6.104 · Software Design · MIT · Fall 2025

state & action recitation

the meaning of state declarations

what does this state mean?

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concept PasswordAuth

state
a set of User with
  a username String
  a password String

what does this state mean?

concept PasswordAuth

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there's a set of Users
say {u1, u2, u3}

each user has a username, which is a string
u1's username is "Alice"
u2's username is "Bob"

each user has a password, which is a string
u1's password is "foo"
u2's password is "bar"

you can visualize this as "objects"
u1 = {
  username: "Alice"
  password: "foo"
  }

but abstractly the "fields" are relations
username = {(u1, "Alice"), (u2, "Bob")}

and how about this one?

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concept UsersAndGroups

state
a set of Group with
  a name String
  a created Date
  a members set of User
a set of User with
  a username String
  a password String

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there's a set of Groups
say {g1, g2}

each group has a name
g1's name is "admin"

each group has a created date
g1's created is "Jan 1, 2025"

each group has a set of users
g1's members set is {u1, u2}

what if the users are defined in another concept?

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concept UserGroups [User]

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users are now defined elsewhere
in a set in some other concept

each group still has a set of users
g1's members set is {u1, u2}
but u1 and u2 are references
identifiers that point to users outside

can we say each user belongs to only one group?

concept UserGroups [User]

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// each user in only one group
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concept PasswordSession

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each associated with a group

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how do these differ?
a set of Groups with ...
a set of Users with ...

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so "object" is misleading
thinking of these as object decls makes it hard to see that a user has a group (in one concept) and a username and password (in another)

can we make it more natural? helping non-CS folk read our concepts

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concept UsersAndGroups

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  a ~~created~~ Date
  a ~~members~~ set of Users
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pluralizing set names
when convenient

implicit field names
lowercase version of set name

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lowercase version of set name

exercise: role-based access control

concept RBAC [User]

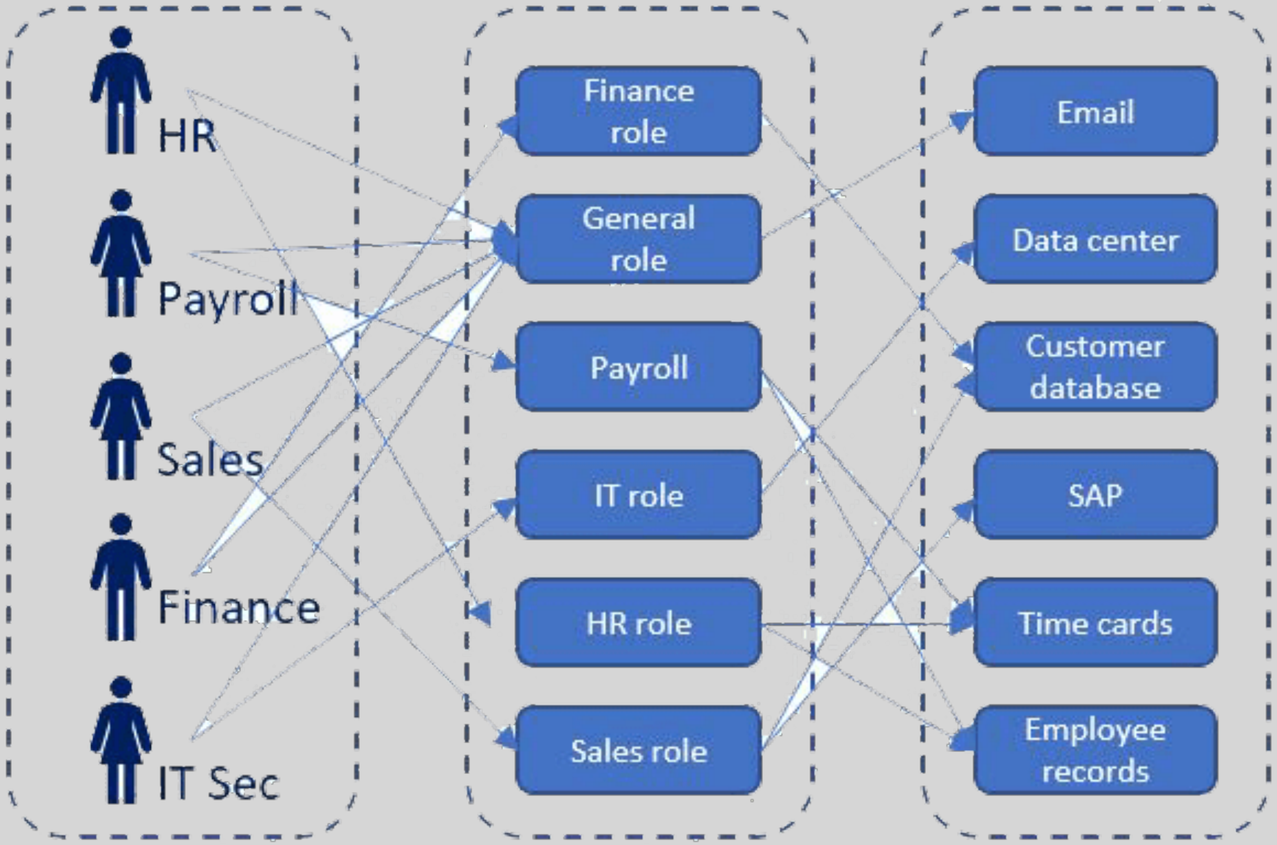
state
???

actions
// create a role with a given name
defineRole (name: String): Role

// assign a role to a user
assignRole (user: User, role: Role)

// grant access to a file for a role
grant (file: File, role: Role)

// succeeds only if user can access file
authorize (file: File, user: User)



exercise: role-based access control

concept RBAC [User, File]

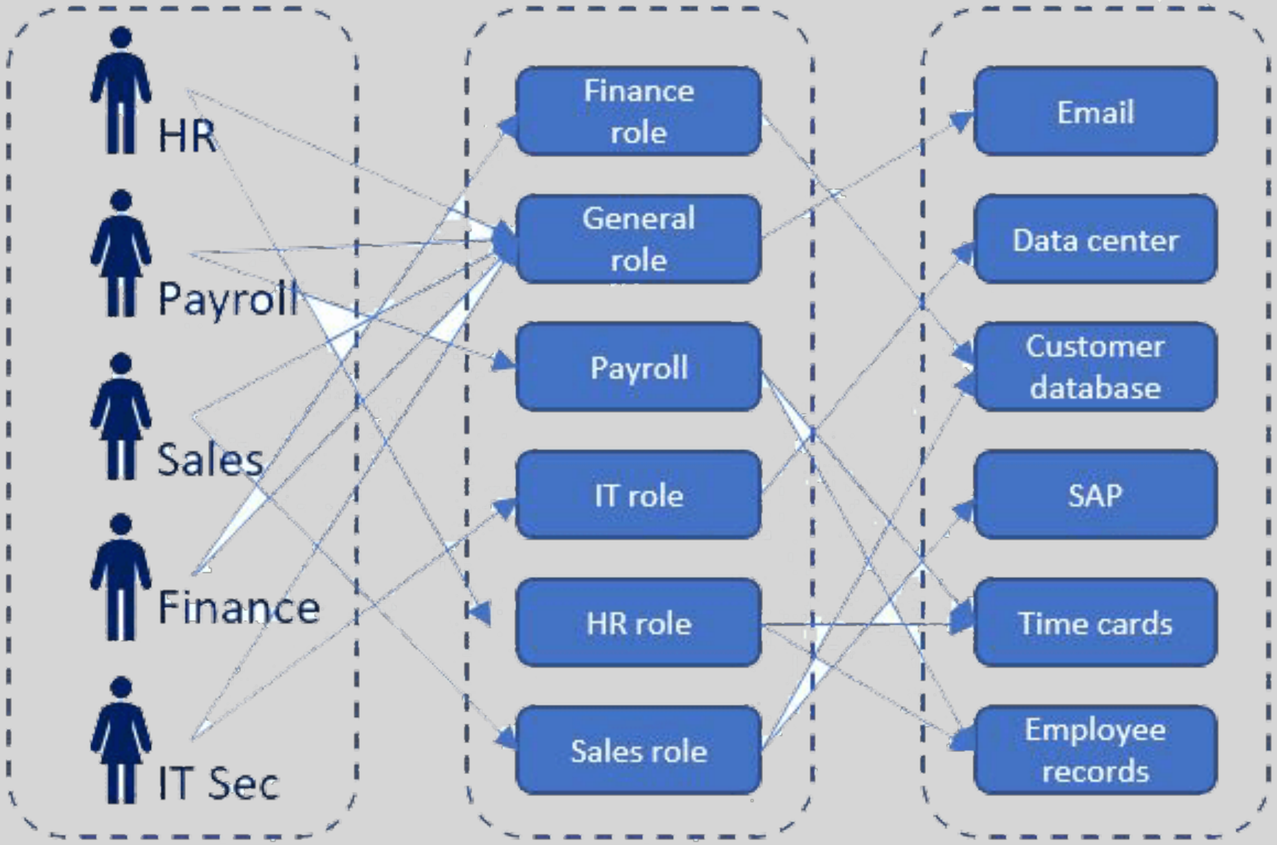
state
a set of Roles with
  a set of Users
  a name String
a set of Files with
  an authorized Role

actions
defineRole (name: String): Role
  requires no role with this name
  effect add role with this name

assignRole (user: User, role: Role)
  requires role exists
  effect add user to set of users for role

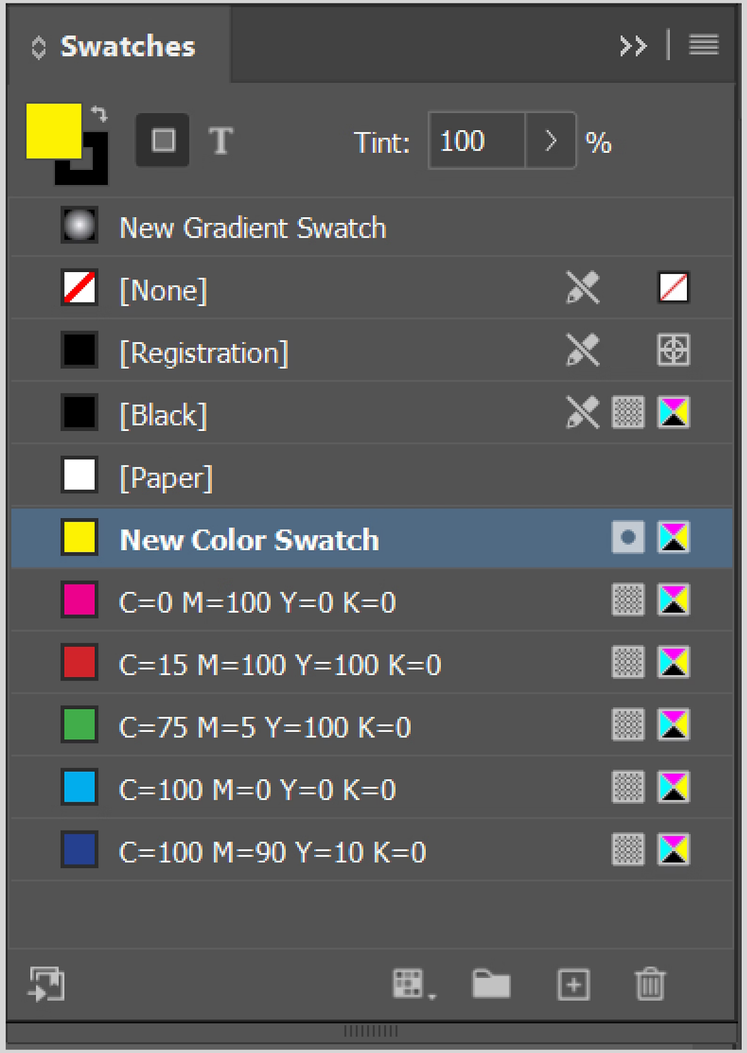
grant (file: File, role: Role)
  effect add role to file

authorize (file: File, user: User)
  requires file has some role that contains user



a cool concept:
Adobe's color swatch

how color swatches work in Adobe apps



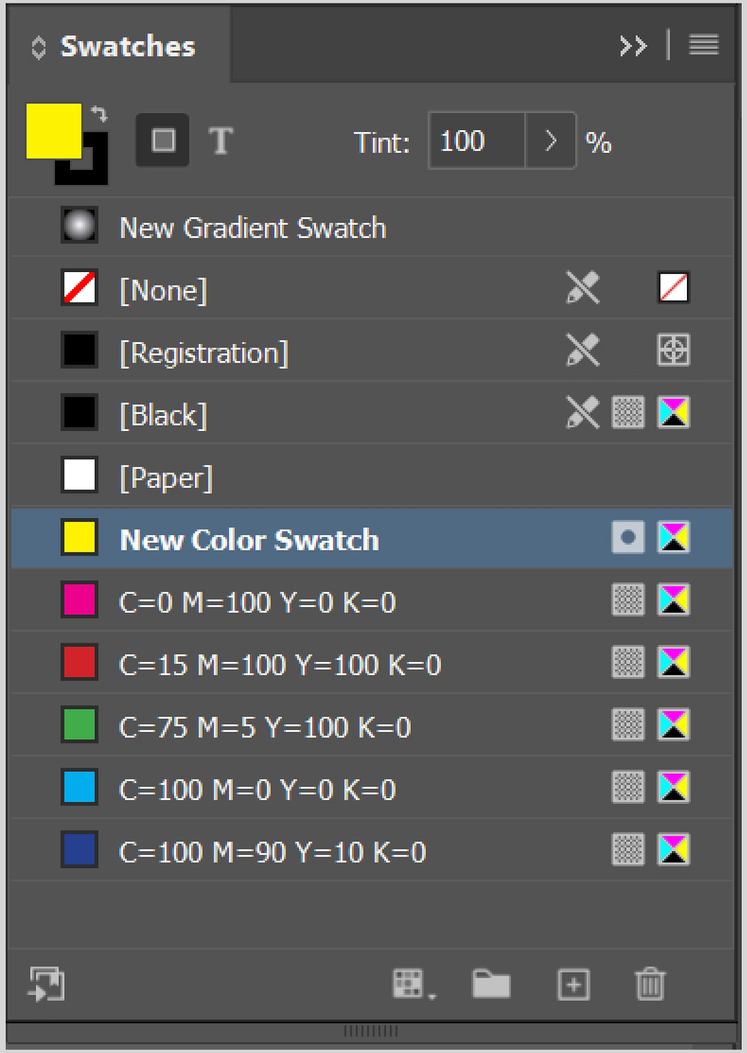
you select an element to color
might have to first select an item,
and then select which part (eg, fill)

then you select a swatch
pick a swatch from the swatch palette
and element gets that color

you can change the swatch color
by clicking on the swatch and editing it

then the elements change too!
all elements colored with that swatch

how color swatches work in Adobe apps



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why is this useful?

let's define a concept!

concept ColorSwatching [Item, Color]

purpose

principle

state

actions

createSwatch (color: Color): (swatch: Swatch)

applySwatch (item: Item, swatch: Swatch)

modifySwatch (swatch: Swatch, color: Color)

write an operational principle
using the actions listed

articulate the purpose
what is this rather tricky concept for?

define the state
not just a collection of swatches!

specify the actions
informally, with requires/effects

a solution

concept ColorSwatching [Item, Color]

purpose

principle

state
a set of Item with
  a Swatch
a set of Swatch with
  a red Number
  a green Number
  a blue Number

actions
  createSwatch (color: Color): (swatch: Swatch)
    effects create a new swatch with given color
  applySwatch (item: Item, swatch: Swatch)
    requires swatch exists
    effects associate item with swatch
  modifySwatch (swatch: Swatch, color: Color)
    requires swatch exists
    effects change swatch color to color

a puzzle: adding an action

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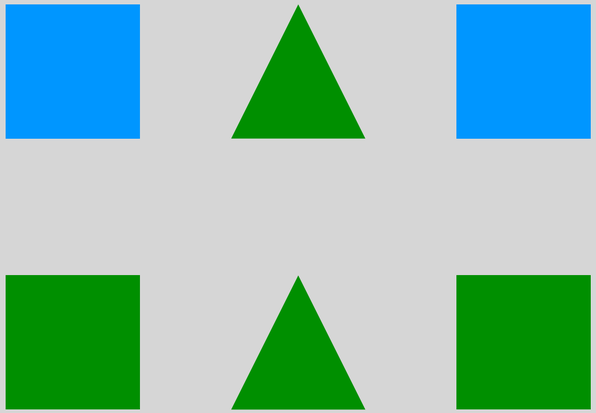
created three items and two swatches

assigned one swatch to squares, one to triangle

a puzzle: adding an action



created three items and two swatches

assigned one swatch to squares, one to triangle

modified the blue swatch to make it green

now all the items are the same color!

a puzzle: adding an action

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now all the items are the same color!

now we want to make them all orange

ouch! can’t modify one swatch to do this!

a puzzle: adding an action

created three items and two swatches

assigned one swatch to squares, one to triangle

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now all the items are the same color!

puzzle: is there an action that could have been performed here that would enable this?

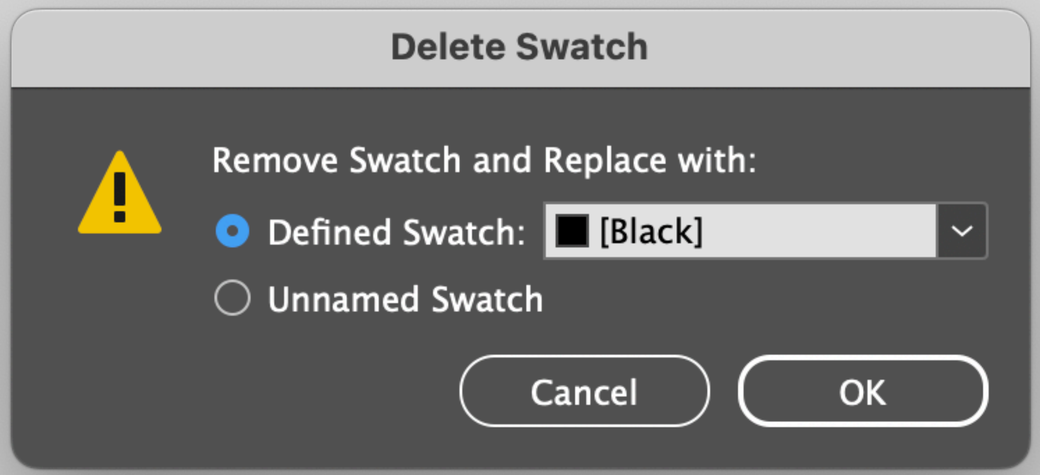
now we want to make them all orange

ouch! can't modify one swatch to do this!

adobe's answer to puzzle

deleteSwatch action
requires a replacement
so this will let you effectively merge swatches

deleteSwatch (s: Swatch, r: Swatch)
requires s and r both existing swatches
effect
delete s and make all items
associated with s associated with r instead



extra slides

which other concepts are like this?

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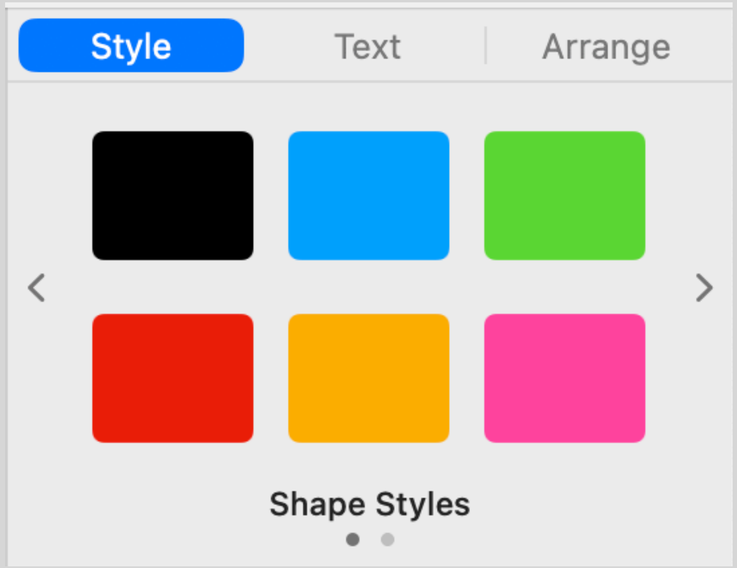

shape styles in Apple Keynote

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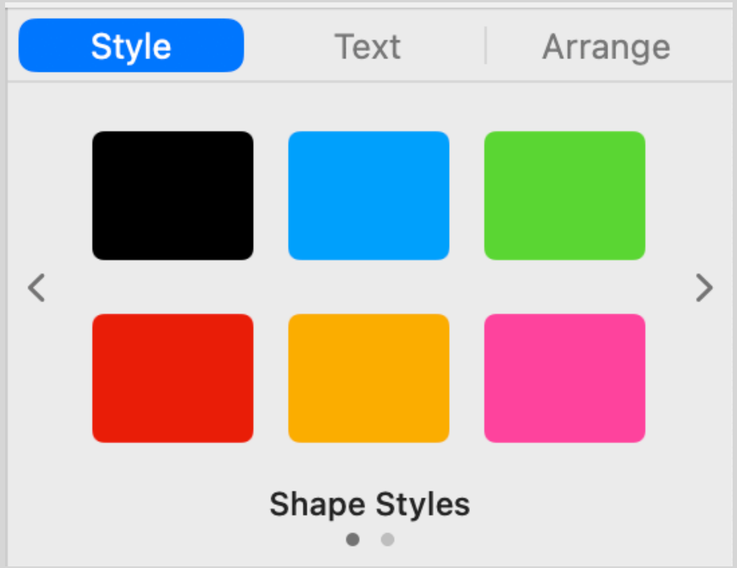

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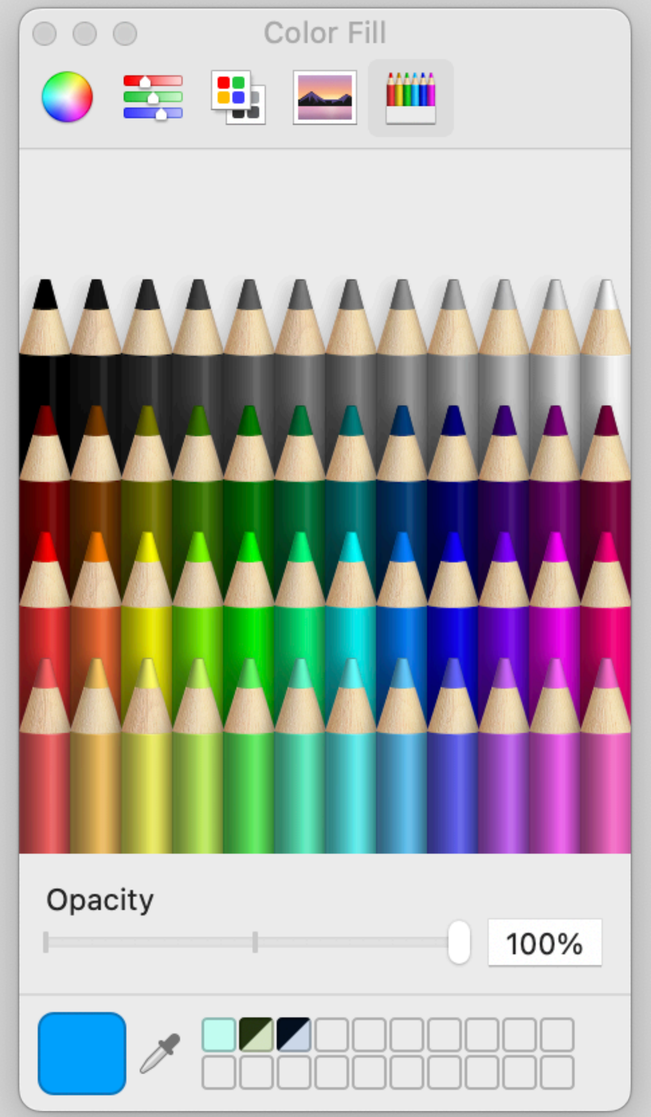

color picker in Apple macOS

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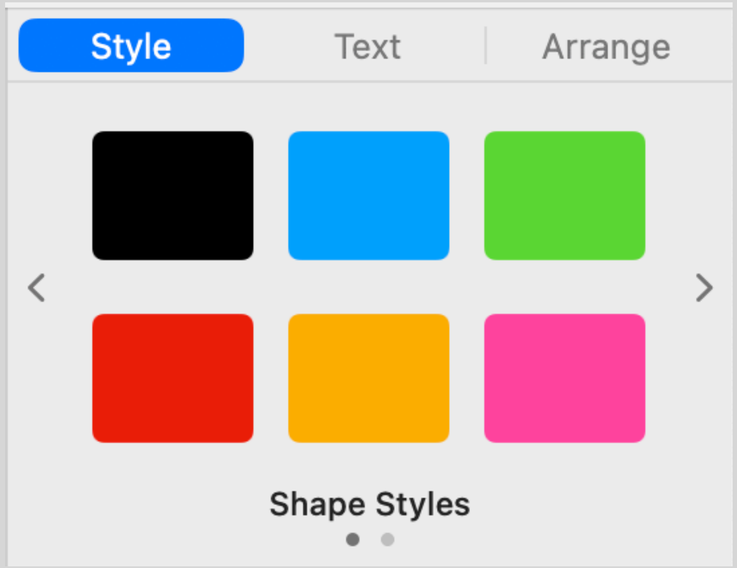

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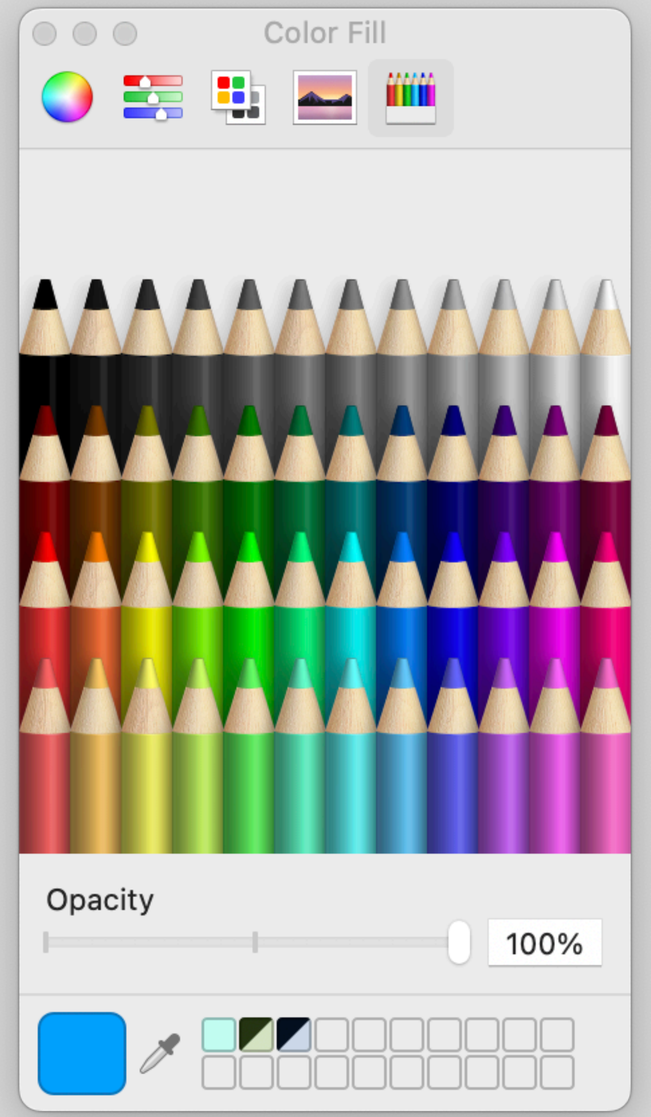

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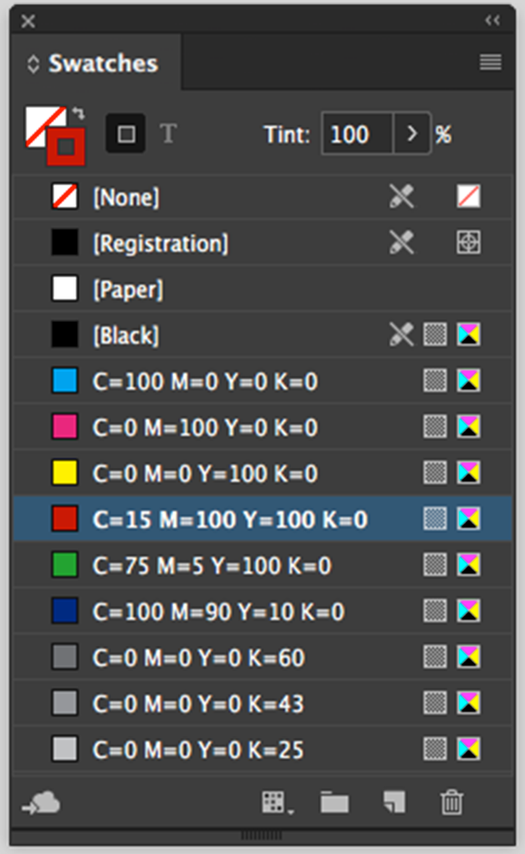
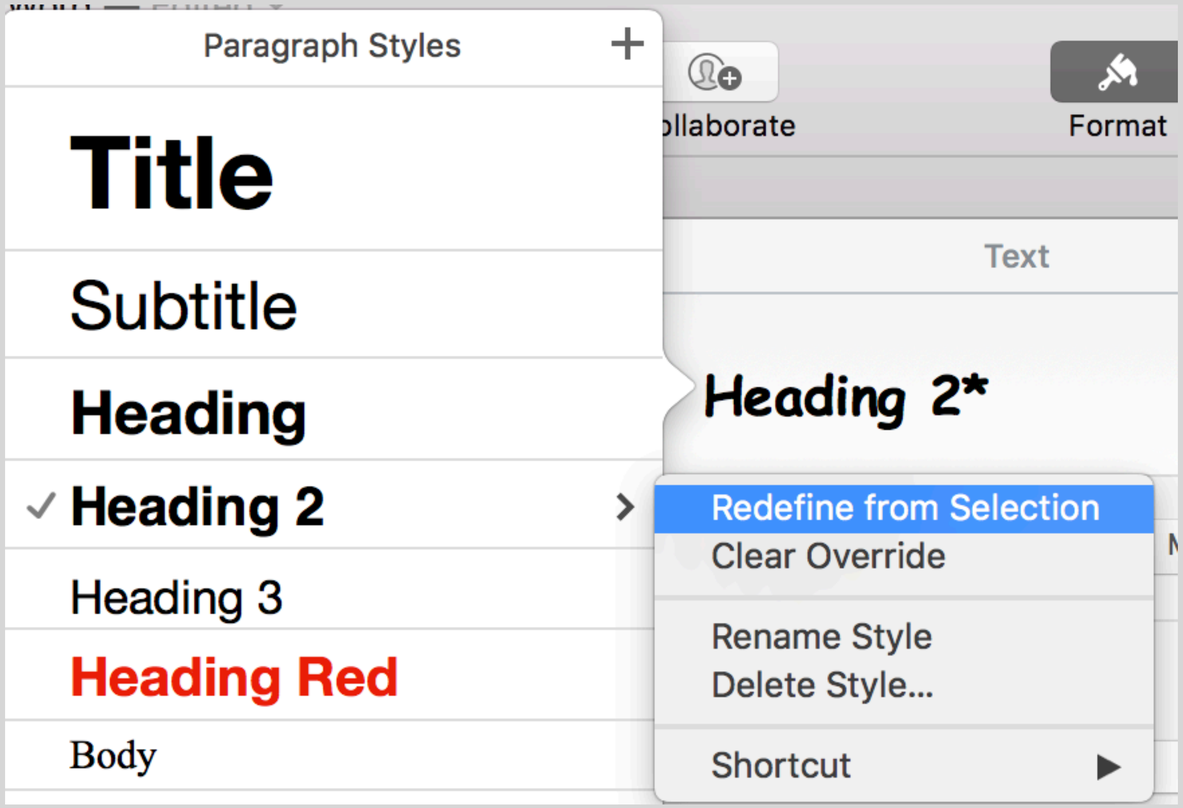


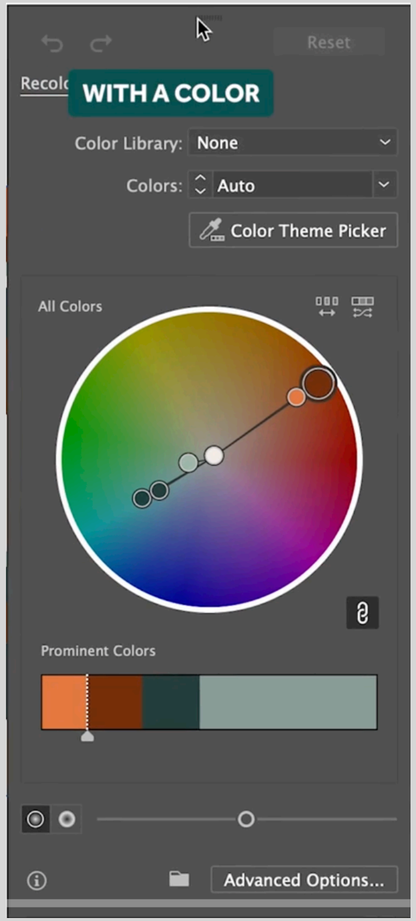
color palette in Adobe Indesign

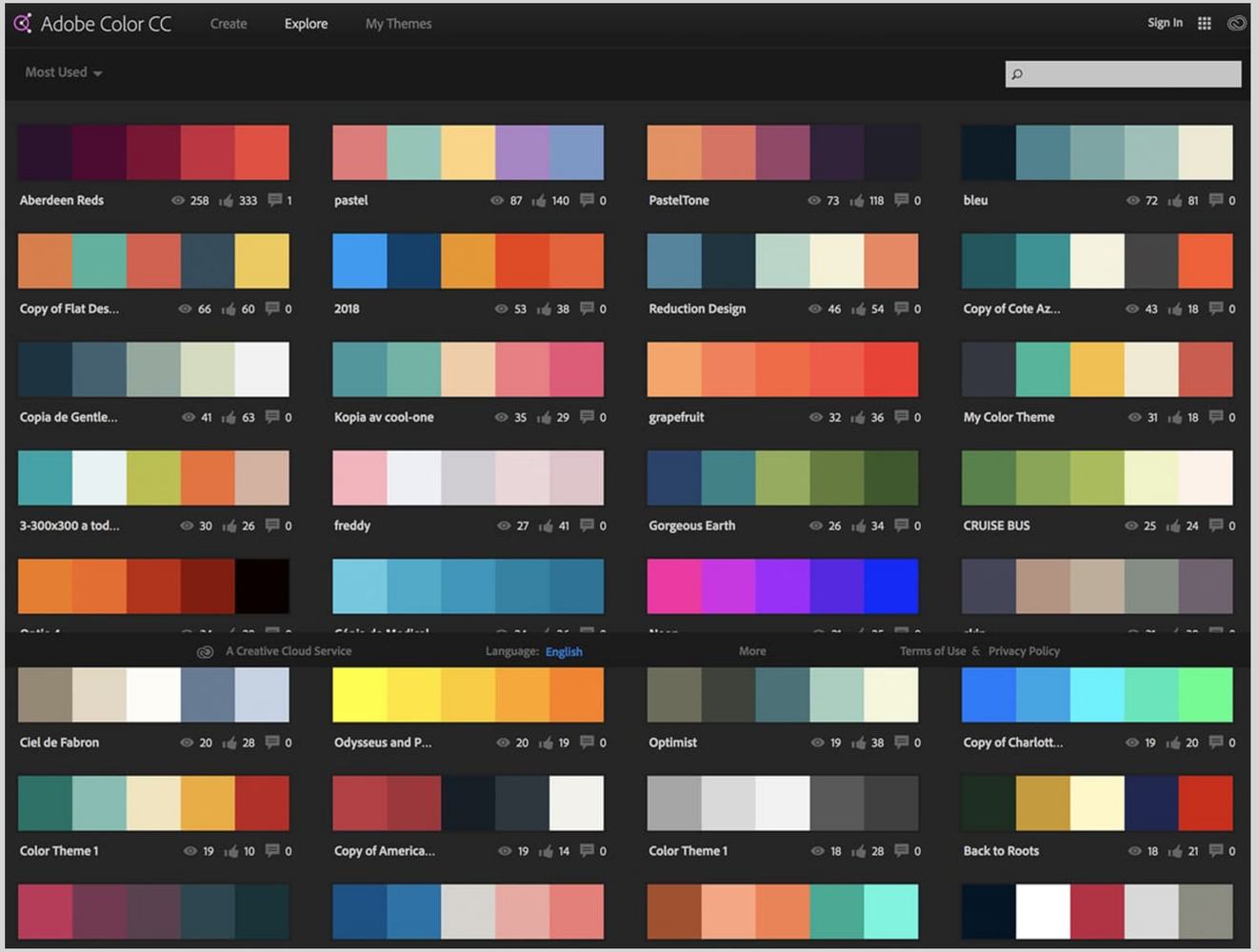
how about this? is it different or the same?



a very clever feature (not asking you to specify this!)

https://www.tiktok.com/@lucyedendesign/video/7467578633247526190





color palettes