

Relationship among Objects & Classes

Identifying Classes, Attributes and Responsibilities

Case Study on Leave Management System

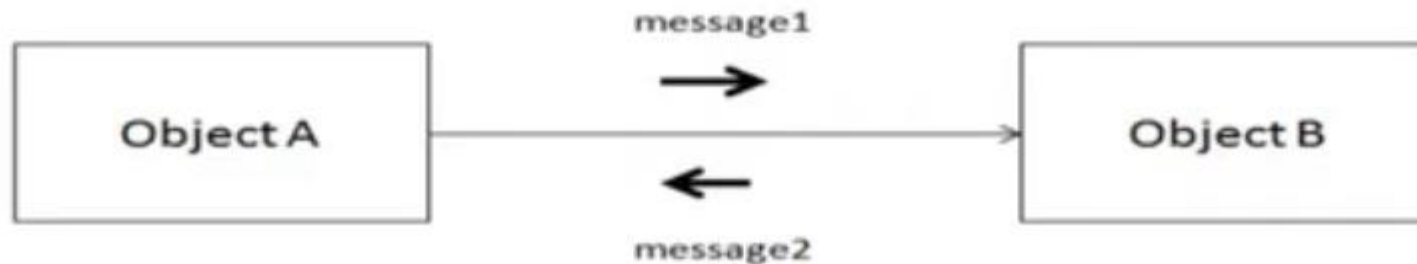
Overview

- Links
- Aggregation
- Classes
- Attributes
- Responsibilities
- Relationship & Hierarchy
- Collaboration
- Modularization
- Refinement in Class Hierarchy

Links & Aggregation

- Links

- A link is depicted by a line between two objects
- The direction of the line, depicts which objects, invokes the services of the other object
 - If there is no direction, then the link is bidirectional, both the objects invokes each other's services
- A message can be unidirectional or bidirectional in a link
- A message is represented with a small directed line and label to define the message



Object A invokes the services of Object B



Leave Management System

- Aggregation

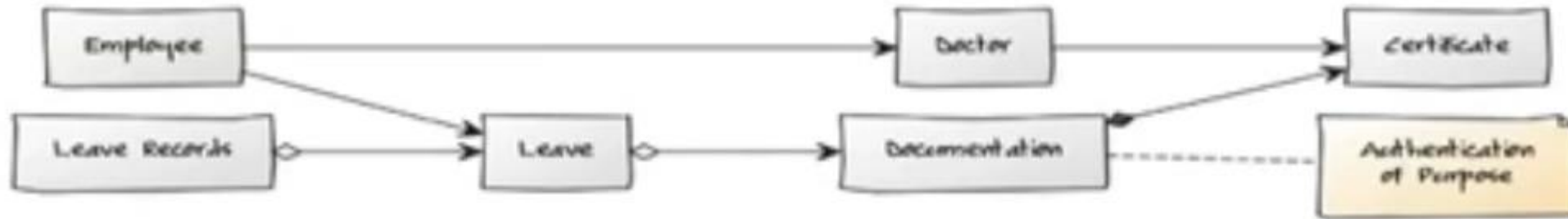
- Links denote peer-to-peer or client/server relationships
- In contrast, **Aggregation** denotes a whole/part hierarchy, with the ability to navigate from the whole (or aggregate) to its parts, that is, contained objects
- Aggregation may or may not denote physical containment
 - **HAS_A (Strong Aggregation)**: Physical containment is necessary – Airplane & its Engine, Car & its Wheels, Book & its Chapters, Chapter & its Sections, etc.
 - **HAS (Weak Aggregation)**: Conceptual aggregation, Physical containment is not present – Shareholders & Shares, Library & Users, etc.

An Aggregation is a specialized form of Association (Link)

- **Aggregation** is sometimes better because it encapsulates parts as secrets of the whole
- **Links** are sometimes better because they permit looser coupling among objects

Leave Management System

- Aggregation in Leave Management System



Drawn using: <http://yuml.me/diagram/scruffy/class/draw>

- **Employee**
Controller Object
Sends **applyLeave()** message to **Leave**
Sends **requestCert()** message to **Doctor**
- **Doctor**
Proxy Object
Receives **requestCert()** message from **Employee**
Sends **issue()** message to **Certificate**
- **Certificate**
Server Object
Receives **issue()** message from **Doctor**
- **Leave Records**
Weak Aggregation of **Leaves**
- **Leave**
Weak Aggregation of **Documentation**
- **Documentation**
Strong Aggregation of **Certificates**



Leave Management System

Input

Informal English Description \Rightarrow

Output

- Classes
- Attributes
- Responsibilities

Class Name	
Attributes	Responsibilities
•	•
•	•
•	•

• Classes (Nouns)

Responsibilities (Verbs)

- Linguistic analysis of the problem description - extraction of **Nouns**

- Rules of thumb¹ :

- Elimination of irrelevant terms
- Elimination of names of values
- Elimination of vague terms
- Identification of attributes
- Identification of operations
- Elimination of terms which are in fact relationships

- Linguistic analysis of the problem description - extraction of **verbs**

- Rules of thumb²:

- Which operations can be executed by a certain object
- Not only the current requirements should be considered, but also re-usability should be taken into account
- Which events are expected
- Which objects can react to these events
- Which other events are raised in turn

Leave Management System

- Identification of Classes (Noun)

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

- 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.

Leave Management System

- Identification of Classes (Noun)
- 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.


Leave Management System

- List of Identified Classes (Noun)

Company	Attendance	Leave	Employees
Contributors	Lead	Executive	Manager
Leave Rules	Days	Year	Name
Type of Leave	Period	Absence	Holiday
PL	CL	EL	DL
SL	ML	LWP	UL
Pre-approval	Month	Service	Quarter
Medical Certificate	Parenthood Certificate	Disciplinary Action	Administration Function
Daily Attendance	Personal Details	Calender Year	Batch Task
Account	Balance	Designation	SysAdmin
Parent	Salary	Week	List
Privilege	Right	Login ID	Leave Status
Employee Code			

Leave Management System

- Identifying Attributes

Company	Attendance	Leave	Employees
Contributors	Lead	Executive	Manager
Leave Rules	Days	Year	Name
Type of Leave	Period	Absence	Holiday
PL	CL	EL	DL
SL	ML	LWP	UL
Pre-approval	Month	Service	Quarter
Medical Certificate	Parenthood Certificate	Disciplinary Action	Administration Function
Daily Attendance	Personal Details	Calender Year 	Batch Task
Account	Balance	Designation	SysAdmin
Parent	Salary	Week	List
Privilege	Right	Login ID	Leave Status
Employee Code			

Noun used only as value should be treated as attribute

- Login ID
- Name
- Employee Code
- Personal details
- Designation
- Salary

Leave Management System

- Structural Clustering

Company	Attendance	Leave	Employees
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- People

- Manager, Lead, Executive
- SysAdmin

- Organizations

- Company

- Things (Documents)

- Medical Certificate, Parenthood Certificate

Leave Management System

- Structural Clustering

Company	Attendance	Leave	Employees
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- Events

- Holiday, Disciplinary Actions
- CL, ML, UL ...etc

- Temporal Nouns

- Date, Year, Time, Days, Calender year, Week, Month

- Incidental Nouns

- Leave Rule, Administrative Functions, Period

Leave Management System

- Structural Clustering

- People
 - Manager, Lead, Executive
 - SysAdmin
- Organizations
 - Company
- Things (Documents)
 - Medical Certificate, Parenthood Certificate
- Events
 - Holiday, Disciplinary Actions, CL, ML, UL ...etc
- Temporal Nouns
 - Date, Year, Time, Days, Calender year, Week, Month
- Incidental Nouns
 - Leave Rule, Administrative Functions, Period

- Behavioural Clustering

- What takes place in the system
 - Leaves – CL, ML, UL ...etc
- Initiator and Participant
 - Initiator – Lead and Manager; SysAdmin
 - Participant – Executive, Lead and Manager

Leave Management System

- Abstraction Summary

- **Key Abstractions:** Leave, Employee, CL, EL, ...
- **Non-Key (Supporting) Abstractions:** Medical Certificate, Parenthood Certificate, Disciplinary Actions, ...
- **Incidental Abstractions:** Leave Status, Administrative Functions, ...
- **Attribute (Property) Abstractions:** name, personal details, employee code, ...

Leave Management System

- Resultant Classes

- ① Company
- ② Employee
- ③ Executive
- ④ Lead
- ⑤ Manager
- ⑥ Leave
- ⑦ SL

- ⑧ ML
- ⑨ PL
- ⑩ CL
- ⑪ EL
- ⑫ DL
- ⑬ LWP
- ⑭ UL
- ⑮ SysAdmin

Leave Management System

- Identification of Responsibilities (verbs)
 - Linguistic analysis of the problem description - extraction of verbs
 - Rules of thumb²:
 - Which operations can be executed by a certain object
 - Not only the current requirements should be considered, but also re-usability should be taken into account
 - Which events are expected
 - Which objects can react to these events
 - Which other events are raised in turn

Leave Management System

- Identification of Responsibilities (verbs)

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:
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 - *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.

Leave Management System

- Identification of Responsibilities (verbs)
 - 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.

Leave Management System

- List of all Identified Responsibilities (verbs)

Wants	Manage	Work	Report
Approve	Regret	Credit	Join
Prorate	Cross	En-cash	Paid
Allow	Send	Need	Become
Enjoy	Avail	Proceeding	Employ
Consider	Deduct	Provide	Request
Cancel	Check	Export	Revoke
Debit	Adjust	Perform	Hire
Fire	Generate	Leave	Can be
		En-cashment	Availed
Can be	Can't be	Can't be	Can't be
Clubbed	Availed	Carried forward	Clubbed
Can't be	Accumulated	Proposed for	Join Back
Continued	Up		
Doesn't Draw	Can be Revoked	Leave Credited	

Many extracted verbs are in derived forms – so we extract the unique stems

Leave Management System

- List of all Identified Responsibilities (verbs)

Wants	Manage	Work	Report
Approve	Regret	Credit	Join
Prorate	Cross	En-cash	Paid
Allow	Send	Need	Become
Enjoy	Avail	Proceeding	Employ
Consider	Deduct	Provide	Request
Cancel	Check	Export	Revoke
Debit	Adjust	Perform	Hire
Fire	Generate	Leave	Can be
		En-cashment	Availed
Can be	Can't be	Can't be	Can't be
Clubbed	Availed	Carried forward	Clubbed
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Continued	Up		
Doesn't Draw	Can be Revoked	Leave Credited	

Many extracted verbs are in derived forms – so we extract the unique stems

Leave Management System

- List of all Identified Responsibilities (verbs) Stem Only

Wants	Manage	Work	Report
Approve	Regret	Credit	Join
Prorate	Cross	En-cash	Pay
Allow	Send	Need	Become
Enjoy	Avail	Proceed	Employ
Consider	Deduct	Provide	Request
Cancel	Check	Export	Revoke
Debit	Adjust	Perform	Hire
Fire	Generate	Club	Carry forward
Continue	Accumulate	Propose	Join Back
Draw			

Leave Management System

- Relation of verbs with Classes

Class	Related Verbs / Responsibilities	
Employee	<ul style="list-style-type: none">• Work• Record• Request• Cancel• Avail	<ul style="list-style-type: none">• Check• Export• Report• Approves• Regret

Casual Leave	<ul style="list-style-type: none">• Credit• Prorate• Approve• Cannot be availed• cannot be clubbed
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Class	Responsibilities	
Employee	<ul style="list-style-type: none">• Work• Record• Request• Cancel• Avail	<ul style="list-style-type: none">• Check• Export• Report• Approves• Regret
Casual Leave	<ul style="list-style-type: none">• Credit• Prorate• Approve• Cannot be availed• cannot be clubbed	

Blue responsibilities are core – common for all employees

Leave Management System

- Abstraction Summary

- **Key Actions:** Report, Request (leave), Approve (leave), Regret (leave), ...
- **Non-Key (Supporting) Actions:** Can be clubbed, ...
- **Auxiliary Actions:** Perform, ...

Leave Management System

- Employee Class with Attributes and Responsibilities


Employee	
Attributes	Responsibilities
<ul style="list-style-type: none">• Name• Personal details• Designation • Employee code• Login id	<ul style="list-style-type: none">• Record Daily Attendance• Request for Leave• Cancel an Approved Leave not yet availed• Avail Leave (if approved)• Check / Export own Leave Status for a period

- Similarly attributes and responsibilities can be for Executive, Lead and Manager classes
- Try and complete the rest

Leave Management System

- Leave Class with Attributes and Responsibilities

Leave	
Attributes	Responsibilities
<ul style="list-style-type: none">• Type of Leave• Start Date• Duration of Leave• Employee Id	<ul style="list-style-type: none">• Validity Check• Accounting••

- Similarly attributes and responsibilities can be for CL, EL, ML ...etc.
 - Try and complete the rest
- 

Leave Management System

- Relationship & Hierarchy in Class

- We analyzed the responsibilities of classes already
- Next the relationships and hierarchy between the classes must be clarified
- Three steps are:
 - Identify possible relationships / collaboration between classes
 - For those with relationships, describe the nature of the relationship
 - Identify the Hierarchy between related classes

Leave Management System

- Collaboration

Class Name	Responsibilities	Collaborators
Company	<ul style="list-style-type: none">• Manage	<ul style="list-style-type: none">• Employee• Leave
Employee	<ul style="list-style-type: none">• Record Daily Attendance• Request for Leave...	<ul style="list-style-type: none">• Leave
Executive	<ul style="list-style-type: none">• Record Daily Attendance• Request for Leave...	<ul style="list-style-type: none">• Leave• Lead
Lead	<ul style="list-style-type: none">• Approve Leave• Request for Leave...	<ul style="list-style-type: none">• Leave• Executive• Manager
Manager	<ul style="list-style-type: none">• Credit, Debit, Adjust Leave• Hire, Fire Employee• Force-execute...	<ul style="list-style-type: none">• Leave• Executive• Lead• SysAdmin
Leave	<ul style="list-style-type: none">• Validity Check• Accounting	<ul style="list-style-type: none">• Employee

Leave Management System

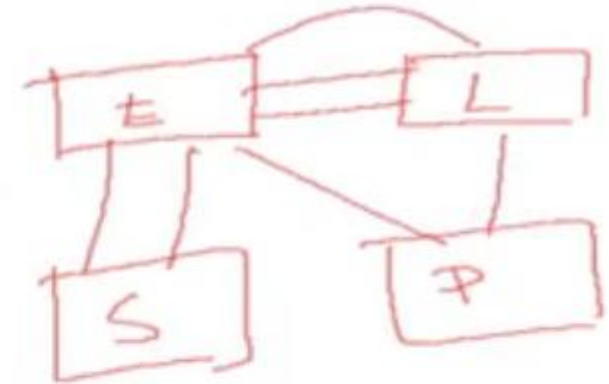
- Collaboration

Class Name	Responsibilities	Collaborators
CL	<ul style="list-style-type: none">• Credit, Prorate• Count, Club...	<ul style="list-style-type: none">• Employee• Leave
SL	<ul style="list-style-type: none">• Credit, Carry Over• Prorate, Club...	<ul style="list-style-type: none">• Employee• Leave
EL	<ul style="list-style-type: none">• Credit, Carry Over• Accumulate, Encash...	<ul style="list-style-type: none">• Employee• Leave
DL	<ul style="list-style-type: none">• Create...	<ul style="list-style-type: none">• Employee• Leave
PL	<ul style="list-style-type: none">• Credit, Prorate• Count, Club...	<ul style="list-style-type: none">• Employee• Leave
ML	<ul style="list-style-type: none">• Count, Club...	<ul style="list-style-type: none">• Employee• Leave
LWP	<ul style="list-style-type: none">• Avail, Club• ...	<ul style="list-style-type: none">• Employee• Leave

Leave Management System

- Collaboration

Class Name	Responsibilities	Collaborators
CL	<ul style="list-style-type: none">• Credit, Prorate• Count, Club ...	<ul style="list-style-type: none">• Employee• Leave
SL	<ul style="list-style-type: none">• Credit, Carry Over• Prorate, Club ...	<ul style="list-style-type: none">• Employee• Leave
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PL	<ul style="list-style-type: none">• Credit, Prorate• Count, Club ...	<ul style="list-style-type: none">• Employee• Leave
ML	<ul style="list-style-type: none">• Count, Club ...	<ul style="list-style-type: none">• Employee• Leave
LWP	<ul style="list-style-type: none">• Avail, Club• ...	<ul style="list-style-type: none">• Employee• Leave



Leave Management System

- Modularization

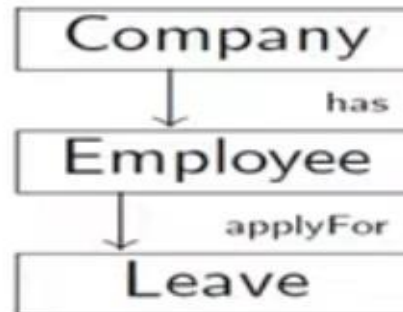
Depending upon the collaboration of the classes we can decompose the system into 3 cohesive and loosely coupled modules



Leave Management System

- Modularization

Depending upon the collaboration of the classes we can decompose the system into 3 cohesive and loosely coupled modules



- Quality Measures

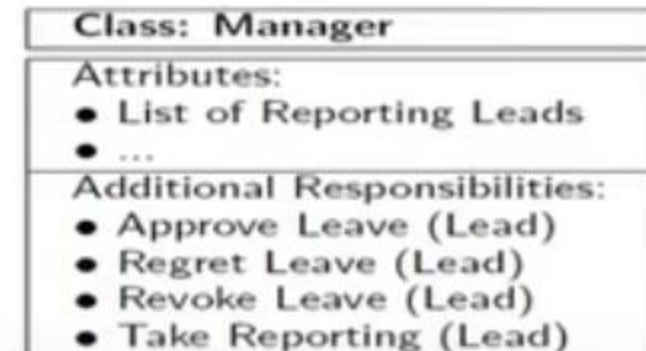
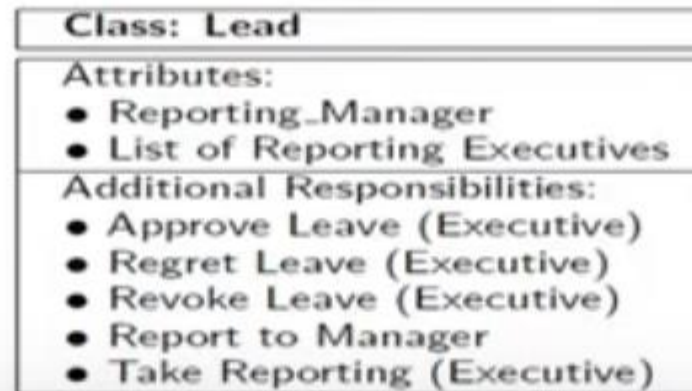
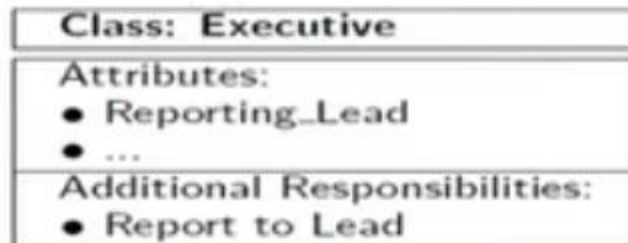
Module	Impact On				
	Coupling	Cohesion	Sufficiency	Completeness	Primitiveness
Company	Low	High	Low	Low	Low
Employee	Low	High	Low	Low	Low
Leave	Low	High	Low	Low	Low

Leave Management System

- Employee Hierarchy



IS-A



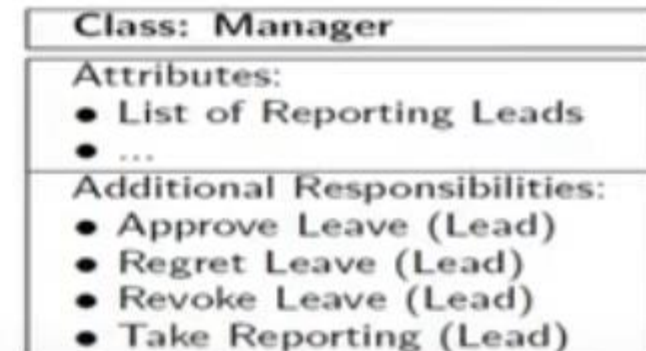
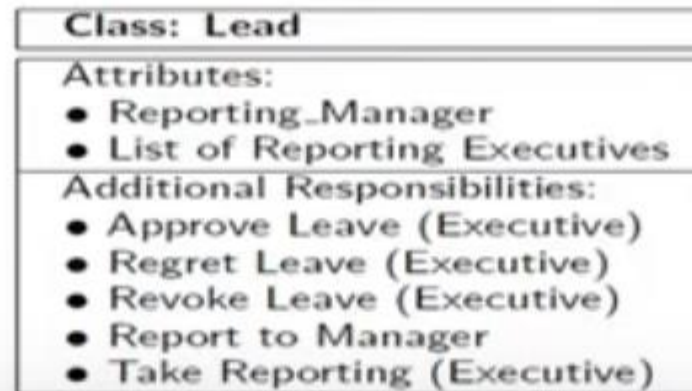
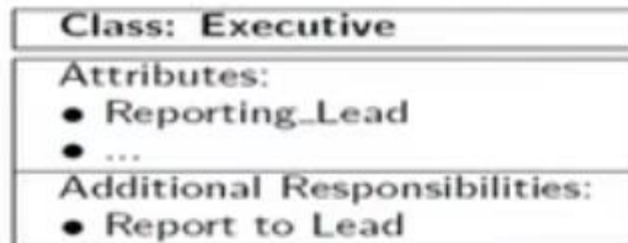
- For brevity, all characteristics and all responsibilities are not shown
- Suggest refinements to Employee hierarchy

Leave Management System

- Employee Hierarchy



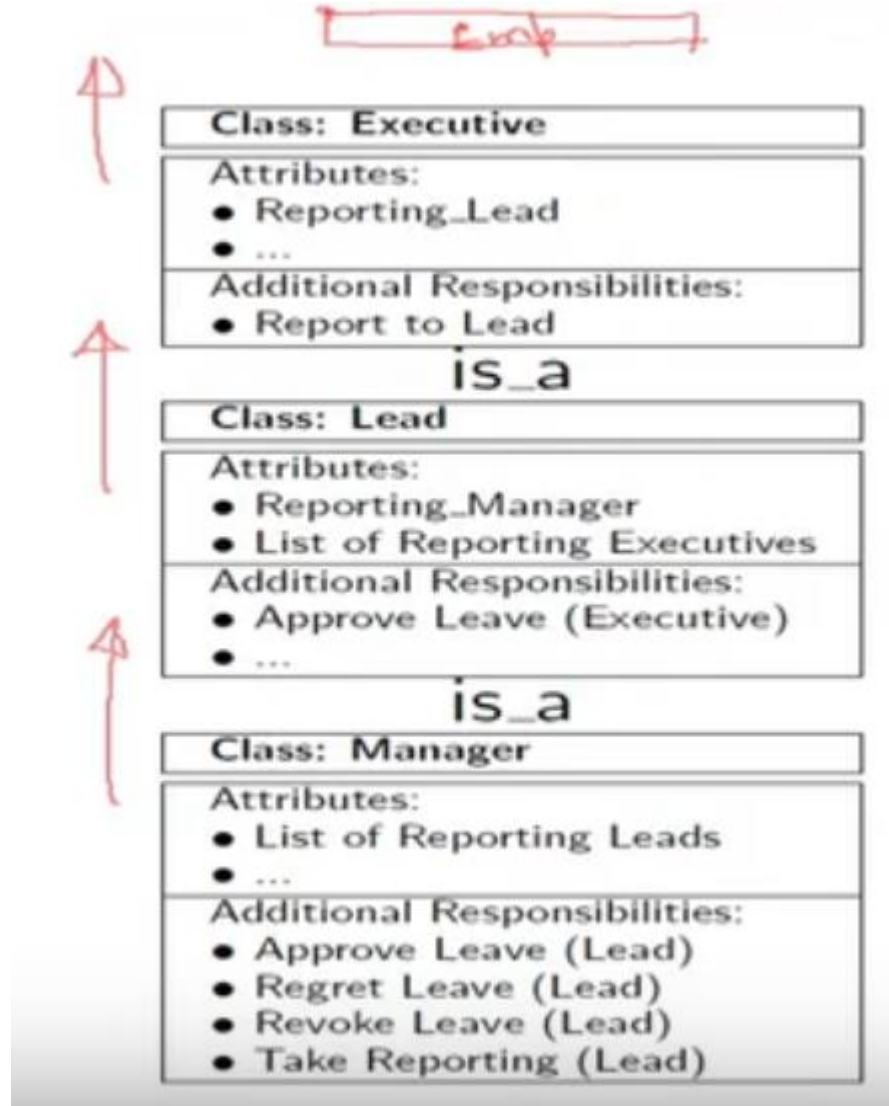
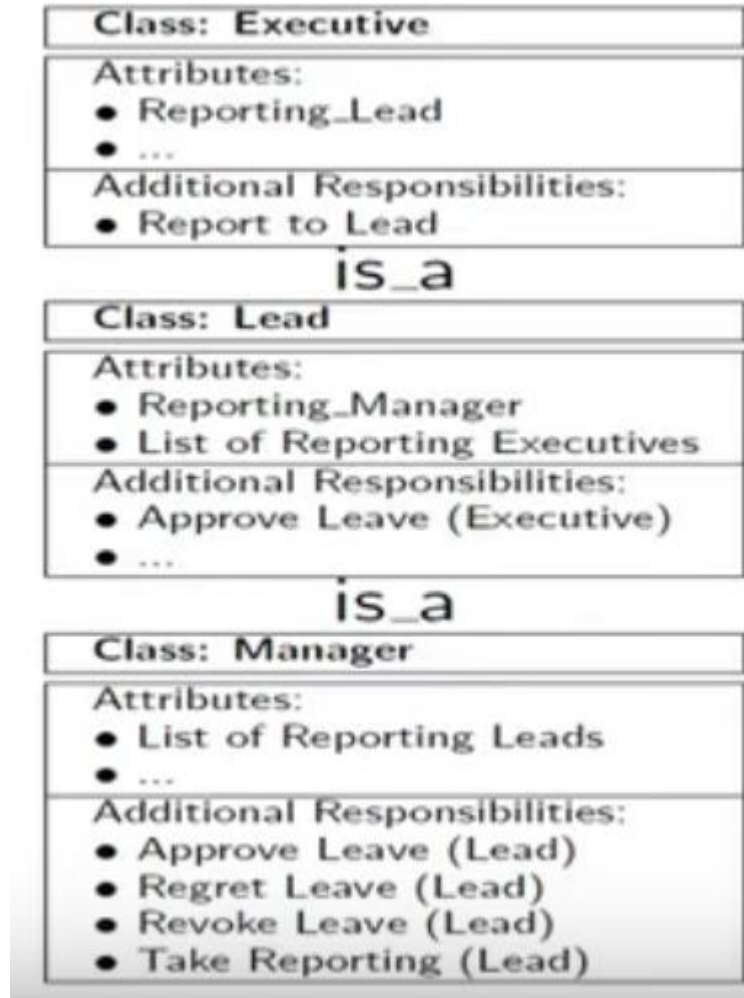
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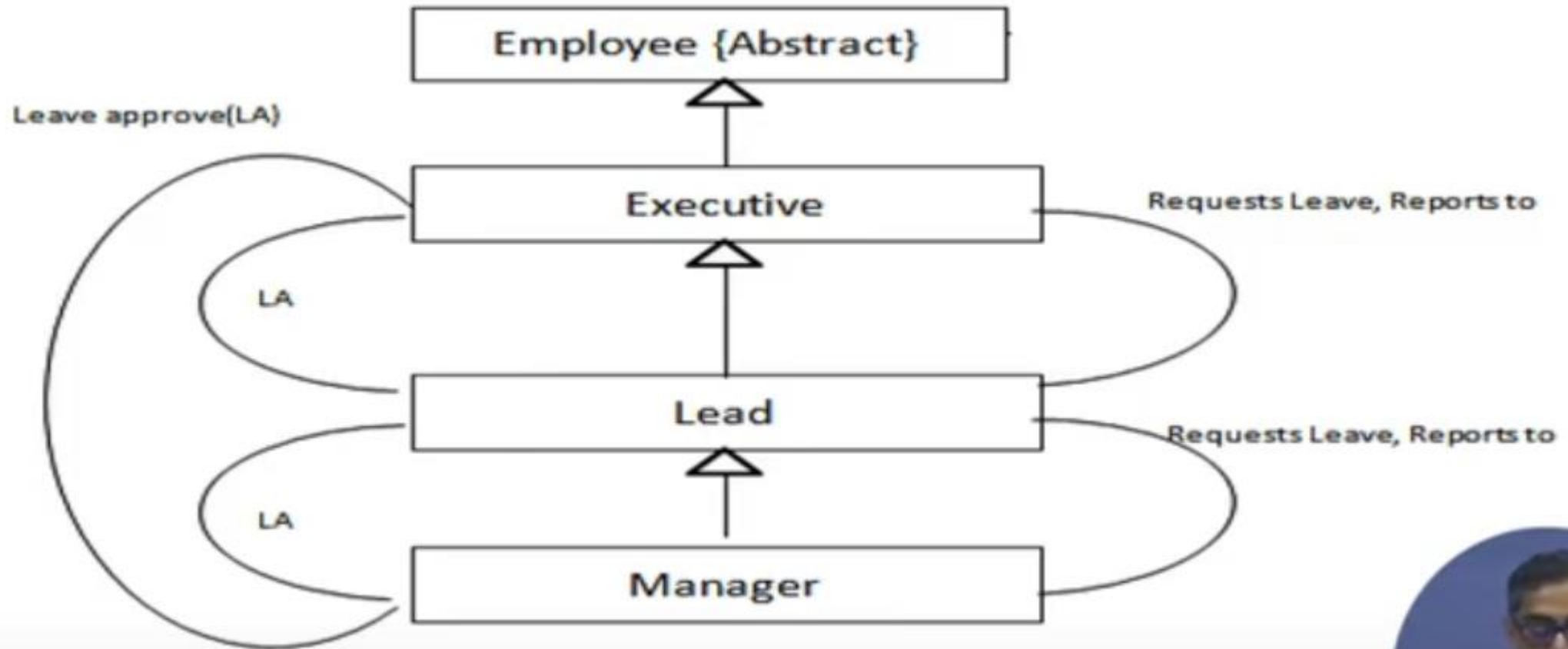
Leave Management System

- Employee Hierarchy



Leave Management System

- Employee Hierarchy

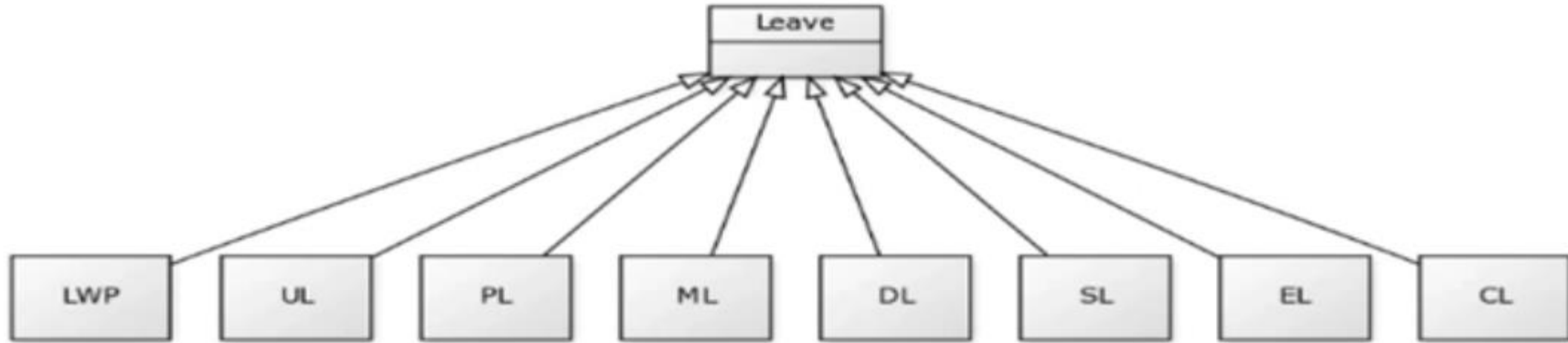


Leave Management System

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

Leave Management System

- Leave Hierarchy



- **Quality Check**

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

Leave Management System

- Refinement if Leave Hierarchy

Analysis of pre & post conditions

Classes

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

Leave Management System

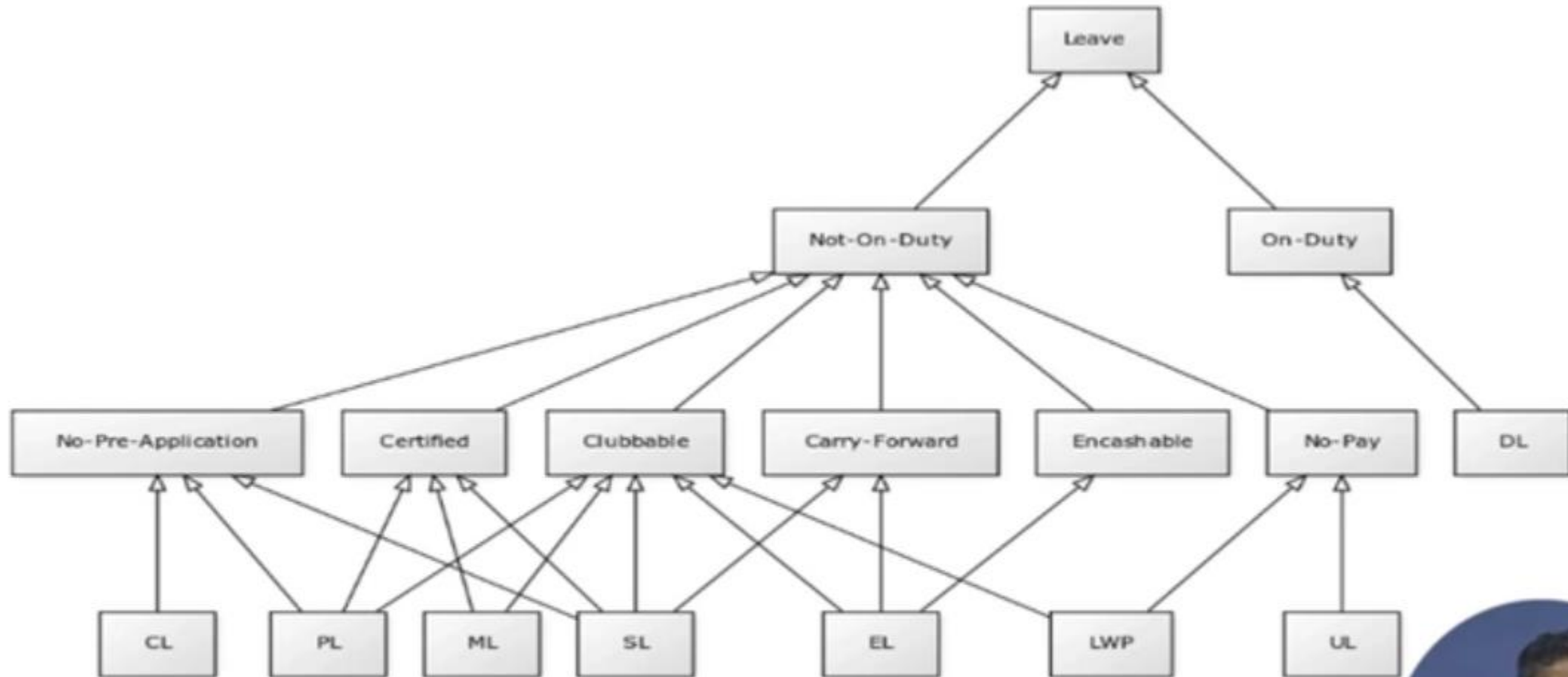
- Refinement if Leave Hierarchy

Property	CL	EL	SL	DL	ML	PL	LWP	UL
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Leave Management System

- Refinement if Leave Hierarchy

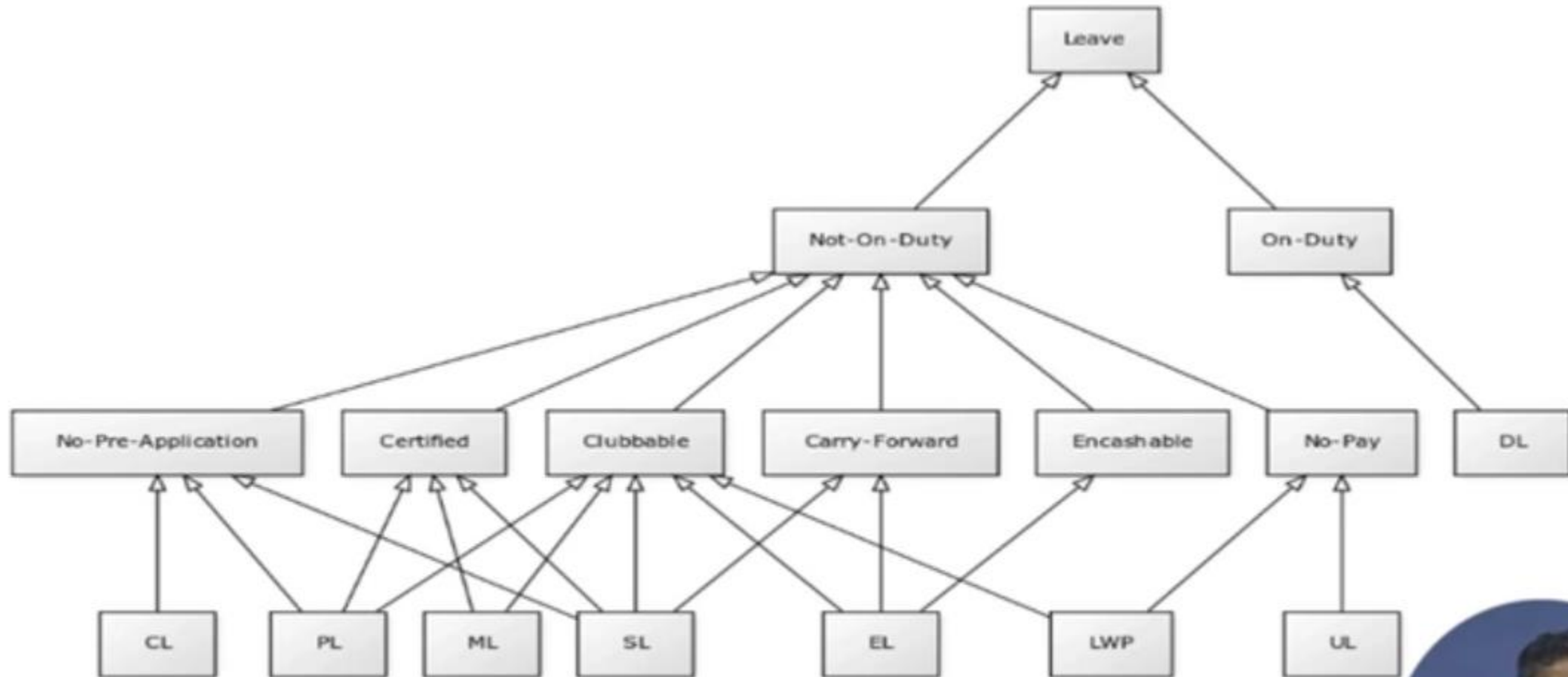


- **Quality Check**
 - Balanced Hierarchy



Leave Management System

- Refinement if Leave Hierarchy



- **Quality Check**
 - Balanced Hierarchy



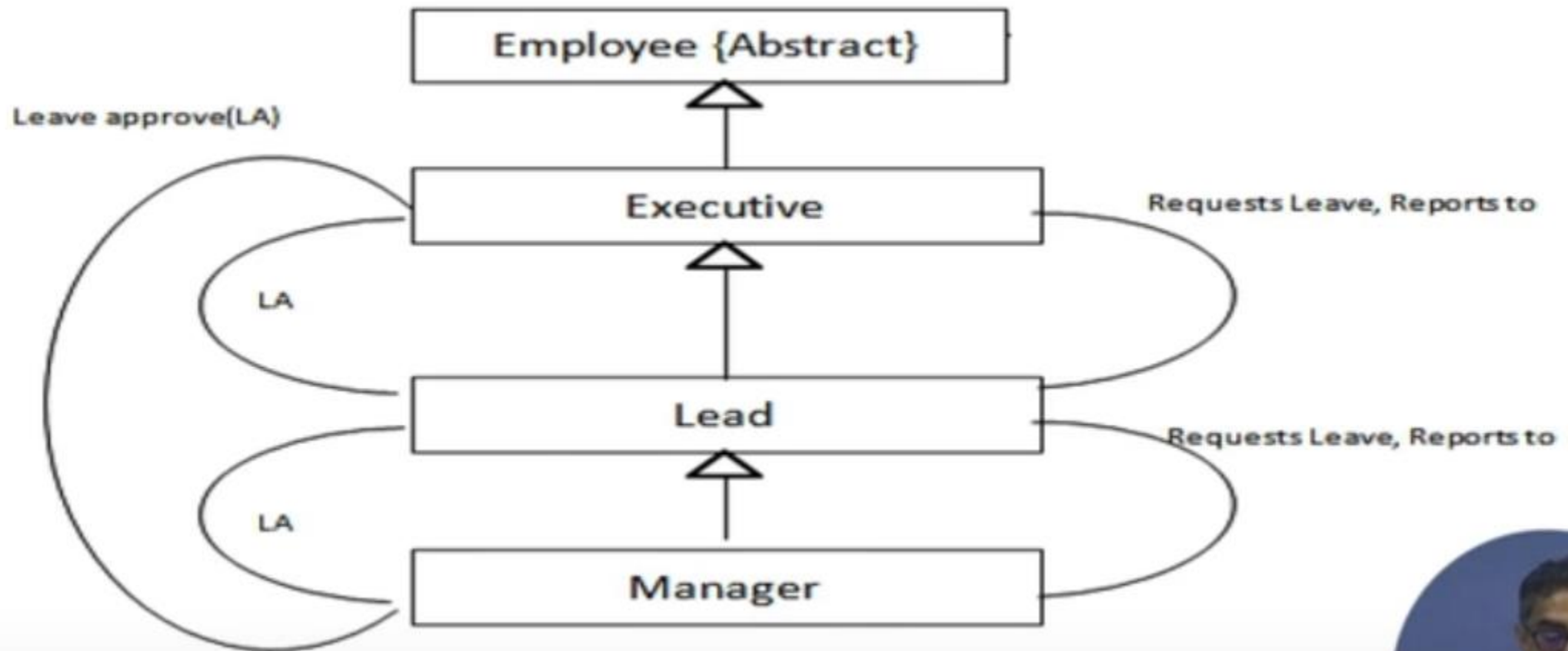
Leave Management System

- Quality Measures

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

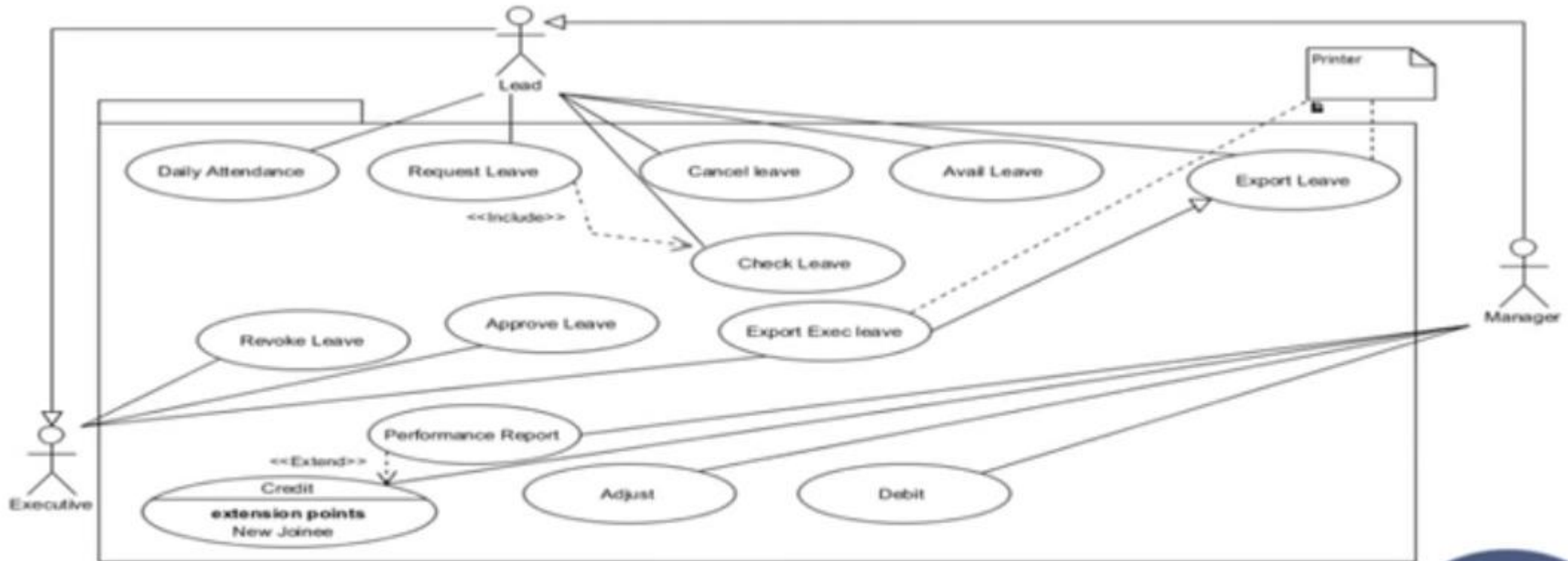
Leave Management System

- Relationship among Employee Classes



Leave Management System

- Relationship among Classes



Employees and Leave Actions are Related



Summary

- Links
- Aggregation
- Classes
- Attributes
- Responsibilities
- Relationship & Hierarchy
- Collaboration
- Modularization
- Refinement in Class Hierarchy

Reference

NPTEL Course – OOAD

- <https://archive.nptel.ac.in/courses/106/105/106105153/>