Object-Oriented Programming (OOP)

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Class Compatibility

- A class is behaviorally compatible with another if it supports all the operations of the other class

- Such a class is called subtype

- A class can be replaced by its subtype

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...Class Compatibility

- Derived class is usually a subtype of the base class
- It can handle all the legal messages (operations) of the base class
- Therefore, base class can always be replaced by the derived class

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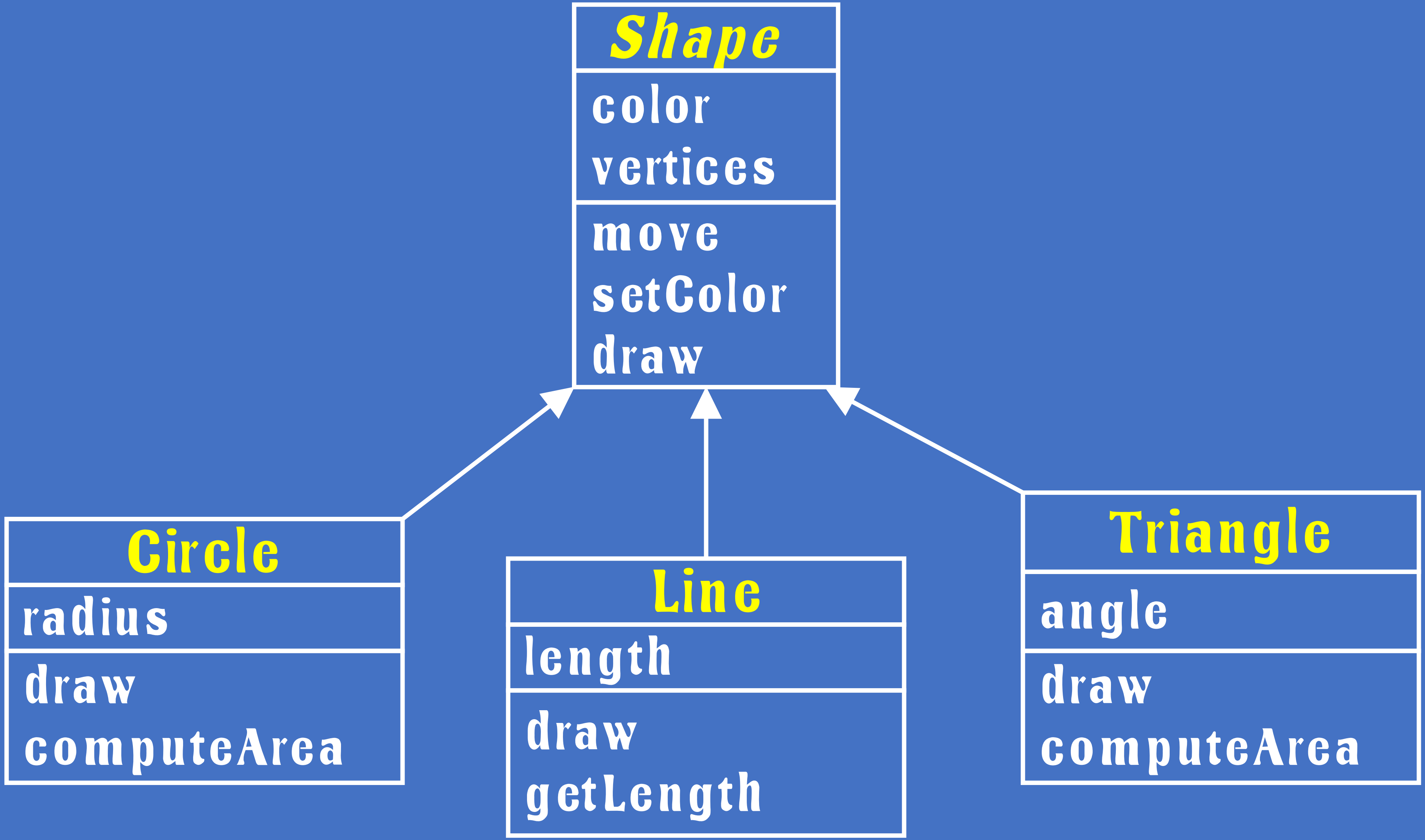
Example – Class Compatibility



Shape

color
vertices

move
setColor
draw

Circle

radius

draw
computeArea

Line

length

draw
getLength

Triangle

angle

draw
computeArea

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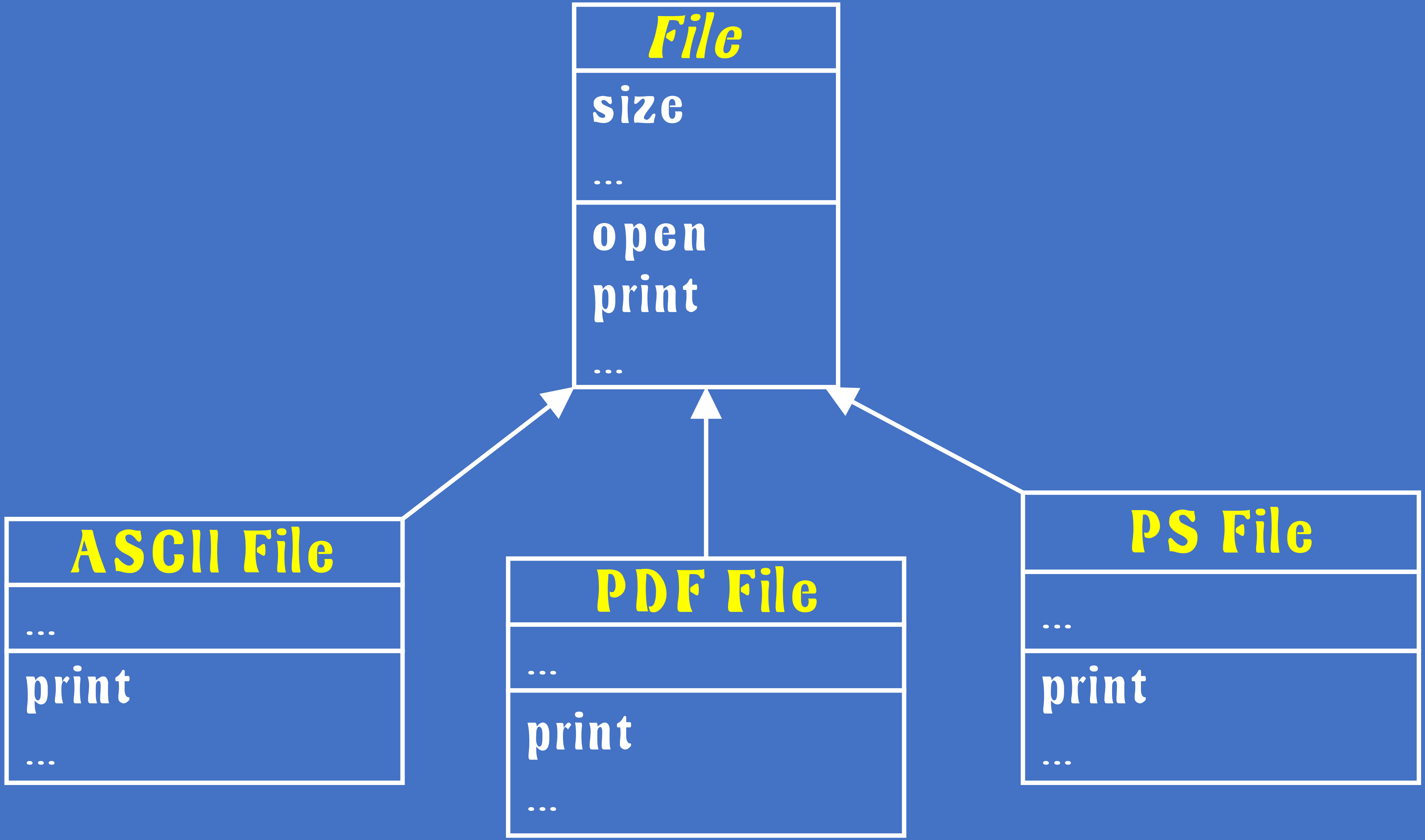
Example – Class Compatibility



File

size

...

open

print

...

ASCII File

...

print

...

PDF File

...

print

...

PS File

...

print

...

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Polymorphism

- In general, polymorphism refers to existence of different forms of a single entity
- For example, both Diamond and Coal are different forms of Carbon

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Polymorphism in OO Model

- In OO model, polymorphism means that different objects can behave in different ways for the same message (stimulus)
- Consequently, sender of a message does not need to know exact class of the receiver

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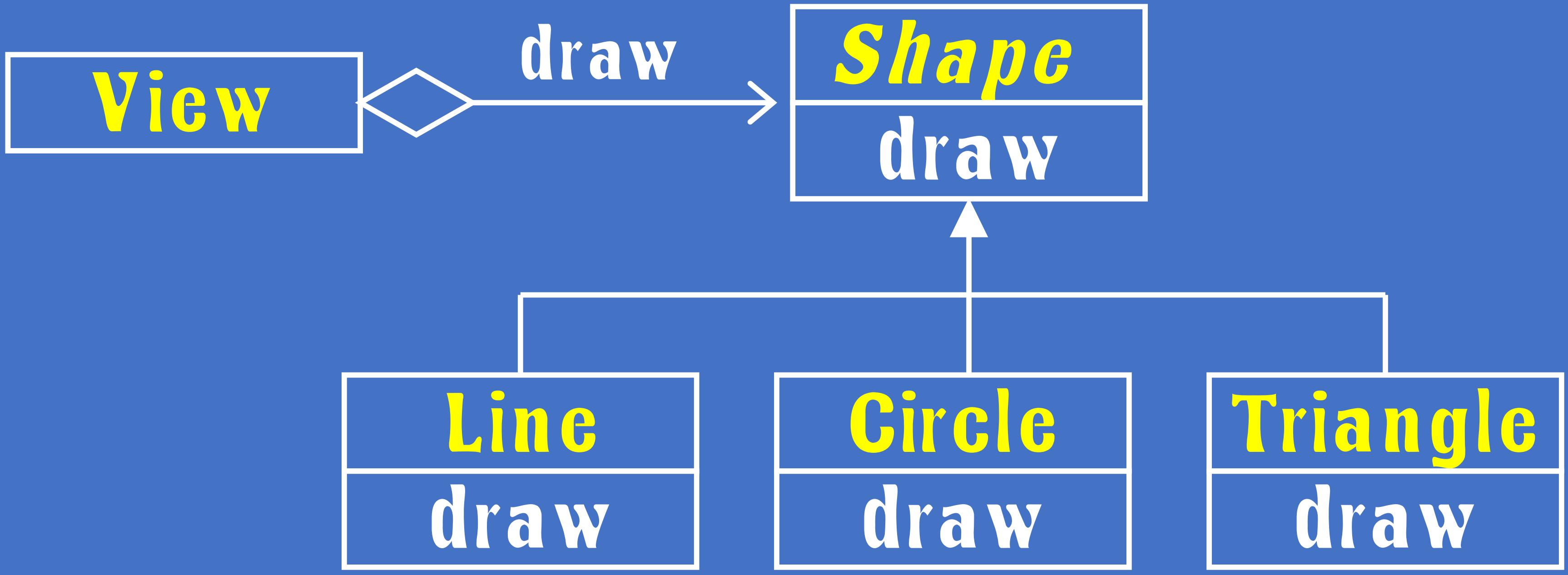
Example – Polymorphism



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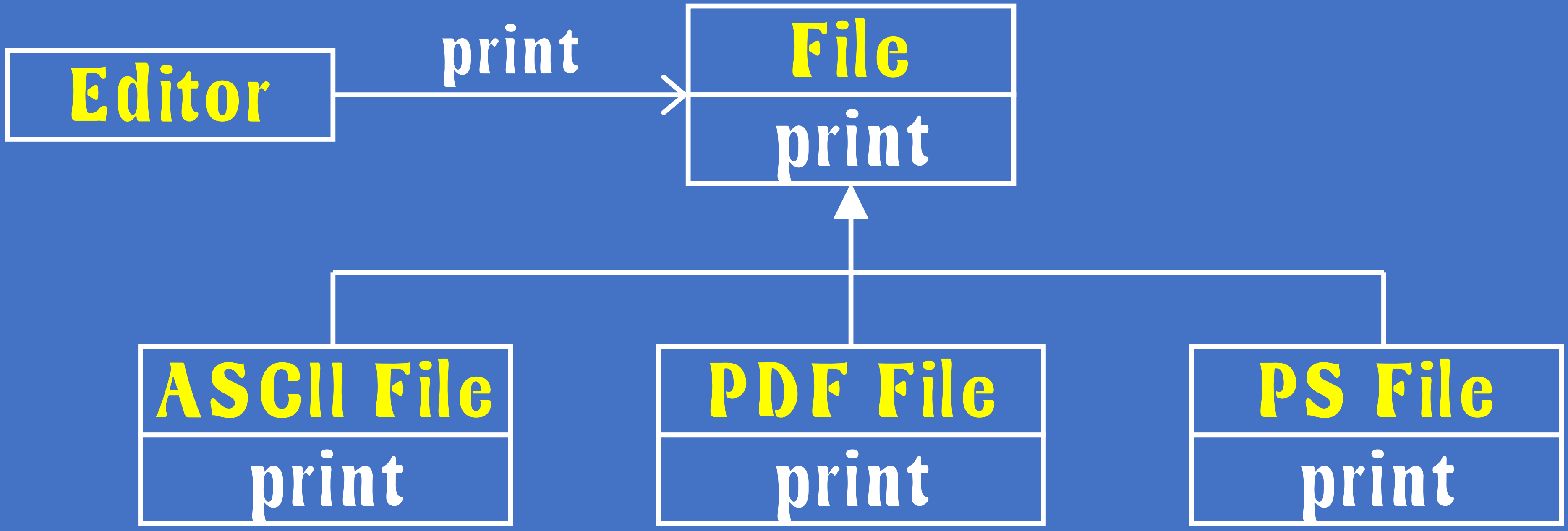
Example – Polymorphism



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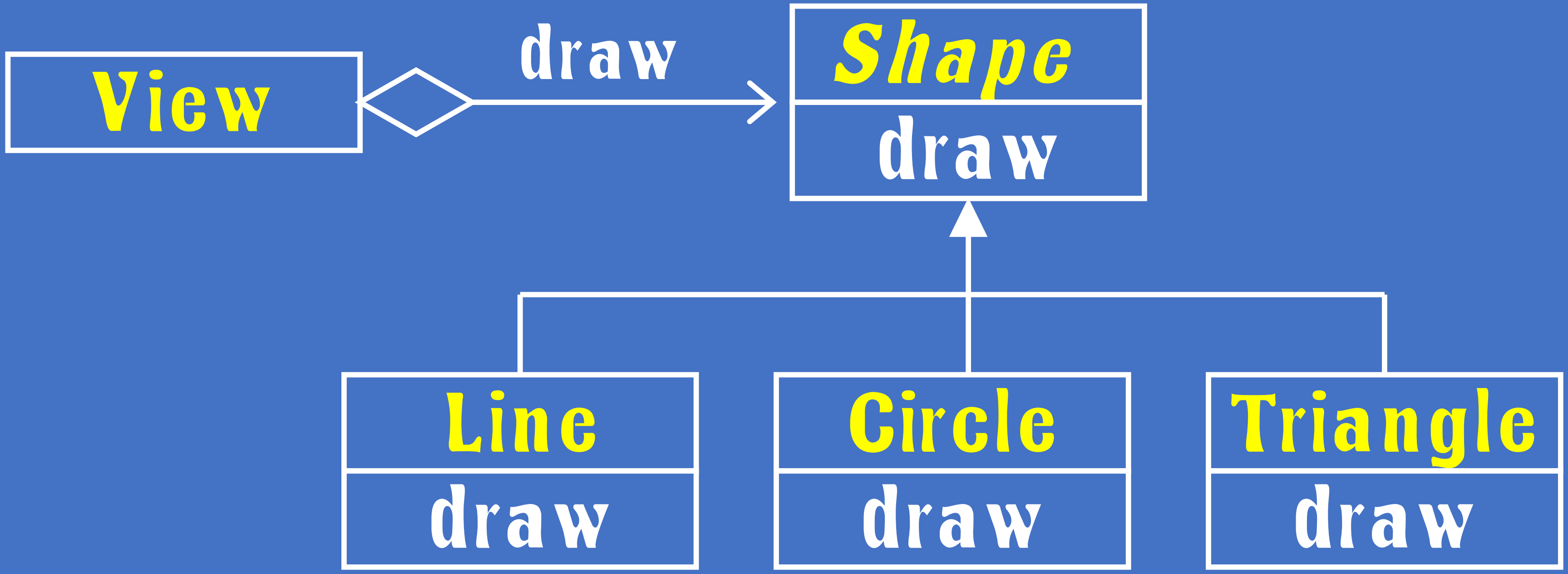
Polymorphism – Advantages

- Messages can be interpreted in different ways depending upon the receiver class



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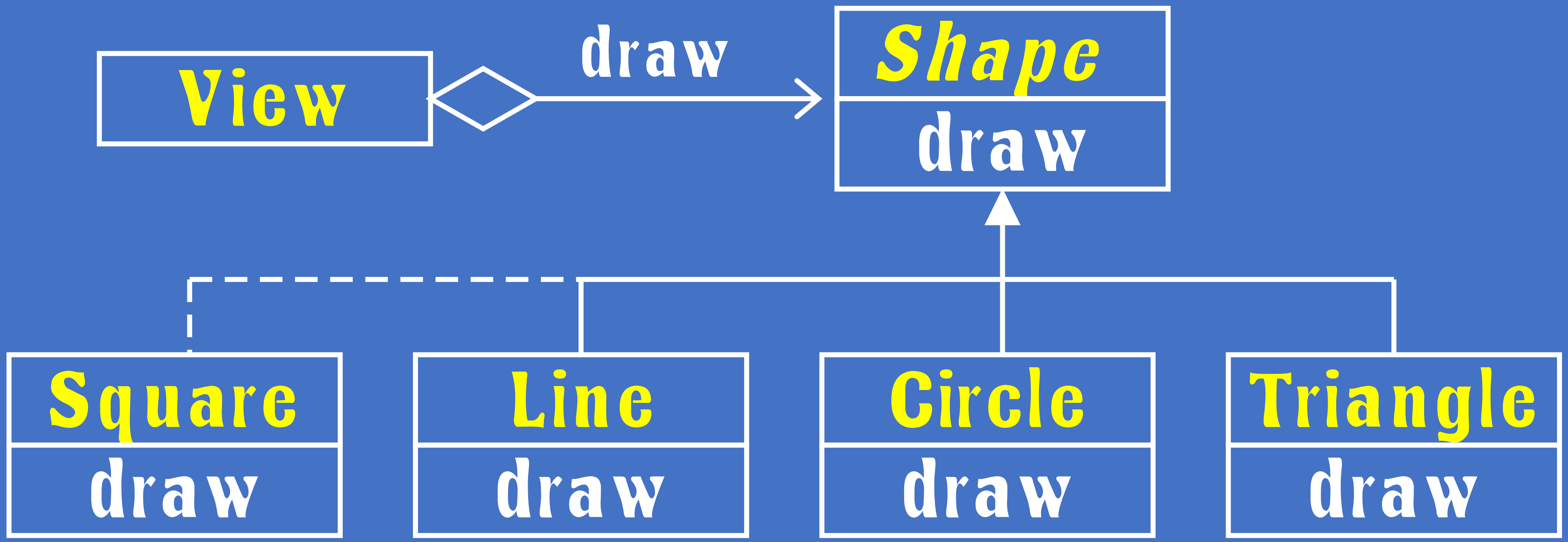
Polymorphism – Advantages

- New classes can be added without changing the existing model



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Polymorphism – Advantages

- In general, polymorphism is a powerful tool to develop flexible and reusable systems

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Object-Oriented Modeling

An Example

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Problem Statement

- Develop a graphic editor that can draw different geometric shapes such as line, circle and triangle. User can select, move or rotate a shape. To do so, editor provides user with a menu listing different commands. Individual shapes can be grouped together and can behave as a single shape.

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Identify Classes

- Extract nouns in the problem statement

- Develop a graphic **editor** that can draw different geometric **shapes** such as **line**, **circle** and **triangle**. **User** can select, move or rotate a **shape**. To do so, **editor** provides **user** with a **menu** listing different **commands**. Individual **shapes** can be grouped together and can behave as a single **shape**.

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...Identify Classes

- Eliminate irrelevant classes
  - Editor – Very broad scope
  - User – Out of system boundary

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…Identify Classes

- Add classes by analyzing requirements

- Group – required to behave as a shape
  - "Individual shapes can be grouped together and can behave as a single shape"

- View – editor must have a display area

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…Identify Classes

- Following classes have been identified:

- Shape
- Line
- Circle
- Triangle
- Menu

- Group
- View

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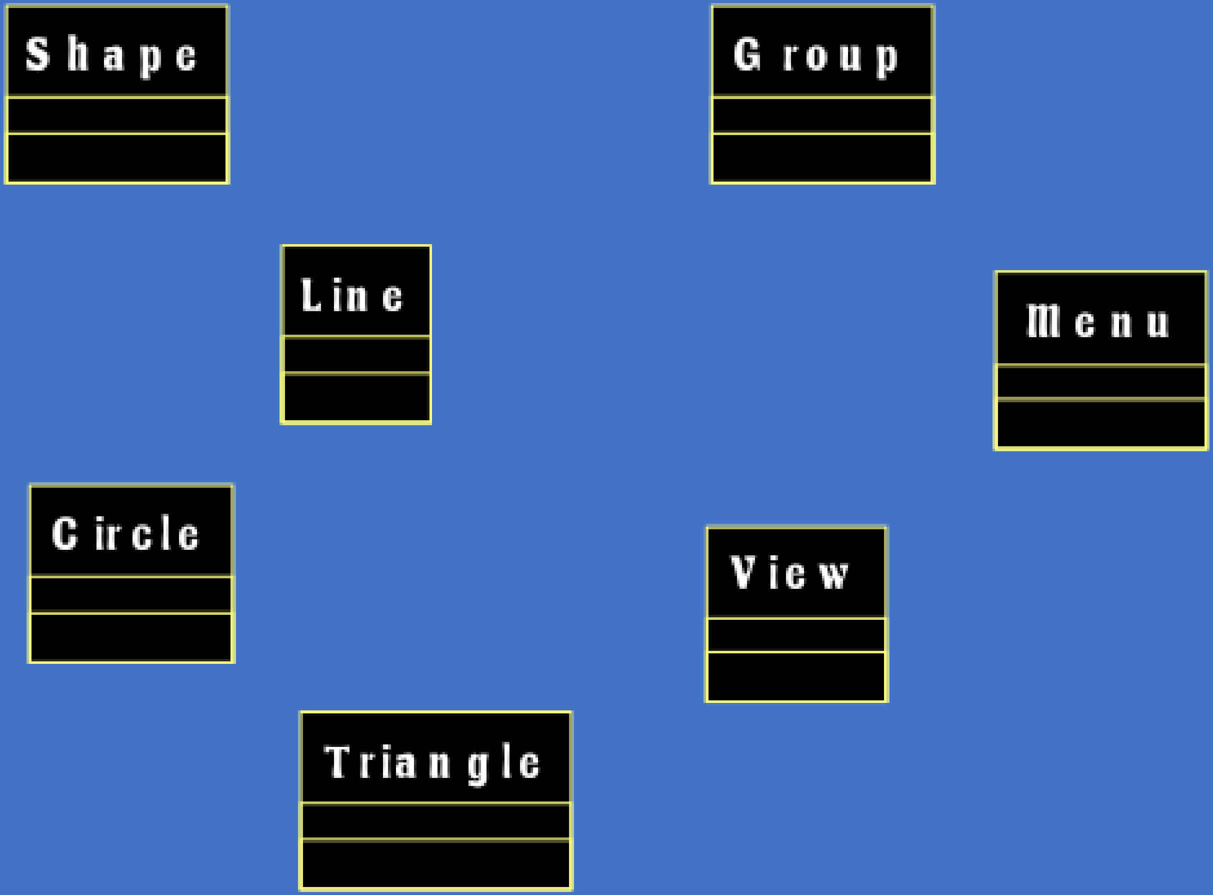
Object Model – Graphic Editor



Shape

Group

Line

Menu

Circle

View

Triangle

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Identify Associations

- Extract verbs connecting objects

- “Individual shapes can be grouped together”
  - Group consists of lines, circles, triangles
  - Group can also consists of other groups (Composition)

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… Identify Associations

- Verify access paths

- View contains shapes
  - View contains lines
  - View contains circles
  - View contains triangles
  - View contains groups
(Aggregation)

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… Identify Associations

- Verify access paths

- Menu sends message to View
  (Simple One-Way Association)

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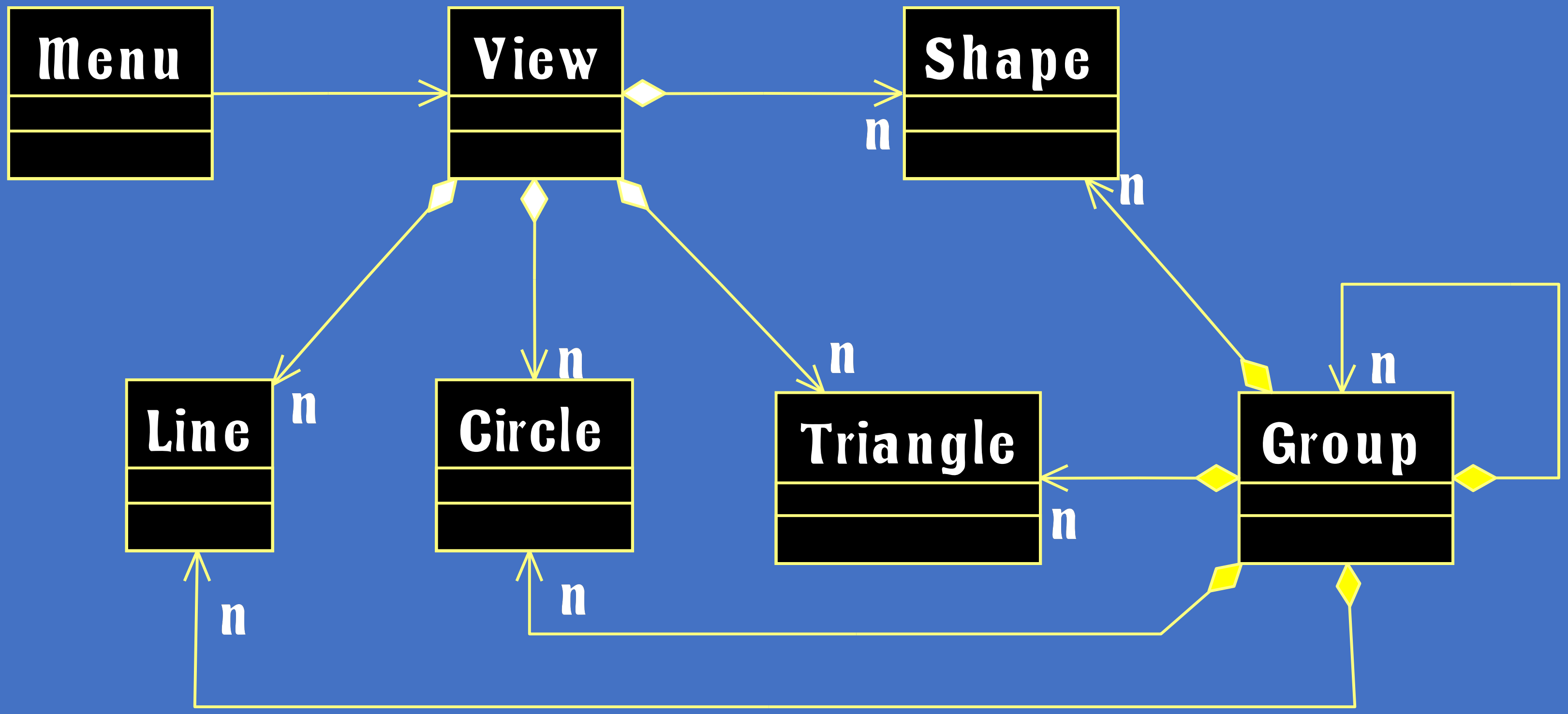
Object Model – Graphic Editor



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Identify Attributes

- Extract properties of the object
  - From the problem statement

- Properties are not mentioned

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…Identify Attributes

- Extract properties of the object
  - From the domain knowledge

- Line
  - Color
  - Vertices
  - Length
- Circle
  - Color
  - Vertices
  - Radius

- Triangle
  - Color
  - Vertices
  - Angle
- Shape
  - Color
  - Vertices

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…Identify Attributes

- Extract properties of the object
  - From the domain knowledge

- Group
  - noOfObjects
- View
  - noOfObjects
  - selected

- Menu
  - Name
  - isOpen

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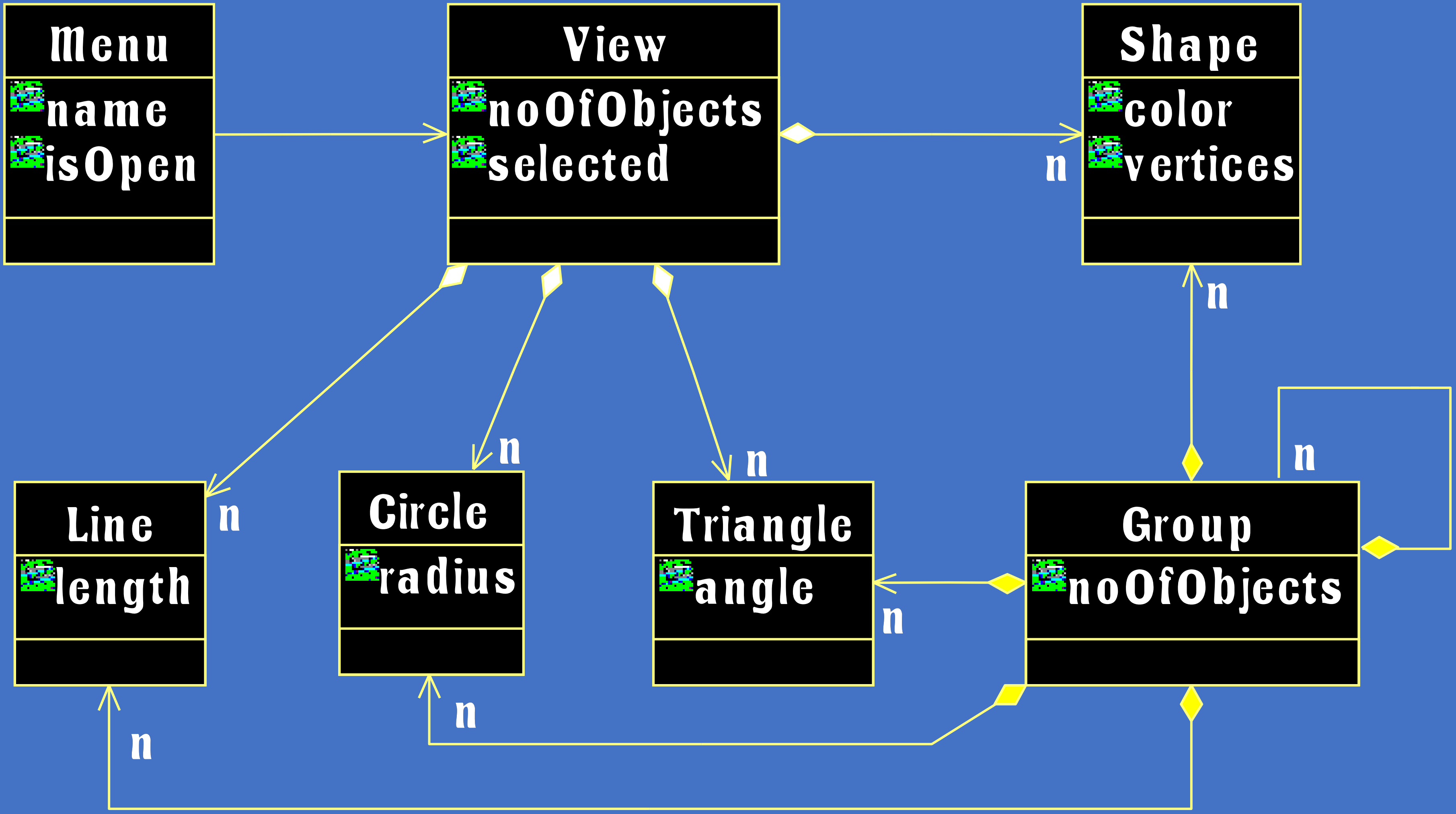
Object Model – Graphic Editor



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Identify Operations

- Extract verbs connected with an object

- Develop a graphic editor that can draw different geometric shapes such as line, circle and triangle. User can select, move or rotate a shape. To do so, editor provides user with a menu listing different commands. Individual shapes can be grouped together and can behave as a single shape.

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… Identify Operations

- Eliminate irrelevant operations
- Develop – out of system boundary
- Behave – have broad semantics

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...Identify Operations

- Following are selected operations:

- Line
  - Draw
  - Select
  - Move
  - Rotate

- Circle
  - Draw
  - Select
  - Move
  - Rotate

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...Identify Operations

- Following are selected operations:

- Triangle
  - Draw
  - Select
  - Move
  - Rotate

- Shape
  - Draw
  - Select
  - Move
  - Rotate

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…Identify Operations

- Following are selected operations:

- Group
  - Draw
  - Select
  - Move
  - Rotate

- Menu
  - Open
  - Select
  - Move
  - Rotate

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…Identify Operations

- Extract operations using domain knowledge

- View
  - Add
  - Remove
  - Group
  - Show
  - Select
  - Move
  - Rotate

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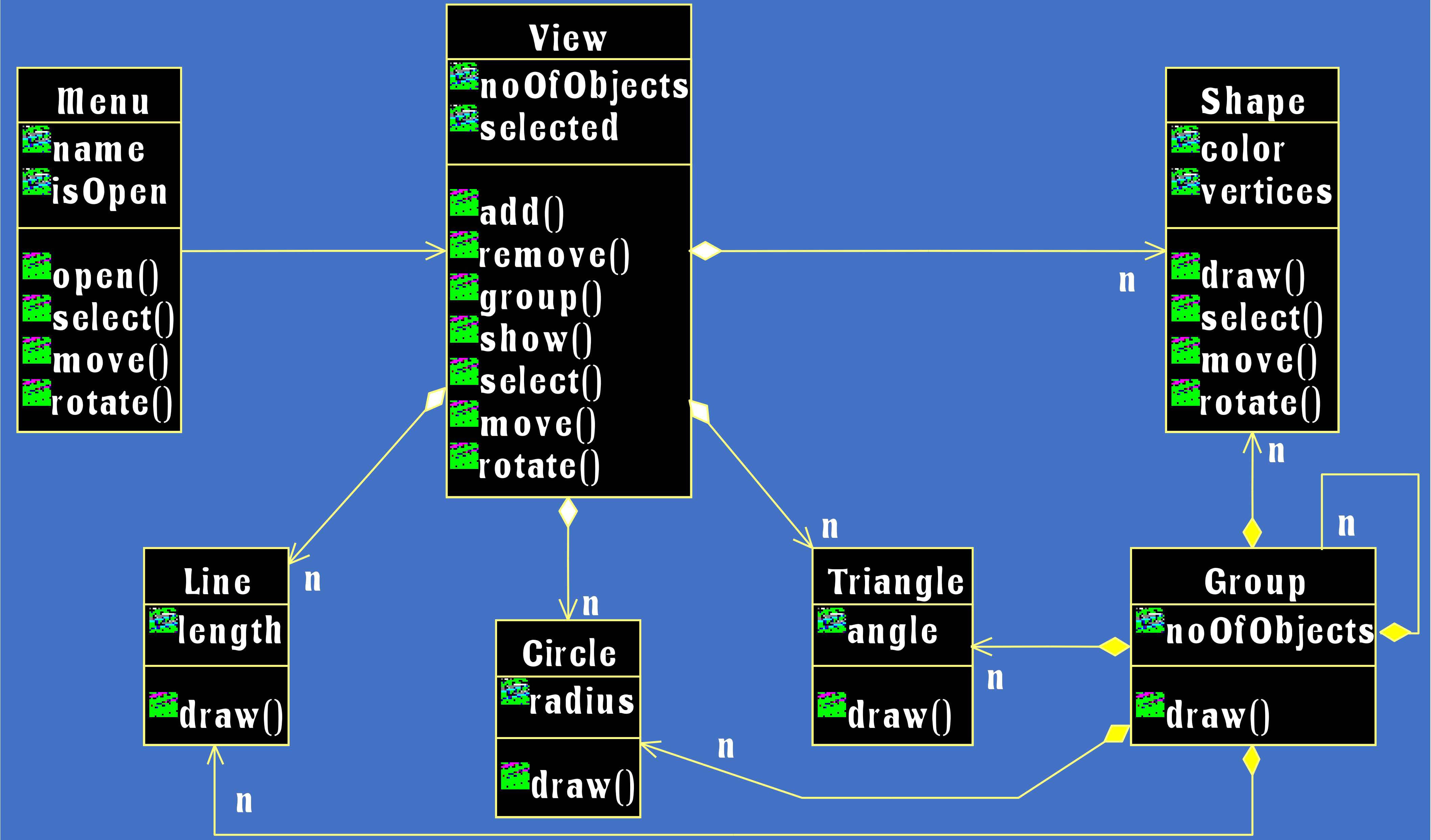

View
noOfObjects
selected
add()
remove()
group()
show()
select()
move()
rotate()

Menu
name
isOpen
open()
select()
move()
rotate()

Shape
color
vertices
draw()
select()
move()
rotate()

Line
length
draw()

Circle
radius
draw()

Triangle
angle
draw()

Group
noOfObjects
draw()

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Identify Inheritance

- Search “is a kind of” by looking at keywords like “such as”, “for example”, etc

- “...shapes such as line, circle and triangle...”
  - Line, Circle and Triangle inherits from Shape

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…Identify Inheritance

- By analyzing requirements

- “Individual shapes can be grouped together and can behave as a single shape”
  - Group inherits from Shape

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Refining the Object Model

- Application of inheritance demands an iteration over the whole object model

- In the inheritance hierarchy,
  - All attributes are shared
  - All associations are shared
  - Some operations are shared
  - Others are overridden

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...Refining the Object Model

- Share associations
- View contains all kind of shapes
- Group consists of all kind of shapes

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…Refining the Object Model

- Share attributes
- Shape – Line, Circle, Triangle and Group
  - Color, vertices

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…Refining the Object Model

- Share operations

- Shape – Line, Circle, Triangle and Group
  - Select
  - Move
  - Rotate

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…Refining the Object Model

- Share the interface and override implementation

- Shape – Line, Circle, Triangle and Group
  - Draw

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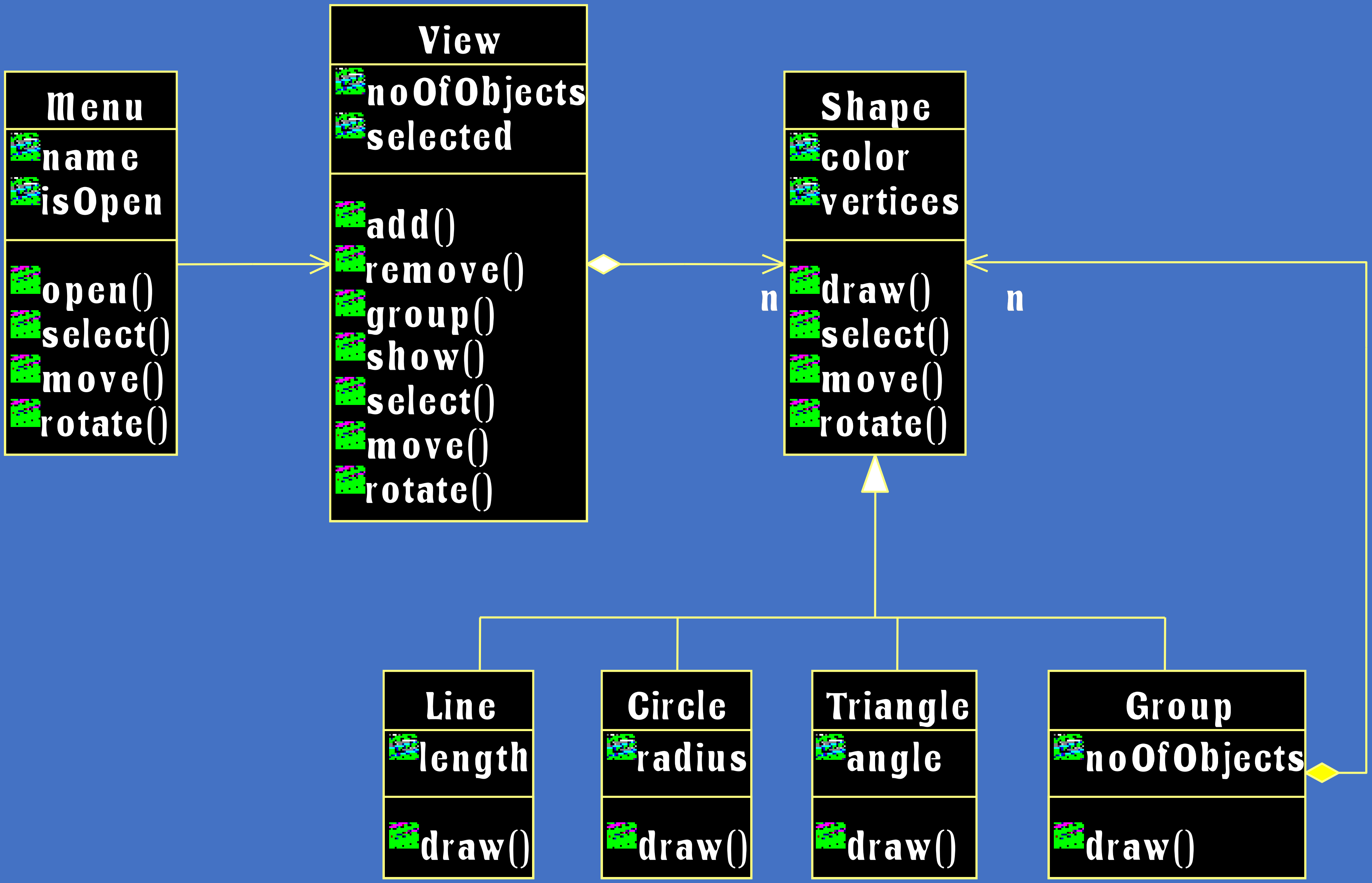

Menu

name
isOpen

open()
select()
move()
rotate()

View

noOfObjects
selected

add()
remove()
group()
show()
select()
move()
rotate()

Shape

color
vertices

draw()
select()
move()
rotate()

n

n

Line

length

draw()

Circle

radius

draw()

Triangle

angle

draw()

Group

noOfObjects

draw()

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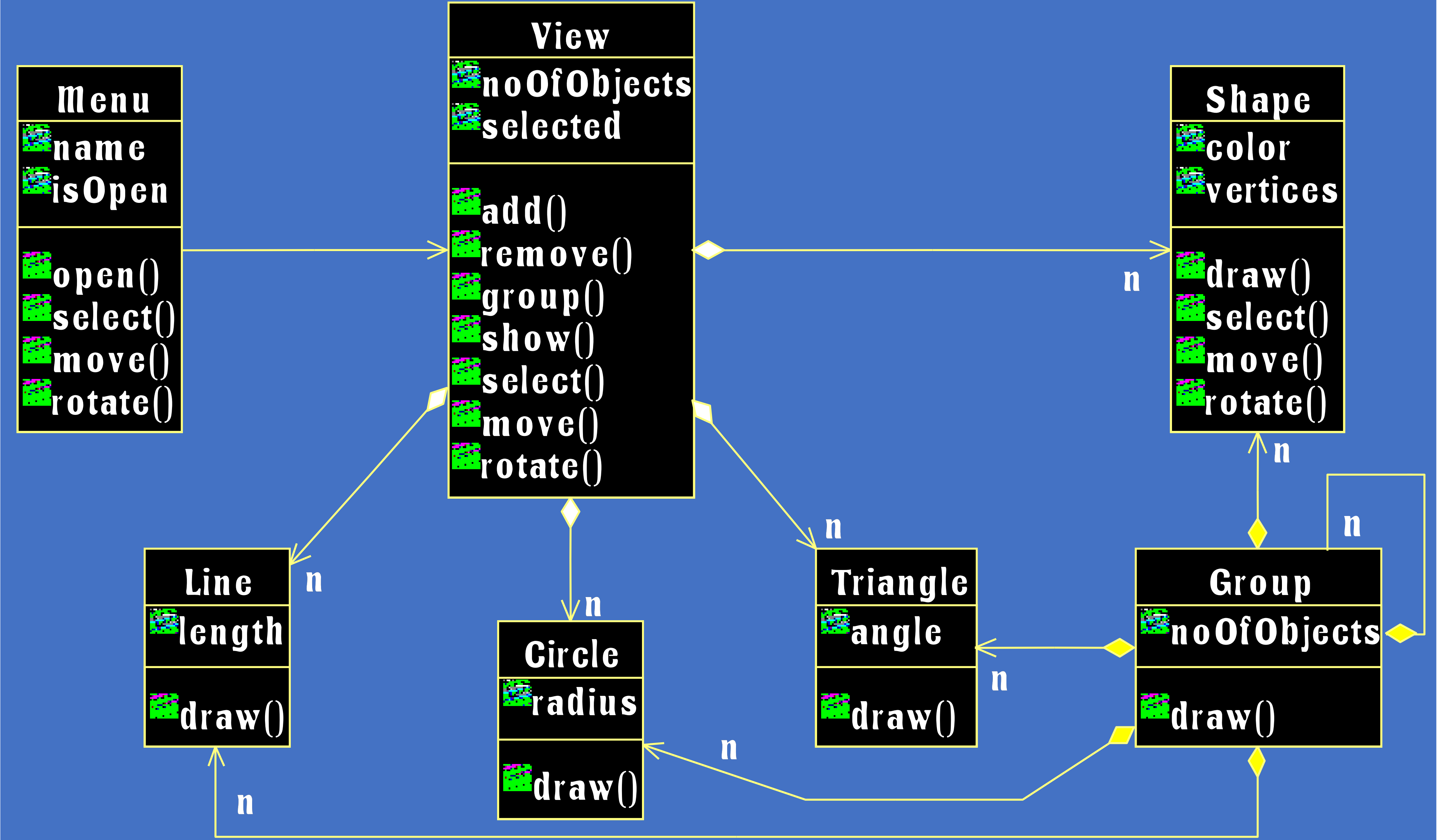

Menu

name
isOpen

open()
select()
move()
rotate()

View

noOfObjects
selected

add()
remove()
group()
show()
select()
move()
rotate()

Shape

color
vertices

draw()
select()
move()
rotate()

Line

length

draw()

Circle

radius

draw()

Triangle

angle

draw()

Group

noOfObjects

draw()

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