sick leave part it is it is tried to see it says that SL's can be pre-op - can be post-facto in case of emergency.

Because certainly you cannot predict always that you are going to fall sick so if you fall sick and you cannot attend office if you apply for sick leave in the post- facto manner that is after you have taken the leave so we have basically utilizing that information and encoding it here saying that in a may be a little bit different manner that must leave be pre-approved'

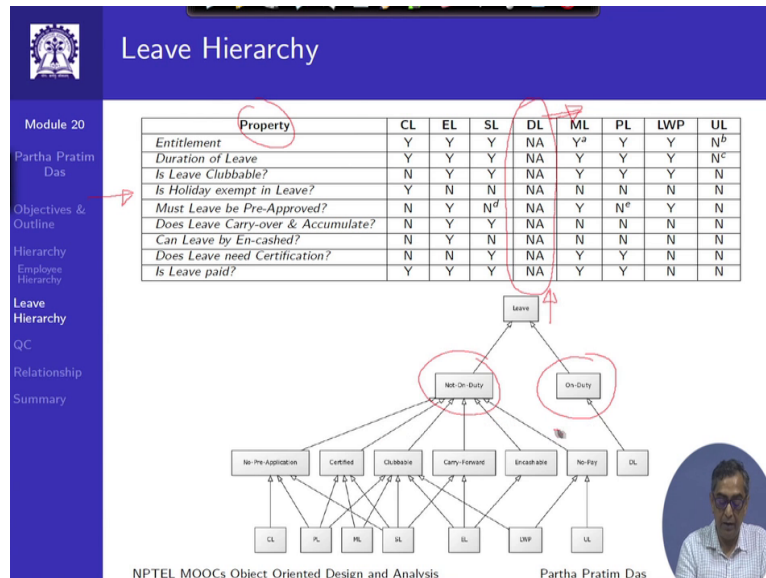
If you are being able to take it post-facto take the approval post facto, then is not pre-approved for a SL and but that is a more exception case it is not that it for every SL at least that sentence does not mean kind of suggests that it is always says that it can be approved post facto in the case of emergency so if you have you know pre-planned medical checkup or you are taking up some sir surgery something then certainly it will be expected that it will still do a pre-approval all that.

So these are the different things and you can - you can just go through the details later on and see the encoding so all the time trying to show you it is not always that you just read and you are not try to analyse and do things in your mind but you can try to use the variety of tools of tabularization and compaction to come to some better conclusion.

So what does this table lead us to? This table say that the leaves are different kinds of precondition and post condition and we can say that can we not then try to reclassify reorganizing the leave based on these properties that is based on some of these properties

For example, if certain leaves or need certification certain say no, this say no, this says no but some say yes so some need certification and some do not - does not it impose a specialization on the set of leaves that you have and that is the basic idea that we will use here.

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And here again show you the same leave hierarchy and I should have actually use different colour but in terms of the original hierarchy this was the route and I am sorry this was the route and the participating classes are this, so the original hierarchy was just kind of a flat where we just said that each one of the leave is DL, CL, SL, ML are the kind leave.

Now you are saying you look at if we say clubbable so we have defined a - we defined that let us have an abstract kind of a leave class as clubbable in class which we will have all the properties of the leave so that will be a specialization of leave, but it will have some additional properties that are required for checking out the clubbability conditions or imposing that conditions and so on.

And then we make all that if this is clubbable, then this is clubbable, this is clubbable, this is clubbable, this one is, this one is, so you say EL, SL, ML, PL Parenthood Leave and the Leave Without Pay these five are clubbable so we show that this five are specialization of clubbable leave.

Now this is an interesting exercise for example if you see that in this - in this whole exercise if you look into this column DL you have everything has any nothing applies so that clearly tells us that it is not only always that the horizontal factorization will have to be used you

could use a vertical factorization also that you say that this particular leave category is out of the general.

So let us try to identify some property which is not identified here so that I can take this column out and that is precisely what I do here. I just see introduced a concept that is a On Duty leave and is a On Duty and a Not On Duty, so naturally DL becomes only specialization that and all the other leave actually come under the others part of the category.

So certainly you can - you can realize you can expect that this intangible classifications we will give you certain bit of benefits positively because if I know that this is the On Duty one and these are all Not On Duty so which means that for any of the other leaves you will not at all look at or you will not at all ask the employee to fill up is the work responsibility during the period of absence whereas only for this you will need to fill it up so that is the different specialization that can be worked out.

For example, if we look at one more example let say the does leave need certification so SL need certification, ML need certification and PL need certification so certainly if it needs certification then you are final effective processing behaviour is going to be different and if you - if you're note in this exercise we have made some progress and terms of just the first round identification of responsibilities and analyzing that we - we got the basic hierarchy.

But now we are looking deeper into and kind of if you - if you remember kind of you are moving somewhat from what was Discovery you would remember we had talked about Discovery and Invention in terms of identification of key abstraction Discovery deals with that user who is domain vocabulary and so on and those are the leave and earned leave casual leave and all that and Invention talk about the developer the implementer.

So that is what the user will not look at the leave as whether it is clubbable or whether it is - it is a certifiable on so on so forth but does not implemented it does help to look at leaves which are certified and not that there are three leaves are that kind and make them specialization and clubbed all certification related functionality all certification related responsibilities in this class.

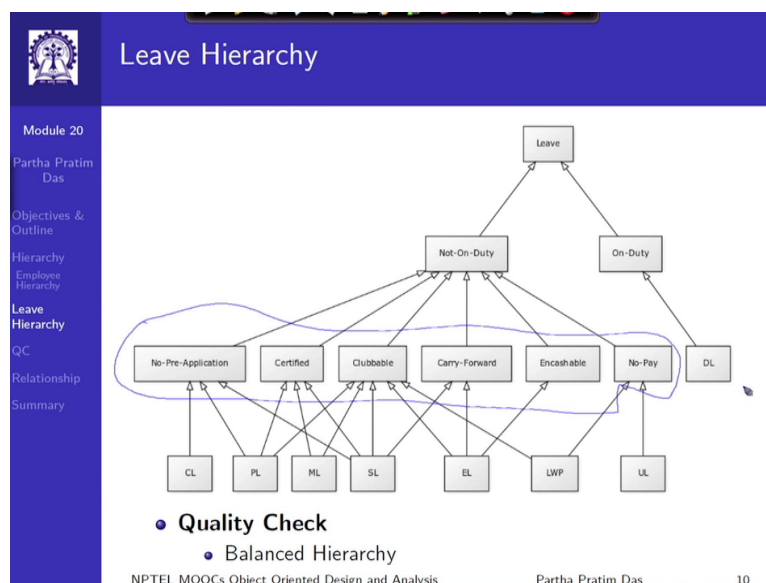
And certainly you can -you can easily figure out that finally a leave is of one of these kinds so anything else that we are doing any of the other that we are doing the rest of this whole hierarchy that we are doing are abstract so we will never have a leaf which is just certified, you will have a specialized in terms of that in terms of either PL or an ML or an SL, so that is a basic.

So this exercise I wanted to really so you mining information from the leave document to show that you will whenever you were given to work on a hierarchy which is a very very critical we have repeatedly said that hierarchy of abstraction is a very very critical part of the O O design if you get - if you do not get the hierarchy right then the whole implementation of the system whole conception of the system becomes is not on solid foundation.

So you really should do a very extensive exercise in terms of trying out different and an again, again, please do not think that this I am saying that this is an absolute hierarchy for the LMS system you could think of different other parameters that you could organize them differently but as long as you have reasonably covered all that is mentioned in the specification.

And as a developer you have all your requirements all your questions answered you have a fairly good design and certainly if we now take this as a - as a final that we have in terms of this leave part of the LMS.

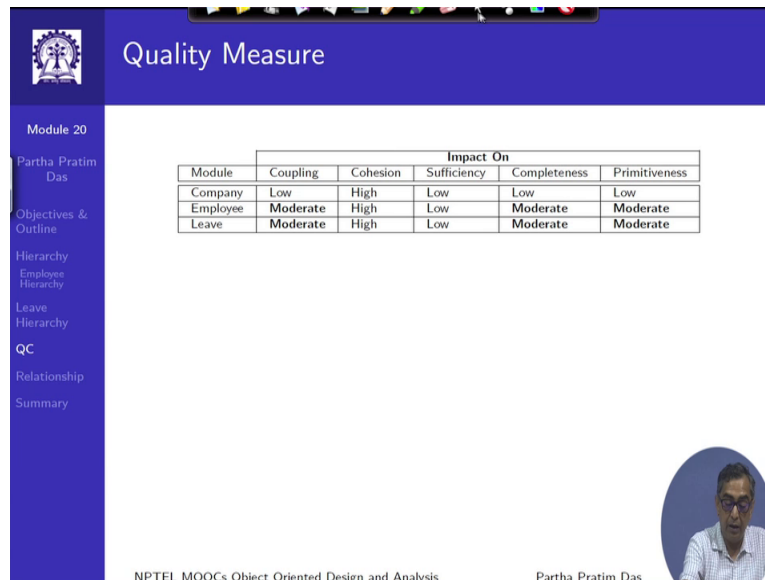
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Then we can certainly say that we have a much better balanced hierarchy now which goes into one, two, three, four different layers and you would see that many of these classes have very limited number of specialization showing that they are very focused abstract classes which kind of focus on the small set of aspects of the design.

And all of this intermediate classes that we show here are represented you of that for each class is basically going to implement on top of the basic leave functionality some of the very specific functionality that need to be imposed on the certain types of leaves. So that is - that is a basic of the hierarchy design, I would emphasize that you please go over this design more carefully and try to refine that further.

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The slide is titled "Quality Measure" and features a table comparing three modules (Company, Employee, Leave) across five quality metrics: Coupling, Cohesion, Sufficiency, Completeness, and Primitiveness. The table is titled "Impact On" and shows that while Coupling is moderate for all, Cohesion is high for all, and Sufficiency, Completeness, and Primitiveness are low for Company and Employee, but moderate for Leave.

Module	Impact On				
	Coupling	Cohesion	Sufficiency	Completeness	Primitiveness
Company	Low	High	Low	Low	Low
Employee	Moderate	High	Low	Moderate	Moderate
Leave	Moderate	High	Low	Moderate	Moderate

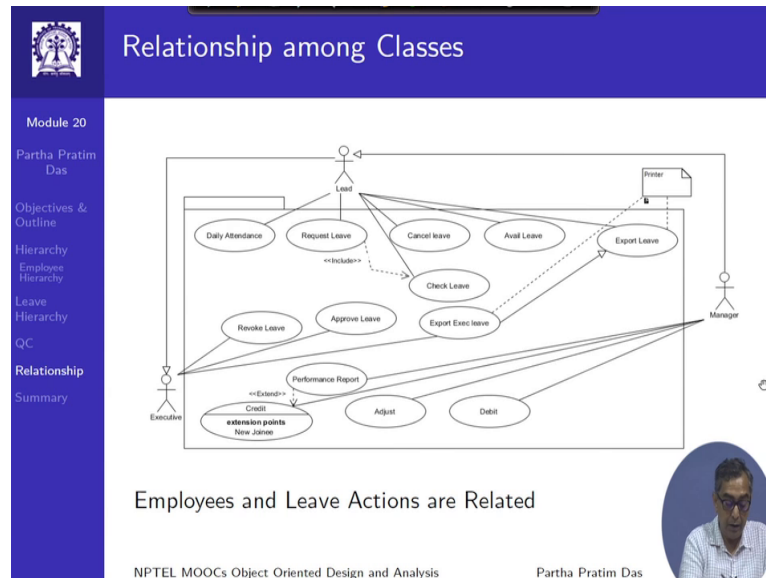
The slide also includes a sidebar with navigation links: Module 20, Partha Pratim Das, Objectives & Outline, Hierarchy, Employee Hierarchy, Leave Hierarchy, QC, Relationship, and Summary. A small video inset of the presenter, Partha Pratim Das, is visible in the bottom right corner.

Coming back to the quality measures certainly we have made some more progress and the very significant one would be in terms of Coupling because now we have the hierarchy in place of as you know I work in process a lot of coupling so in terms of an employee and leave we are at a moderate level of coupling if not at high level of coupling the Cohesion does not change.

But certainly we have made a lot of progress in terms of completeness because particularly for employees and leave we have made write a detailed analysis of how they are structured how they are collaborate how they can be putting modules what are the responsibilities so on.so in terms of days we have made some progress and going ahead in terms of the quality measures in our design.

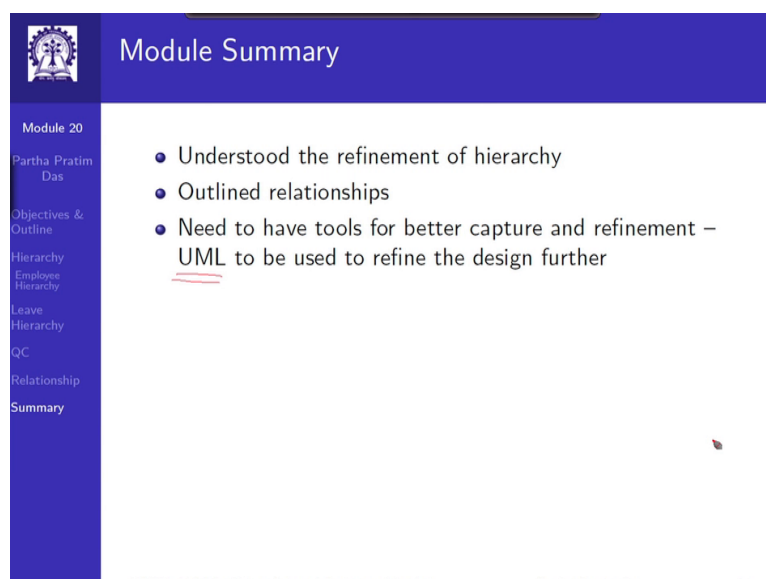
Besides that, there could be besides the hierarchy there could be several other relations that we like to capture we would not do it any detail exercise of that in this current module for example between executives there could be relations of leave approval and there could be request reports and so on, they can be shown in multiple different ways.

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Similarly, if we looking in at a bigger perspective then between the employees these different employees the Manager, is a Lead, is an Executive and different these are different leave actions actually we can see lot of relationship association. And in this manner I would not go on in terms of just elaborating on the relationship because relationships are so many varied kinds associations could be of so many varied kinds that it is about time that we formalize ourselves and start taking help of a more structured tool the UML tool.

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And learn how to first represent whatever we have designed for the LML systems so far the basic information of classes atributes responsibilities and their basic relationships in terms of modules and the hierarchy that we have, and then we will go deeper into learning the Unified Modelling Language taking different aspect of these are called diagrams and as you pick up different diagrams will see which details of the system are captured by the diagram.

And these four modules where we started exploring the and doing kind of a hands on for the LMS design for just the introductory part we will continue doing this over the next couple of weeks as such when we go through the UML a so that by the end of the course at least for the LMS. We will be able to have a set of completed UML designs that you can refer to and in terms of your assignment and practice.

We have - we will be putting up other systems like we have already mentioned about an Assignment Management System and you should do some similar exercise of analyzing and designing for that system.