how to become a great software designer

Daniel Jackson, MIT CSAIL · Boston ACM/IEEE · March 24, 2022

BRENDAN HOFFMAN FOR THE NEW YORK TIMES

s buried at Lychakiv Cemetery in Lviv alongside a fellow soldier, Ivan Koverznev.

ermany to aid the likely not follow suit because they S&P 500 dropped 0.7 percent

na's Role: amplifying emlin Lies

DWARD WONG

GTON — One of Rus- cendiary disinforma- ns ramped up days defense and foreign ssued statements g the Pentagon

Putin Threatens Takeover of Western Co

By ANTON TROIANOVSKI

Besieged by an onslaught of sanctions that have largely undone 30 years of economic integration with the West in the space of two weeks, President Vladimir V. Putin on Thursday opened the door to nationalizing the assets of Western companies pulling out of Russia and exhorted senior officials to "act decisively" to preserve jobs.

With Russia in danger of defaulting on its sovereign debt and facing a sharp contraction in its economy, the West is betting that he looming, generation-defining nomic crisis could make Rus- turn on their president. It is ossible, however, that the uld end up strengthening n, validating his narrative West is determined to de- ussia.

Russian Leader Facing Generation-Defining Economic Crisis

"I have no doubt that these sanctions would have been implemented no matter what," Mr. Putin said in televised remarks on Thursday, arguing that his intervention in Ukraine served merely as a pretext for the West to try to wreck Russia's economy. "Just as we overcame these difficulties in years past, we will overcome them now, too."

But the sanctions imposed in the two weeks since the invasion — combined with multinational companies that employ tens of thousands of Russians voluntarily deciding to withdraw amid the

global outrage — economic press has faced under

With the rub nearly half its v month, prices of risen sharply, cau ing at supermark bank, which has k stock exchange c war began, has i capital controls, pr panies from withd than $5,000 in cash months.

"This will be a gi formational down Ruben Enikolopov, New Economic Schoo

The Institute of Finance, a Washingt sociation of financial dicted that Russia wo percent decline in it

Continued on Pa

se flag Psaki, etary, esday " pre- ited pos- re." the nd al

GRIEF IN KYIV

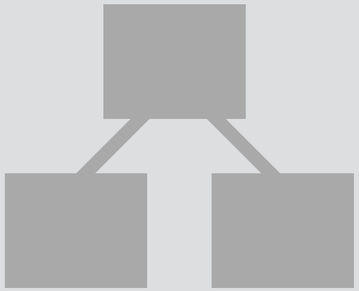
how to build software?

two problems to solve

functional structures

is it usable? effective? fit for purpose?

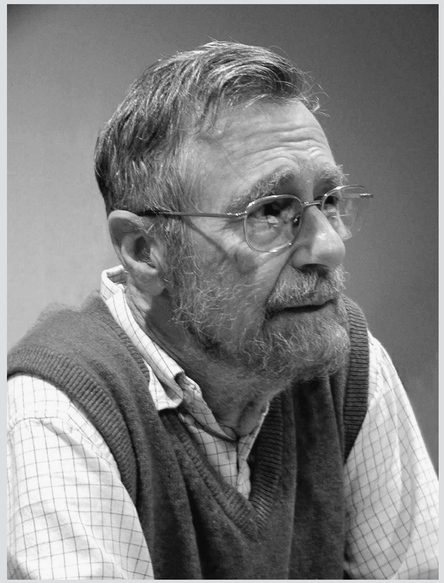
software design



implementation structures

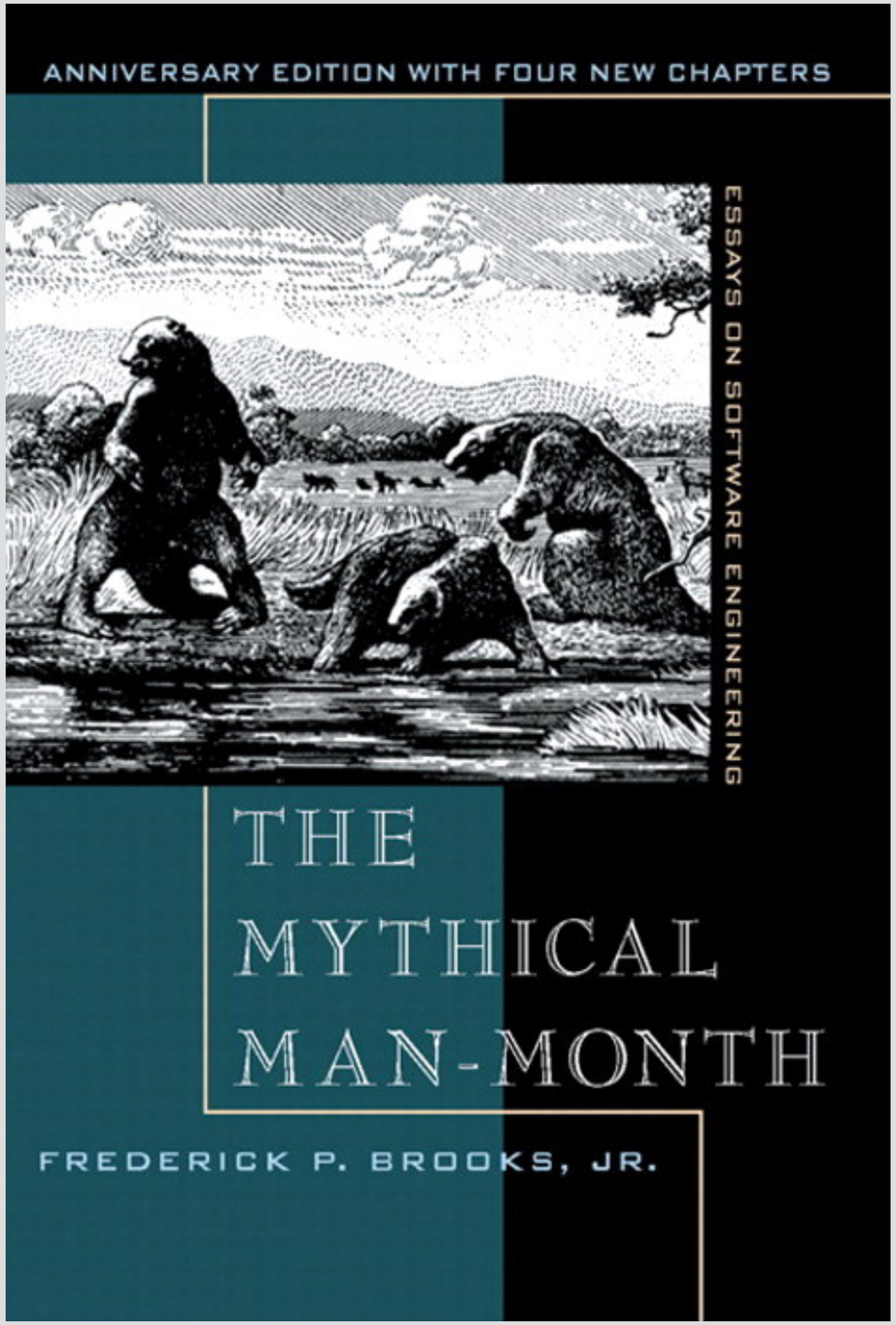
is it robust? performant? maintainable?

software engineering



The rôle of a formal functional specification is simply to act as a logical firewall between two completely different concerns... The **pleasantness problem** concerns the question whether a system meeting such-and-such a formal functional specification would satisfy our needs, meet our expectations and fulfill our hopes. The **correctness problem** concerns the question whether a given design meets such-and-such a formal functional specification.

Dijkstra, EWD952 (1986)



Conceptual integrity is the most important consideration in system design.

Fred Brooks, Mythical Man Month (1975)

I am more convinced than ever. Conceptual integrity is central to product quality.

Mythical Man Month Anniversary Edition (1995)

The essence of a software entity is a construct of interlocking concepts... I believe the hard part of building software to be the specification, design, and testing of this conceptual construct, not the labor of representing it...

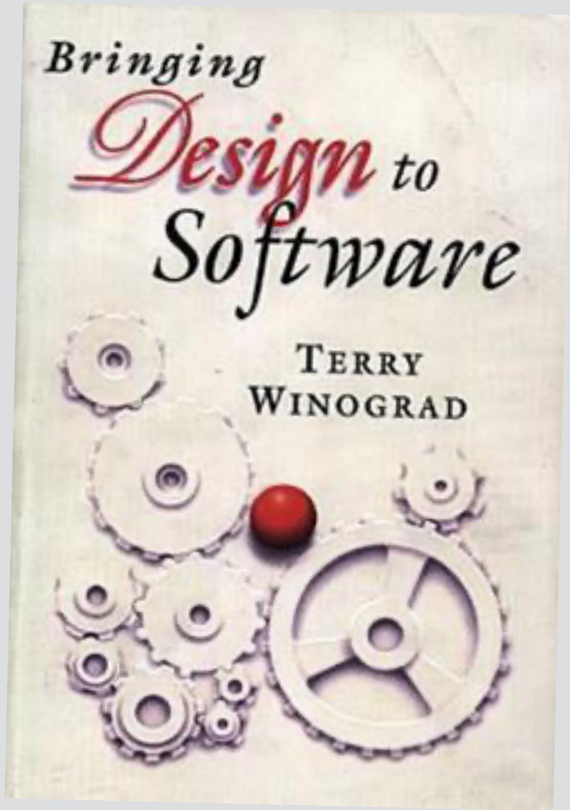
No Silver Bullet (1986)

When you go to design a house **you talk to an architect first**, not an engineer. Why is this?

Because the criteria for what makes a good building fall outside the domain of engineering.

Similarly, in computer programs, the **selection of the various components** and elements of the application must be driven by the conditions of use. **How is this to be done?** By software designers.

A Software Design Manifesto
Mitchell Kapor, 1996
paraphrasing slightly

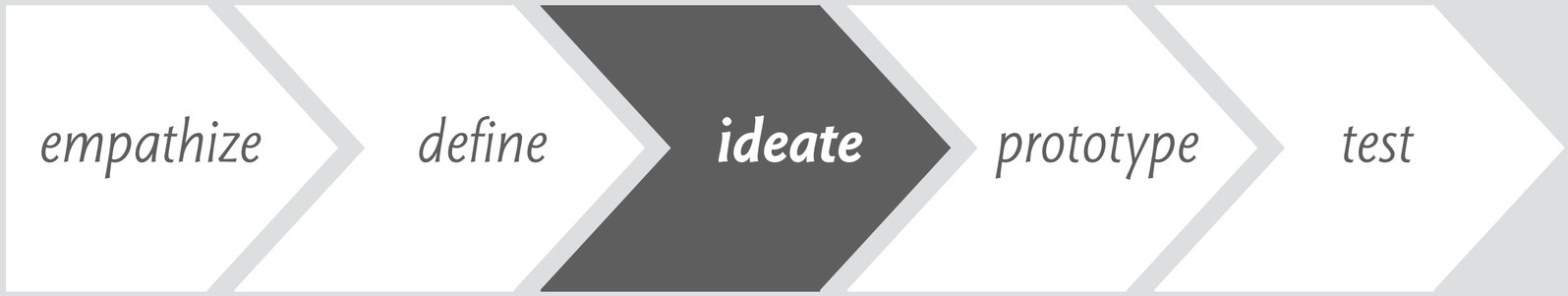


what makes great designers?

design by inspiration

inspiration = talent + process

the design thinking process



problem at hand defines context

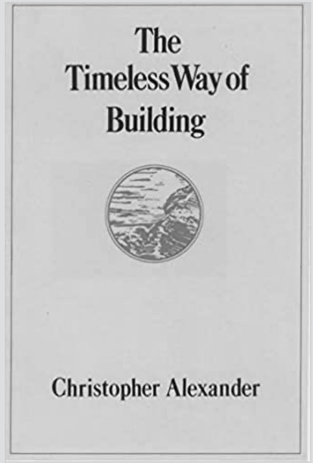
is there any great design that is the result of a great design process?

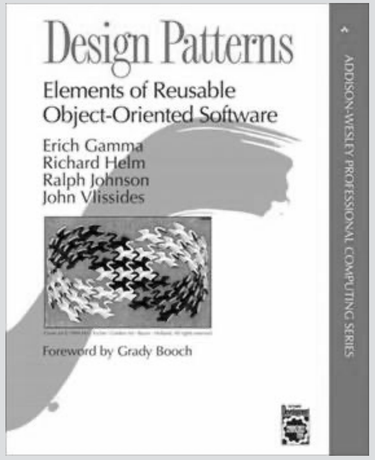
design by expertise

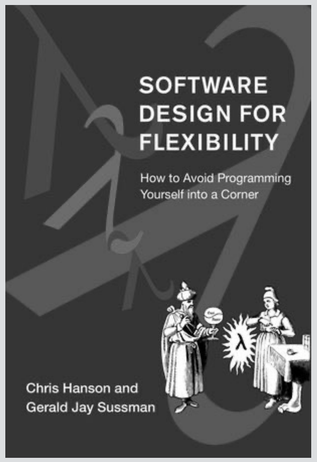
expertise = patterns + design moves

familiar structures familiar steps

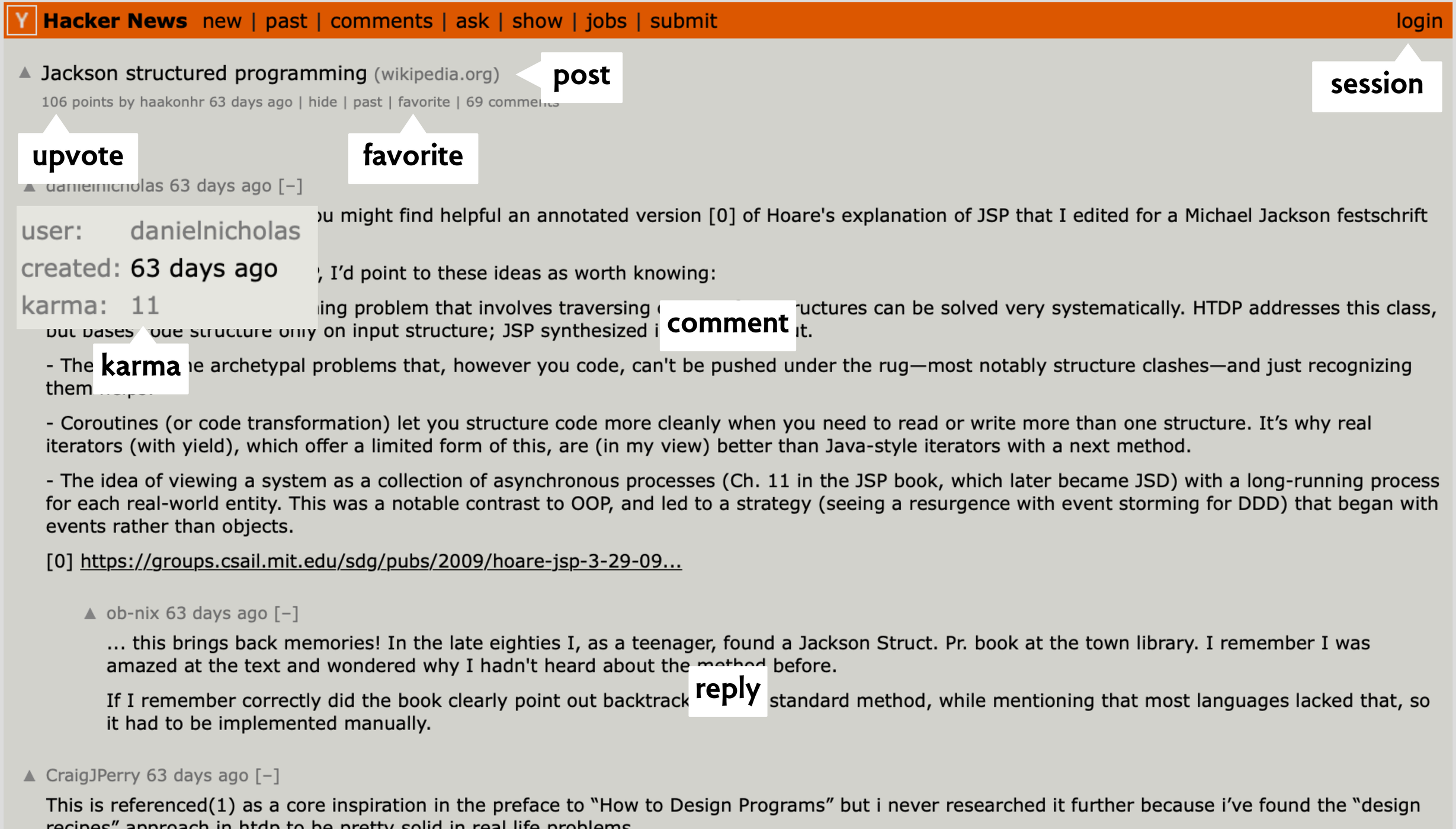
The well-kept secret behind the most successful designs is that they are less new than they appear. Invariably, it turns out that, in some form or other, the designer has done the same thing before. —AFD







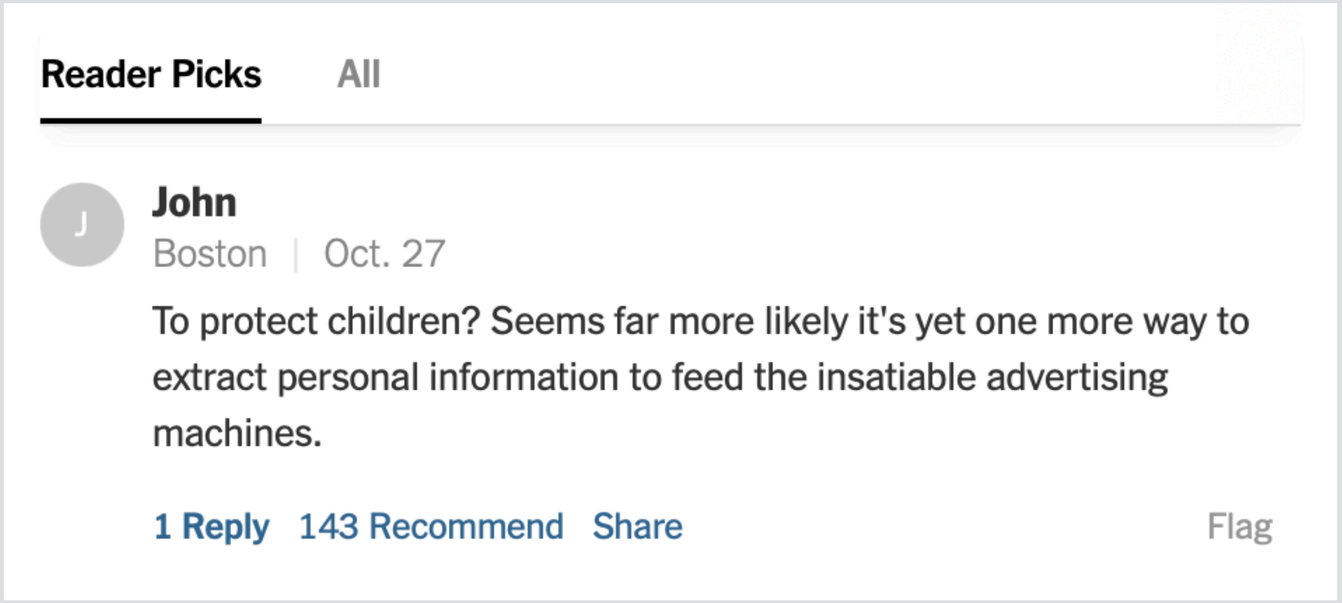
what are the elements of software design?


Hacker News new | past | comments | ask | show | jobs | submit
login
Jackson structured programming (wikipedia.org)
post
106 points by haakonhr 63 days ago | hide | past | favorite | 69 comments
session
upvote
favorite
danielnicholas 63 days ago [–]
user: danielnicholas
created: 63 days ago
karma: 11
u might find helpful an annotated version [0] of Hoare's explanation of JSP that I edited for a Michael Jackson festschrift
, I'd point to these ideas as worth knowing:
ing problem that involves traversing uctures can be solved very systematically. HTDP addresses this class,
comment
but bases ode structure only on input structure; JSP synthesized i t.
karma
- The e archetypal problems that, however you code, can't be pushed under the rug—most notably structure clashes—and just recognizing them
- Coroutines (or code transformation) let you structure code more cleanly when you need to read or write more than one structure. It's why real iterators (with yield), which offer a limited form of this, are (in my view) better than Java-style iterators with a next method.
- The idea of viewing a system as a collection of asynchronous processes (Ch. 11 in the JSP book, which later became JSD) with a long-running process for each real-world entity. This was a notable contrast to OOP, and led to a strategy (seeing a resurgence with event storming for DDD) that began with events rather than objects.
[0] https://groups.csail.mit.edu/sdg/pubs/2009/hoare-jsp-3-29-09...
ob-nix 63 days ago [–]
... this brings back memories! In the late eighties I, as a teenager, found a Jackson Struct. Pr. book at the town library. I remember I was amazed at the text and wondered why I hadn't heard about the method before.
If I remember correctly did the book clearly point out backtrack standard method, while mentioning that most languages lacked that, so it had to be implemented manually.
reply
CraigJPerry 63 days ago [–]
This is referenced(1) as a core inspiration in the preface to "How to Design Programs" but i never researched it further because i've found the "design recipes" approach in htdp to be pretty solid in real life problems.

a concept has a **name**

concept Upvote

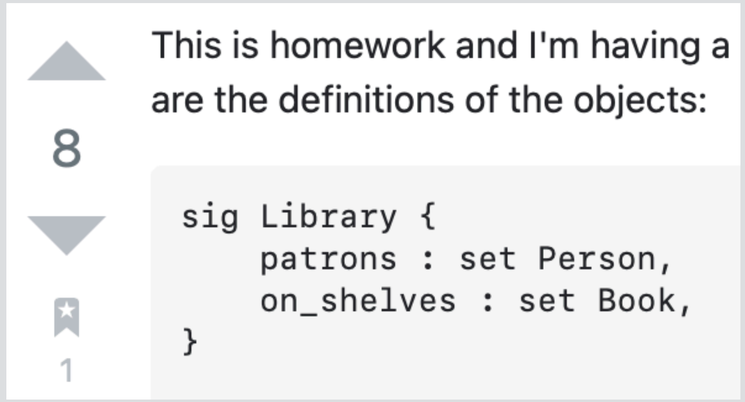
same concept in HackerNews, NYTimes comment section, StackOverflow, etc



a concept has a purpose

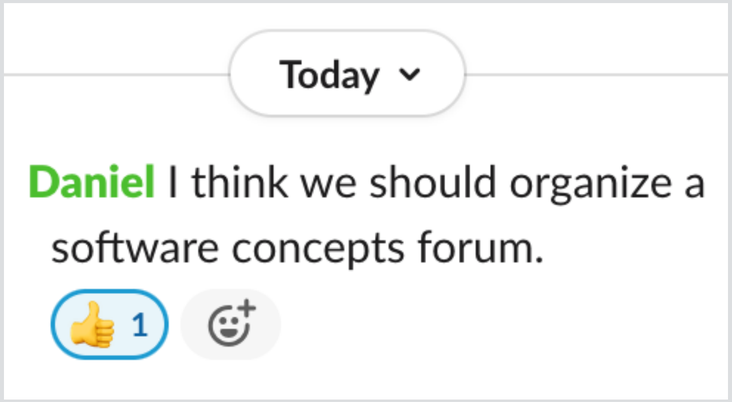
concept Upvote

purpose rank items by popularity



concept Reaction

purpose send reactions to author



concept Recommendation

purpose use prior likes to recommend

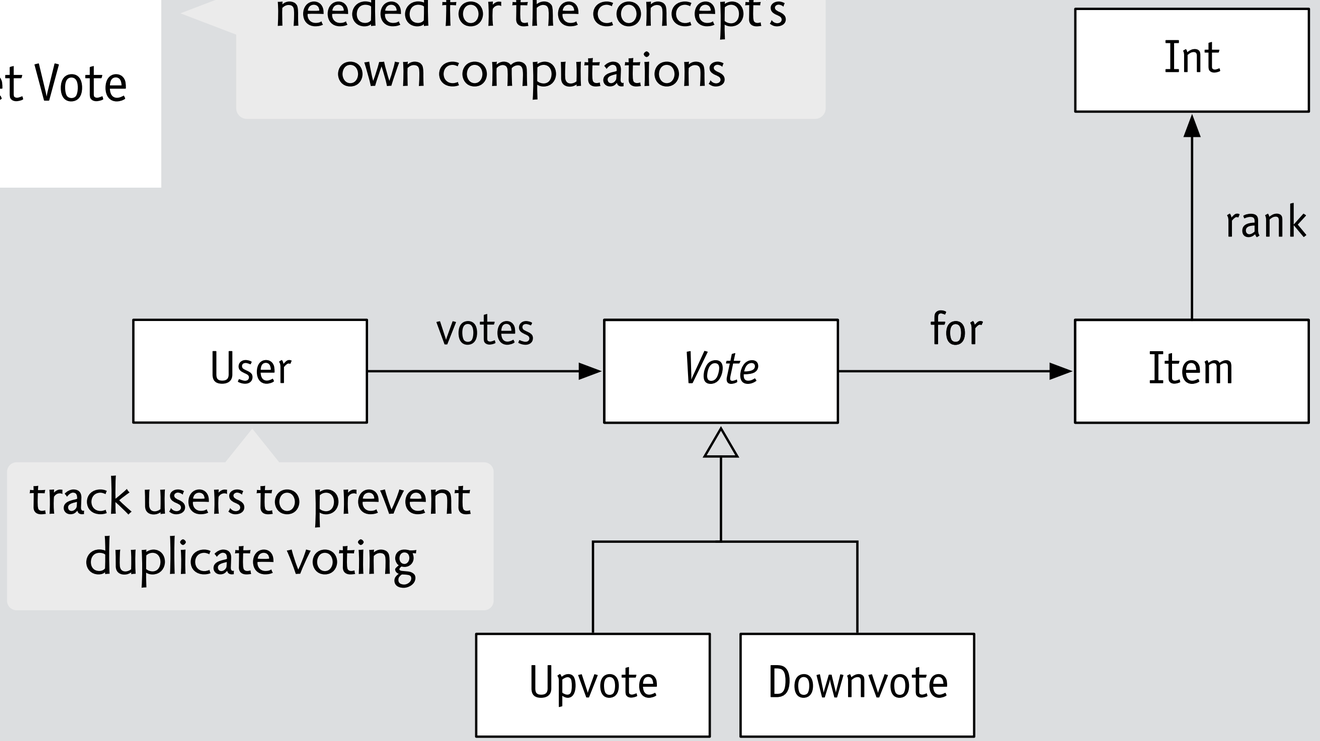
a concept has a state

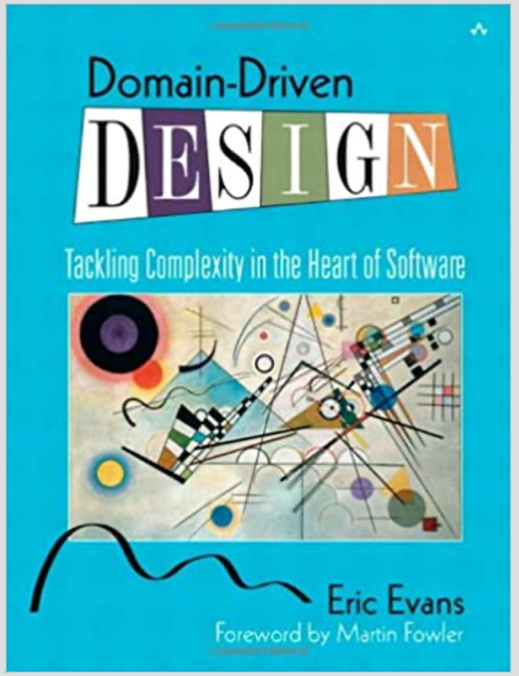
concept Upvote

purpose rank items by popularity

state
votes: User -> set Vote
for: Vote -> one Item
Upvote, Downvote: set Vote
rank: Item -> one Int

include in state **only** what's needed for the concept's own computations





like bounded context in DDD, but even more localized

a concept has actions

concept Upvote

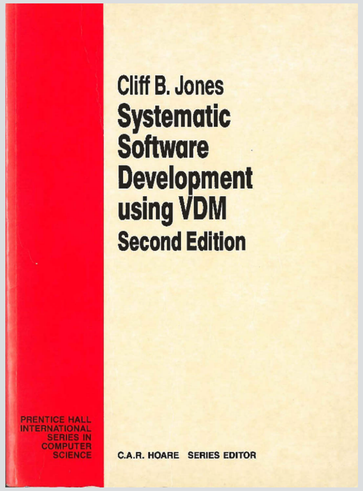
purpose rank items by popularity

state
votes: User -> set Vote
for: Vote -> one Item
Upvote, Downvote: set Vote
rank: Item -> one Int

actions
upvote (u: User, i: Item)
downvote (u: User, i: Item)
unvote (u: User, i: Item)

actions capture the concept
behavior in full

downvote (i: Item, u: User)
// no existing Downvote for i in u.votes
// remove any Upvote for i from u.votes
// add a Downvote for i in u.votes
// update i.rank ...



succinct specification
as actions on states
VDM (1986)
Z (1992)
Larch (1993)
Event-B (2006)
Alloy (2006)

a concept catalog entry

concept Upvote

related concepts
Recommendation, Reaction, ...

design variants
downvote as unvote
use age in ranking
weigh downvotes more

known issues
preventing double votes
(require login, use IP address, save cookie)
saving storage space
(freeze old posts and from user info)

typical uses
social media posts
comments on articles
Q&A responses

often used with
Karma, Session, ...

composing concepts
by synchronization

how to extend behavior?

concept Upvote

actions
upvote (u: User, i: Item)
downvote (u: User, i: Item)
unvote (u: User, i: Item)

suppose I want this behavior:
you can't downvote an item
until you've received
N upvotes on your own items

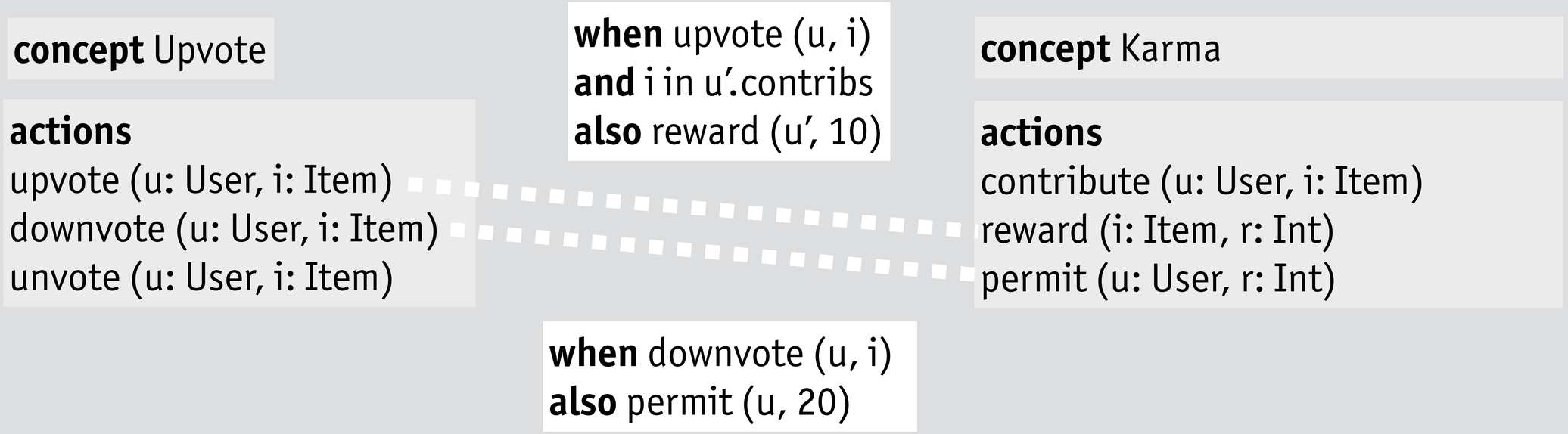
define a new concept!
a hint: not just used by Upvote

concept Karma

purpose privilege good users

state
karma: User -> one Int
contribs: User -> set Item

actions
contribute (u: User, i: Item)
reward (u: User, r: Int)
permit (u: User, r: Int)


concept Upvote
actions
upvote (u: User, i: Item)
downvote (u: User, i: Item)
unvote (u: User, i: Item)
when upvote (u, i)
and i in u'.contribs
also reward (u', 10)
when downvote (u, i)
also permit (u, 20)
concept Karma
actions
contribute (u: User, i: Item)
reward (i: Item, r: Int)
permit (u: User, r: Int)

concept Upvote

upvote (Bob, post1)

upvote (Carol, post1)

downvote (Alice, post2)

when upvote (u, i)
also reward (u, 10)

when downvote (u, i)
also permit (u, 20)

concept Karma

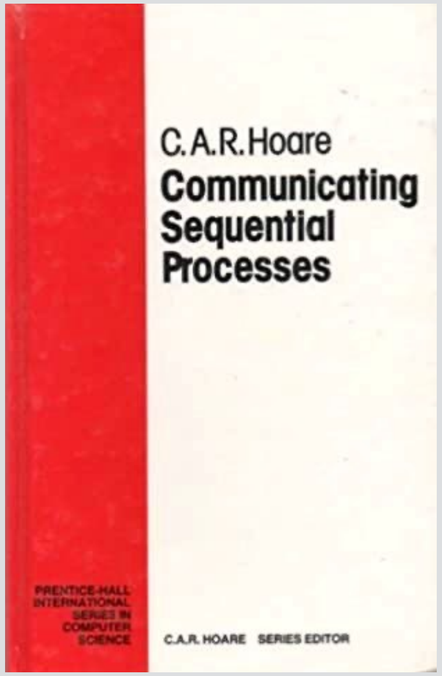
contrib (Alice, post1)

contrib (Bob, post2)

reward (Alice, 10)

reward (Alice, 10)

permit (Alice, 20)

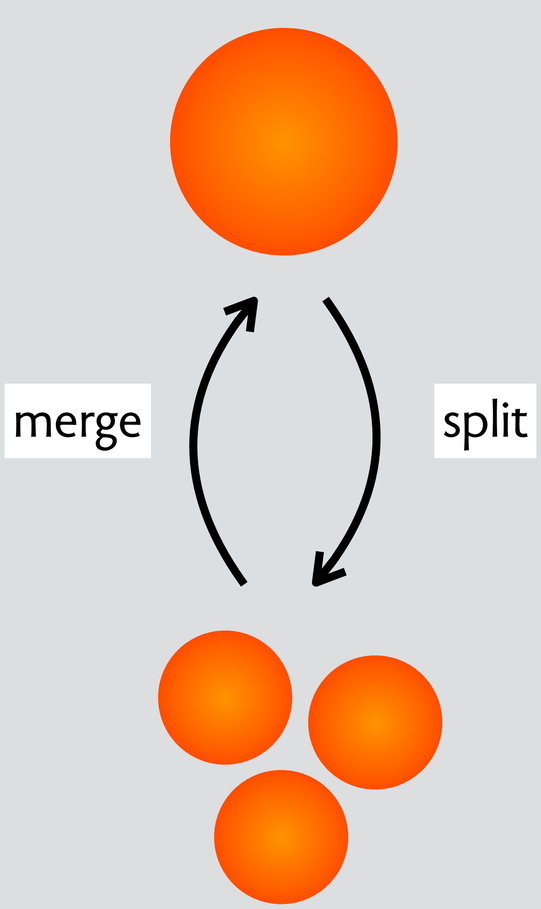


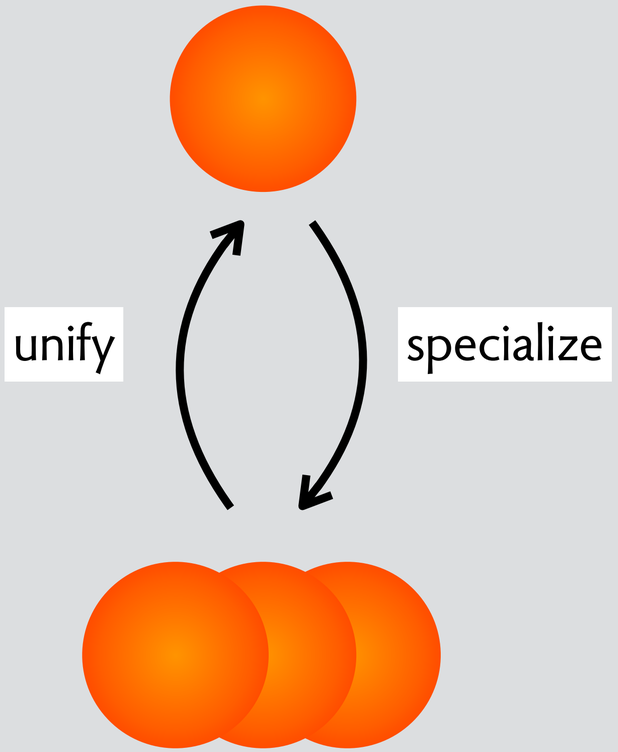
composition uses event sync from Hoare's CSP

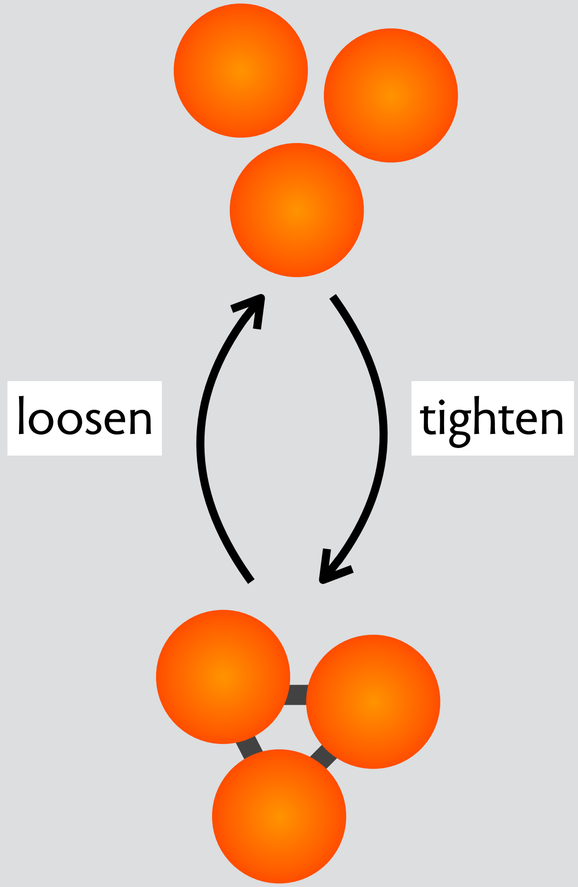
no concept coupling
concepts preserve properties

design moves
mechanical analogs

three pairs of design moves







split-merge: tradeoff simplicity/flexibility

photocopier

split

printer + scanner

emergency flashlight

merge

flashlight + battery + charger

unify-specialize: tradeoff simplicity/specificity

set of wrenches

unify

adjustable wrench

macro lens

specialize

general-purpose lens

tighten-loosen: tradeoff automation/flexibility

light pull / door lock

tighten

loosen

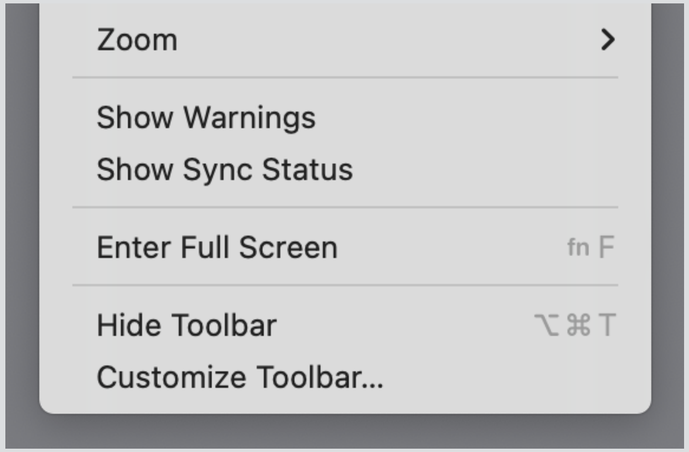
airplane toilet lock

dimmers with separate controls

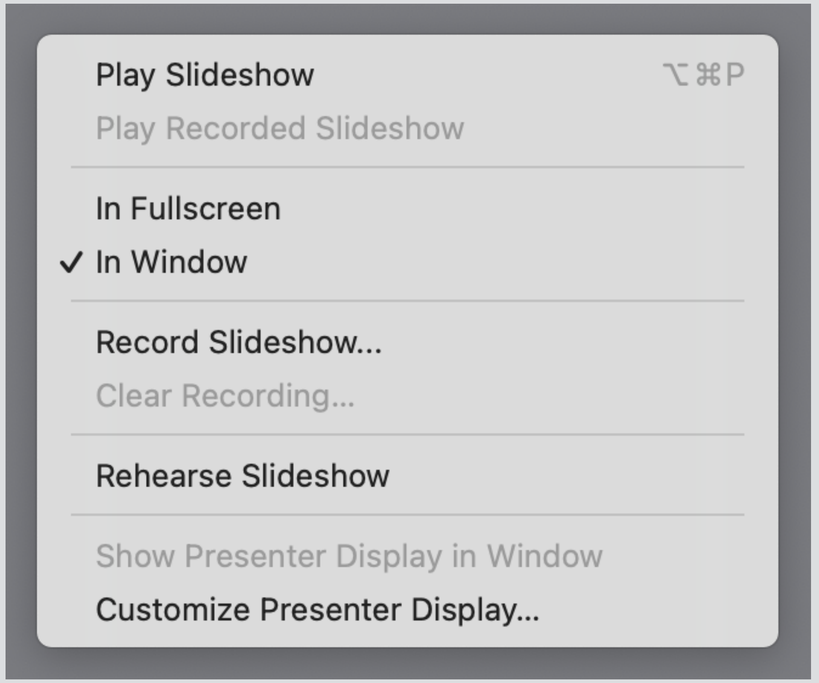
rotary dimmer switch

successful
design moves
in software

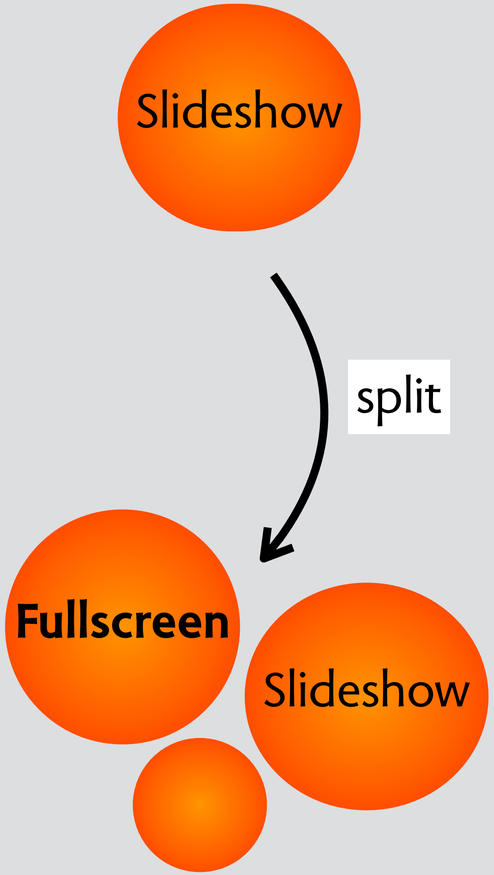
split: emergence of a concept in Keynote



full screen toggle
emerges as partial concept
(c. 2010?)



play-in-window option
now an independent concept
(2021)



merge: a simple & clever new shortening concept

yellkey

enter url and length of time for key to exist.

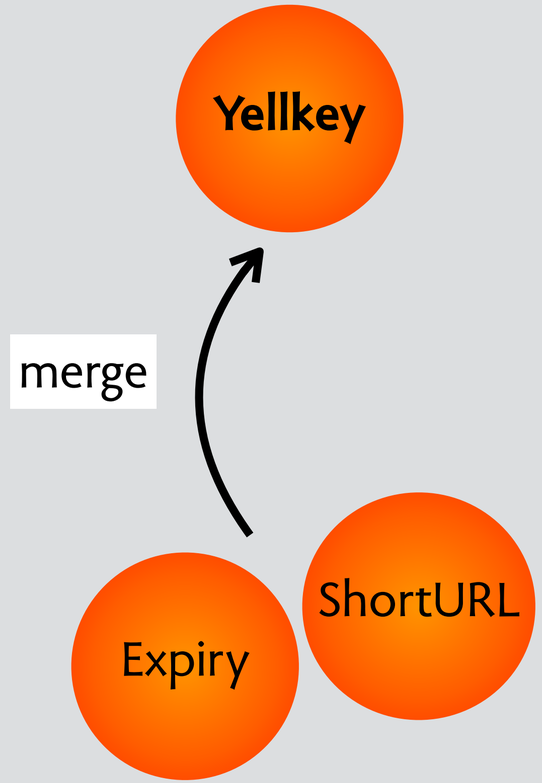
https://dnj.photo

5 minutes

generate yellkey

your key is: **move**.

go to www.yellkey.com/move to use.

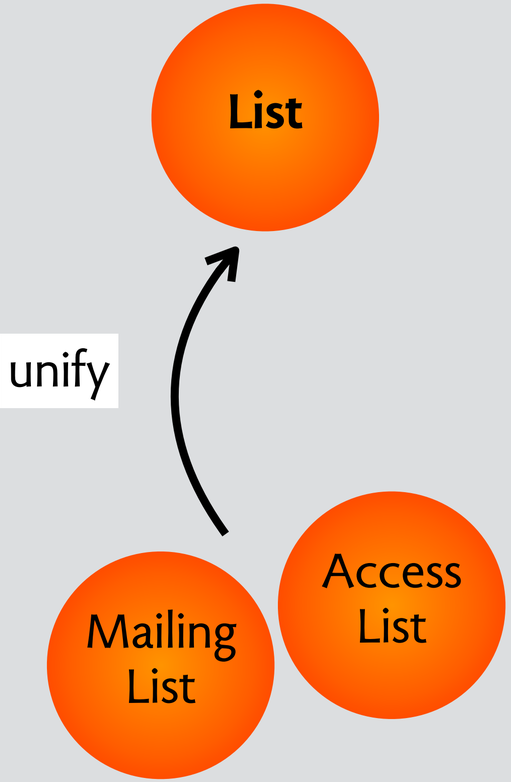


one concept, allows familiar words as short URLs

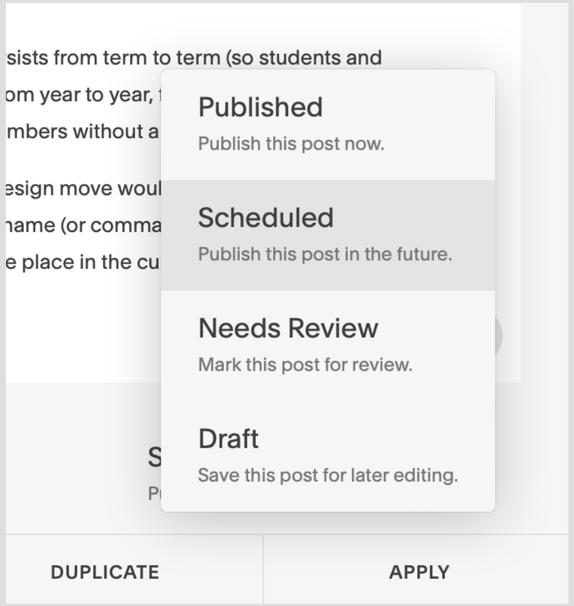
unify: subsuming access control in MIT's Moira

can toggle mailing list attribute

can create admin list with no login users!

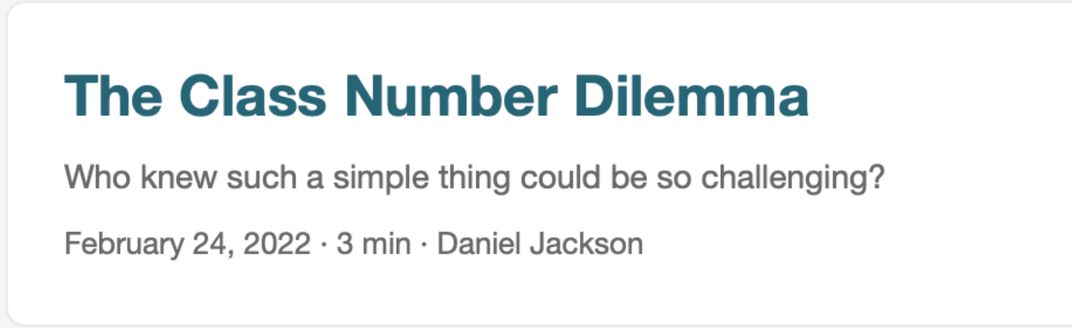


tighten: metadata and publication status in Hugo

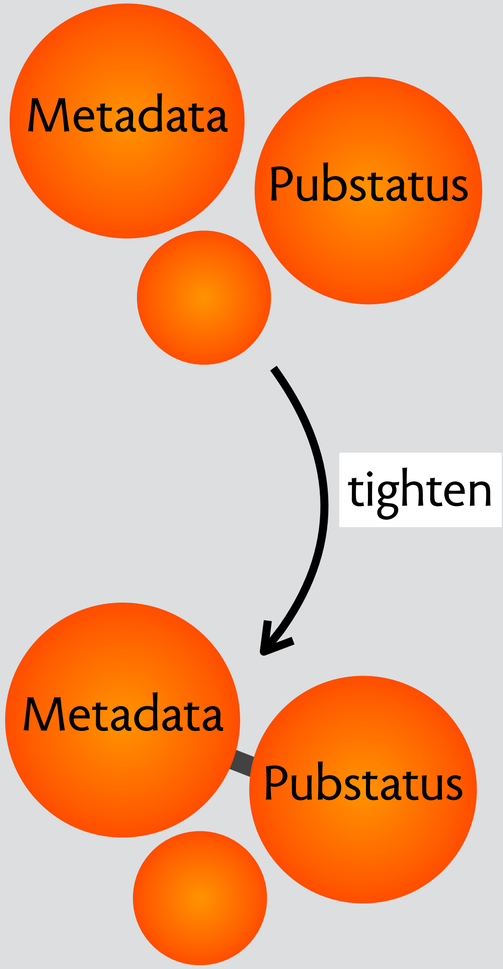


Squarespace: can schedule blog posts but not other pages, and can change pub date independently (only affects order)

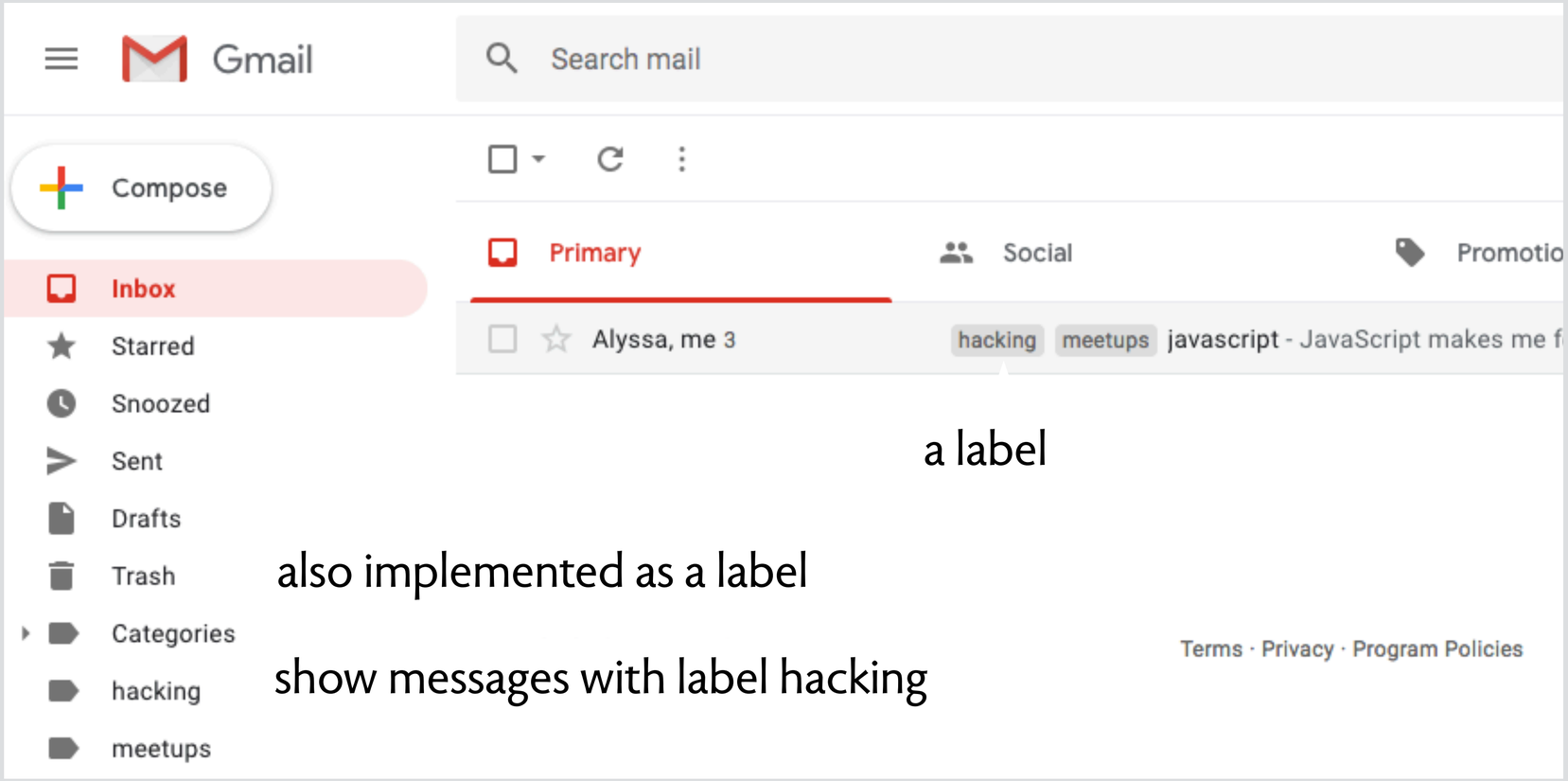
```
---
author: "Daniel Jackson"
title: "The Class Number Dilemma"
date: "2022-02-24"
description: "A Concept Example in Everyday Life"
summary: "Who knew such a simple thing could be so challenging?"

---
```



Hugo: any page can have date field to schedule, just set date in future



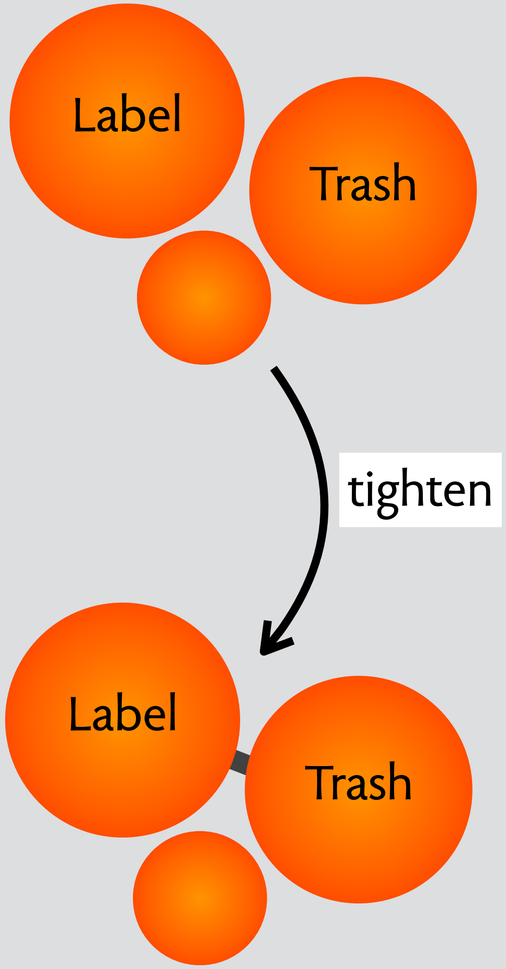
tighten: label and trash concepts in Gmail



a label

also implemented as a label

show messages with label hacking



concept trash

purpose undo deletion

structure
trash: **set** Item

actions
delete (i: Item)
restore (i: Item)
empty ()

when delete (i)
also add (i, ‘trash’)

concept label

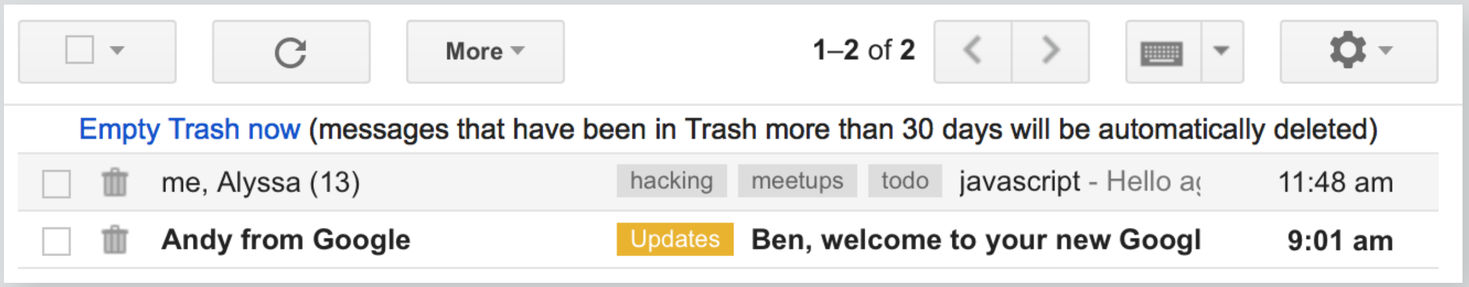
purpose organize with overlapping

structure
labels: Item -> **set** Label

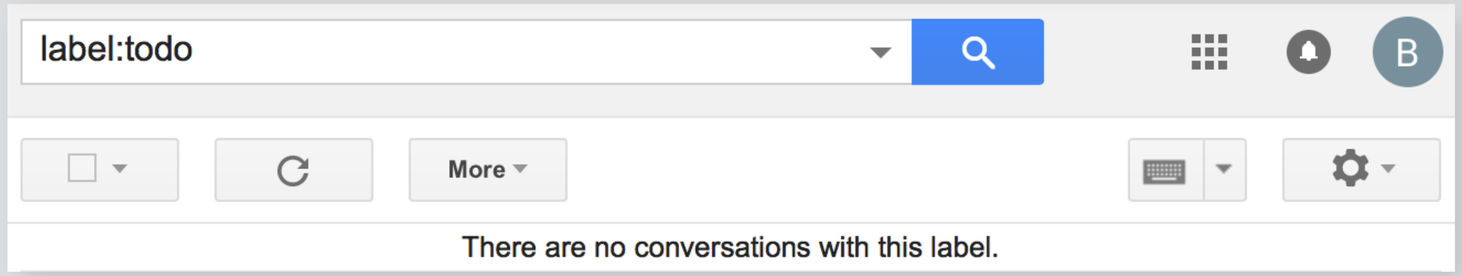
actions
add (i: Item, l: Label)
remove (i: Item, l: Label)
find (ls: **set** Label, **out** is: **set** Item)

integrating these concepts is tricky

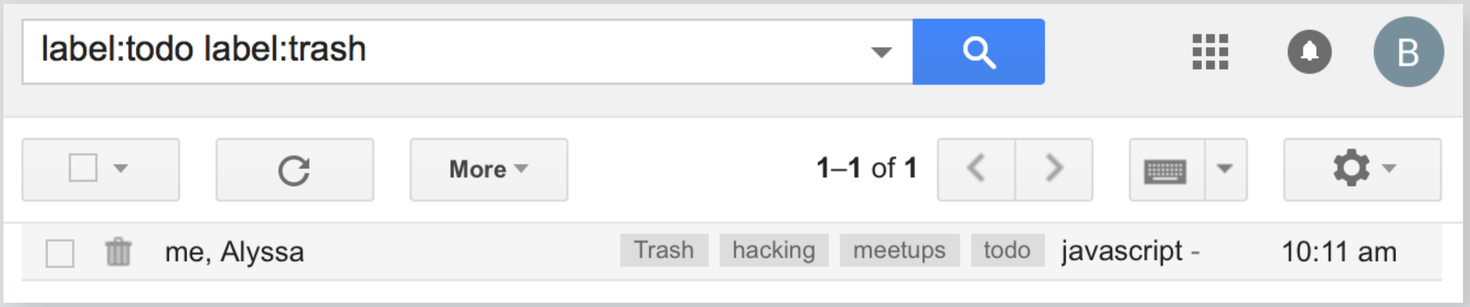
click on trash



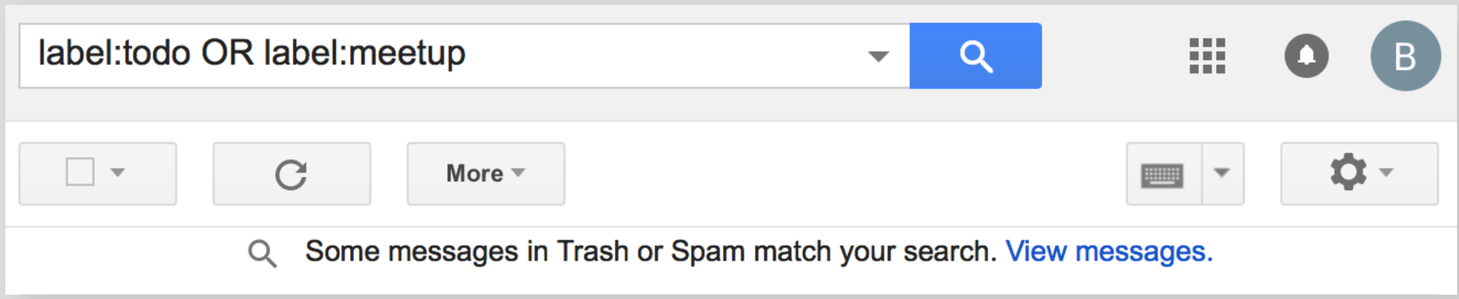
filter on todo label



filter on todo and trash

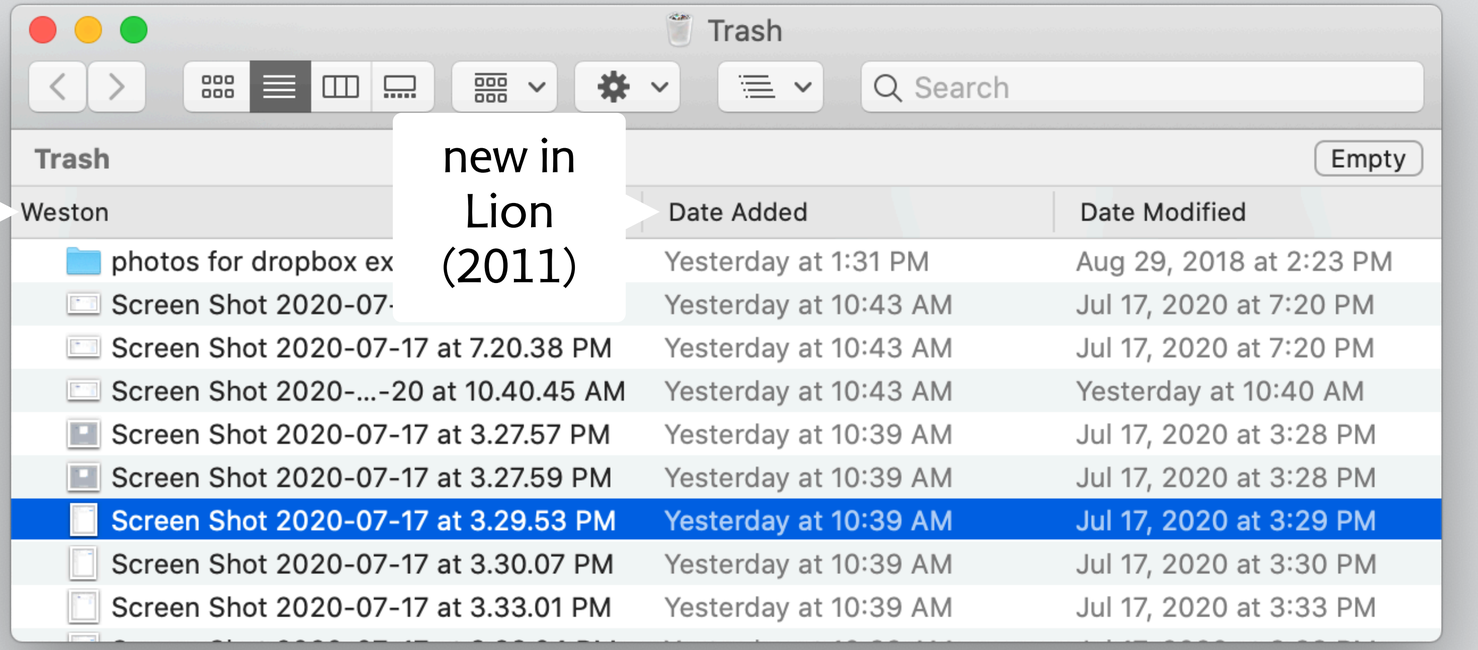


filter on something else

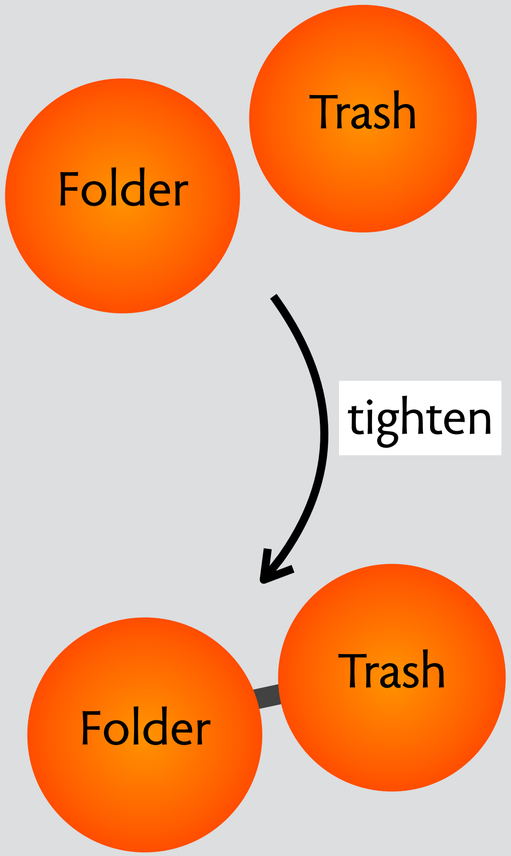


a beautiful (but tricky) synergy

folder sortable by volume!

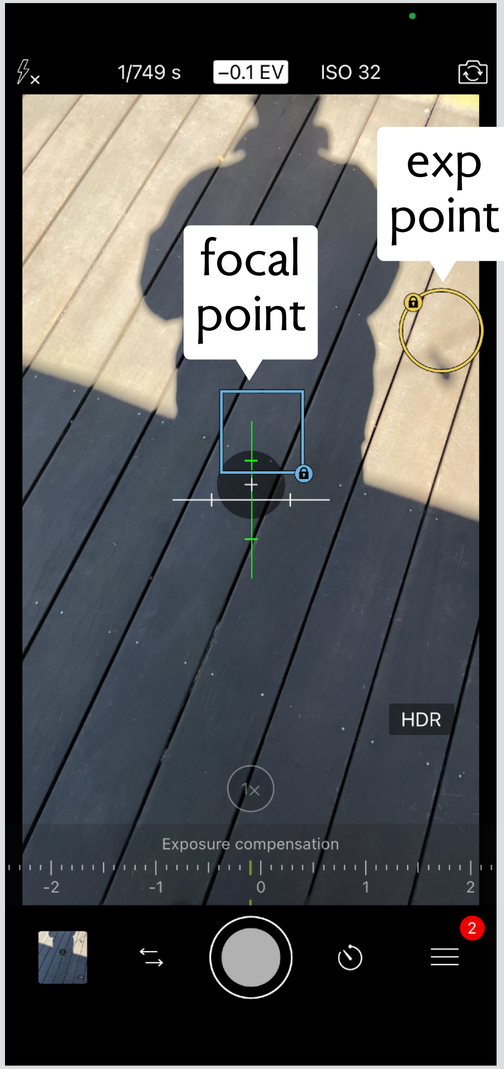


new in Lion (2011)

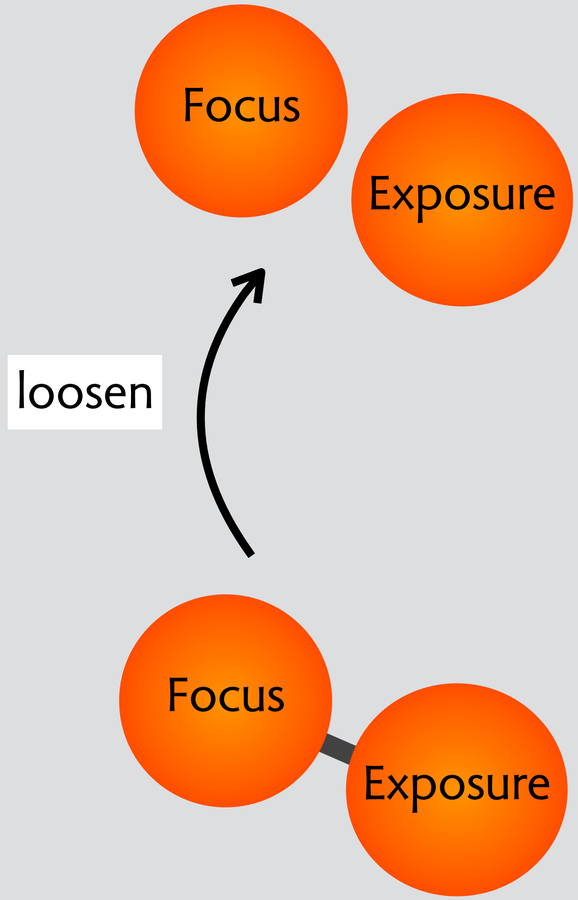


loosen: expert control in ProCamera

focus and exposure points aligned



focus and exposure points separated



design moves in response to problems

aspect ratio
in fujifilm cameras

a lovely camera fuji x100

complex menu system: image quality setting

aspect ratio

image size setting

non-standard ratio + raw?

problem #1: no non-standard ratio unless also save JPG!

raw image showing non-destructive aspect ratio crop

problem #2: very few ratio options

change.org

Petition details Comments Updates

Fuji, give us 4:3, 5:4, and 6:7 aspect ratios on X-series cameras

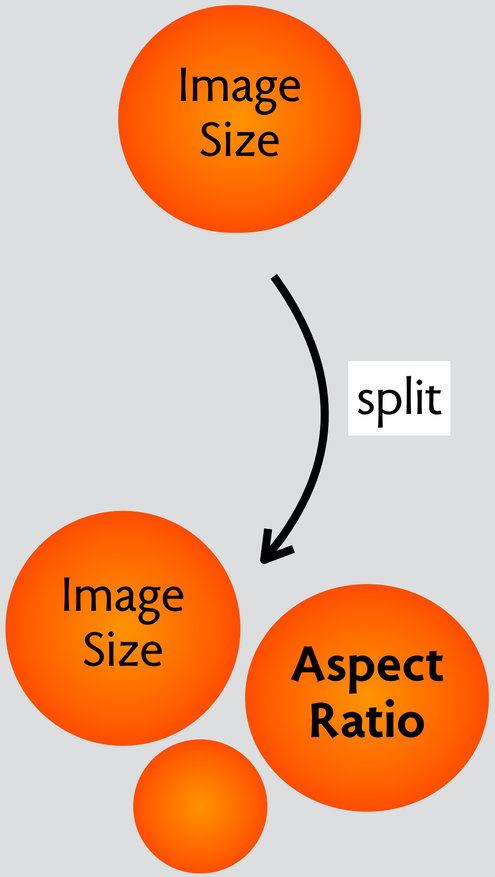
636 have signed. Let's get to 1,000!

At 1,000 signatures, this petition is more likely to be **featured in recommendations!**

diagnosis?

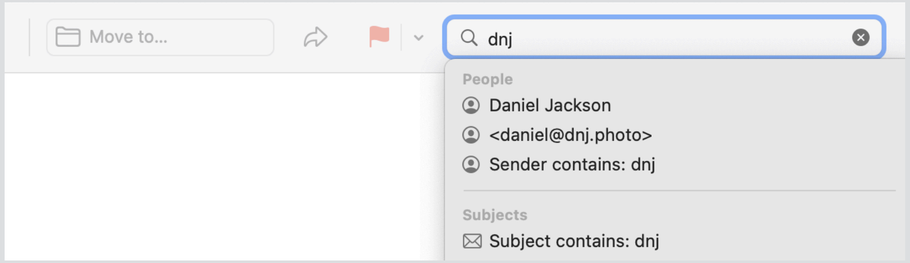
aspect ratio is not a concept
merged into JPEG image size concept
so cannot be controlled independently
I call this "overloading by piggybacking"

solution: split concepts
would allow ratio change to raws without JPEGs
would avoid combinatoric explosion of options

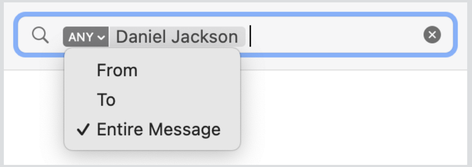


message filters
in apple mail

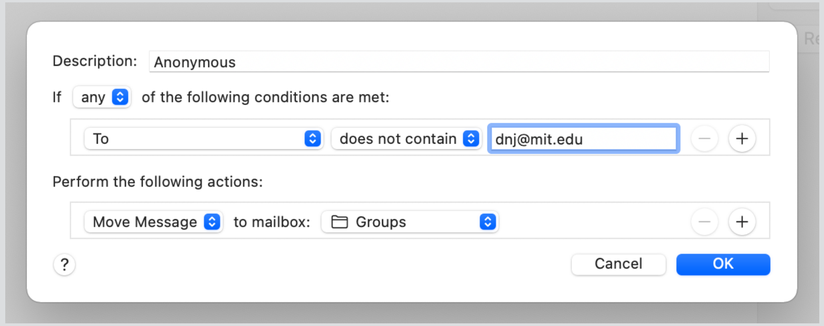
how many ways to filter messages?



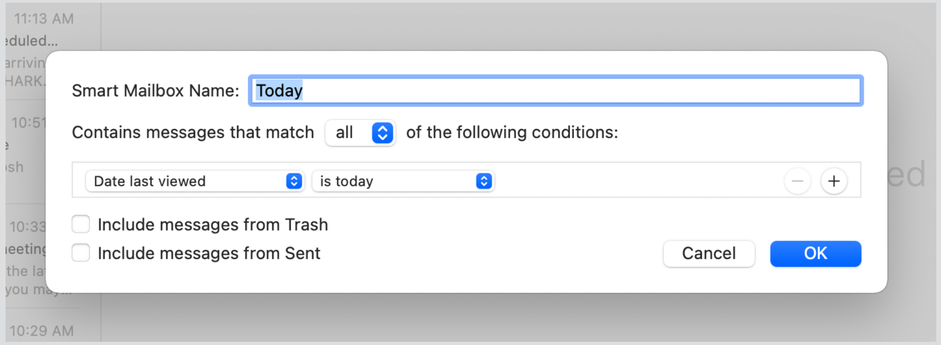
search for a message



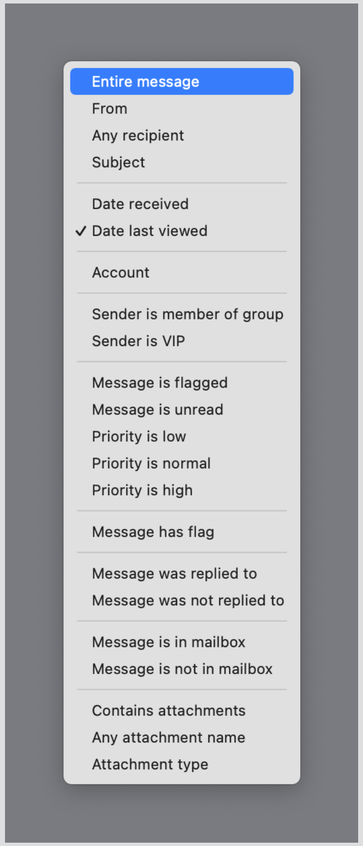
search options



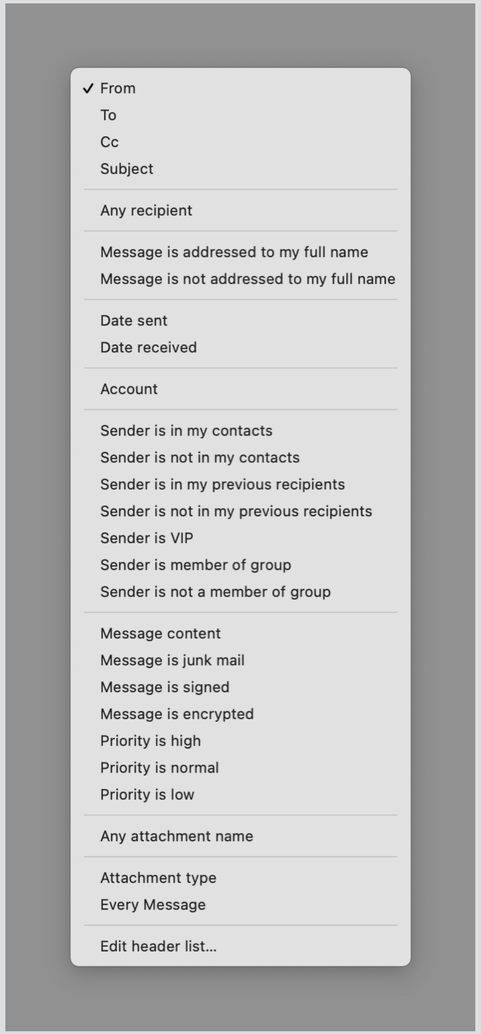
create a rule



define a smart folder



smart folder options

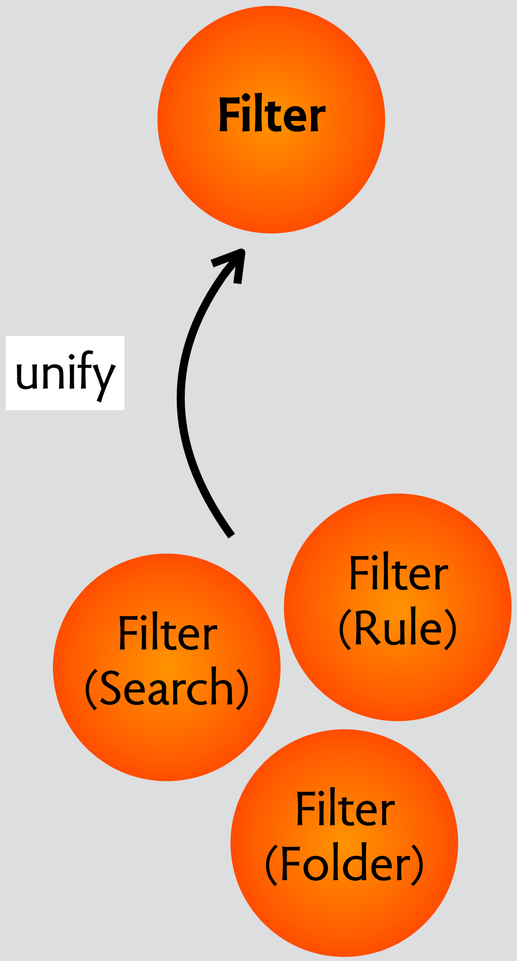


rule options

diagnosis?

search, rule and smart folder
all include their own specialized concepts
incomparable features, different UIs

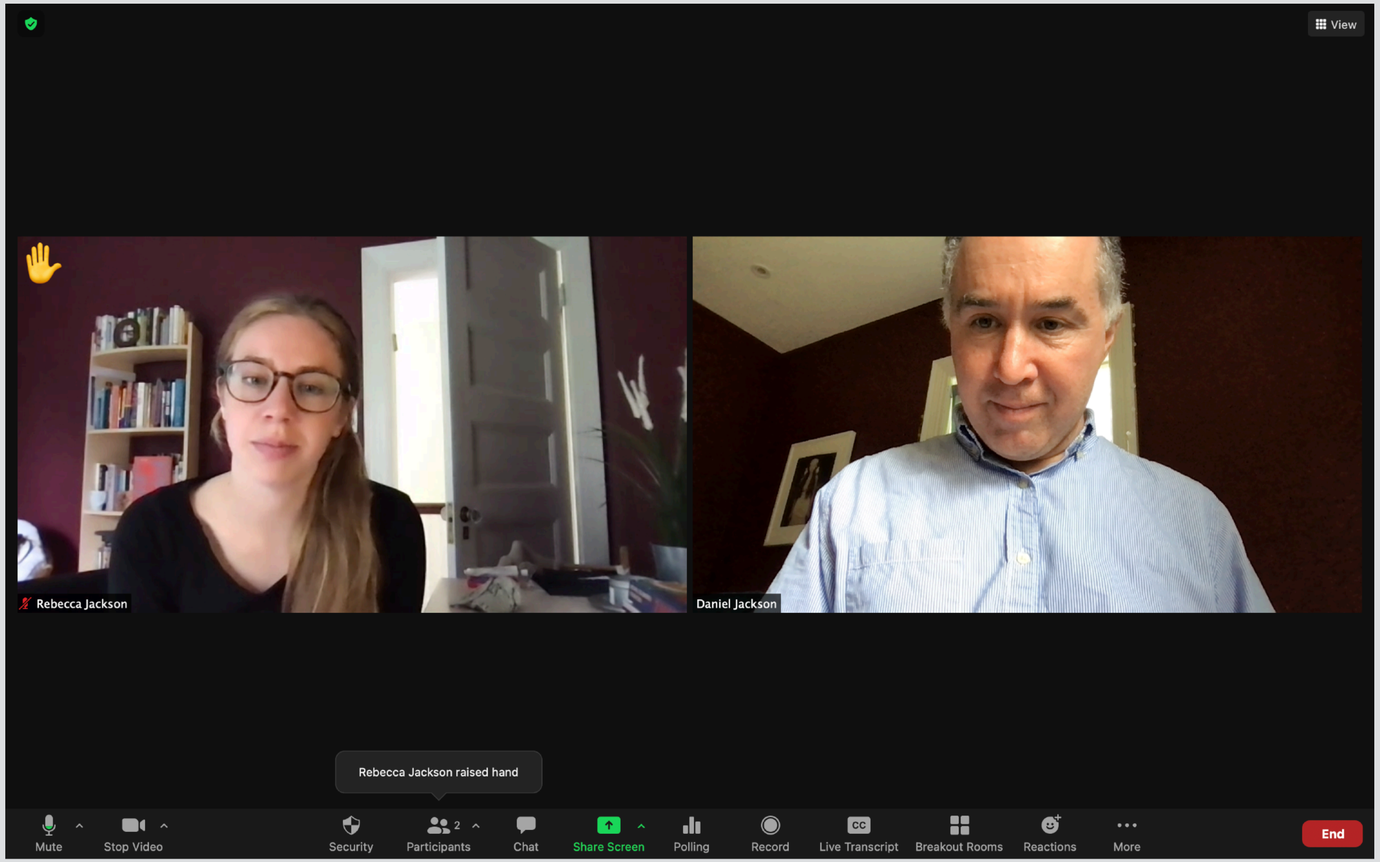
unify in a single message filter concept
include “create folder from search”, eg

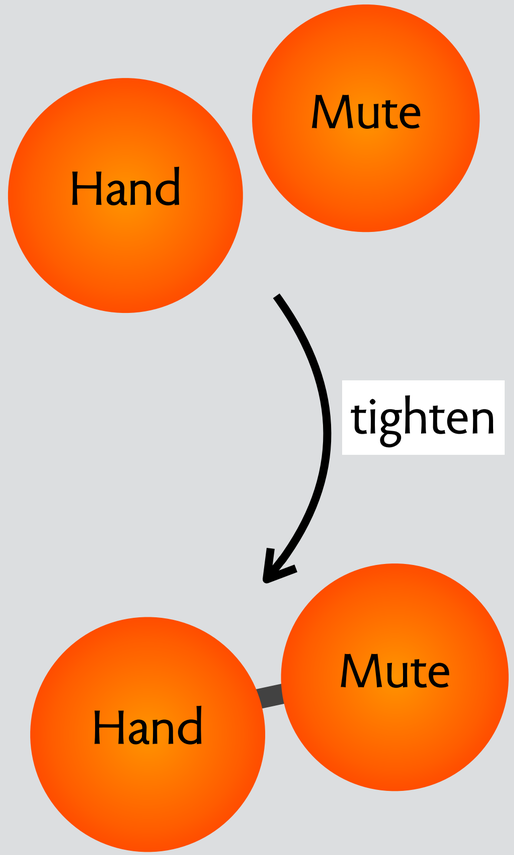


sticky hands

in zoom

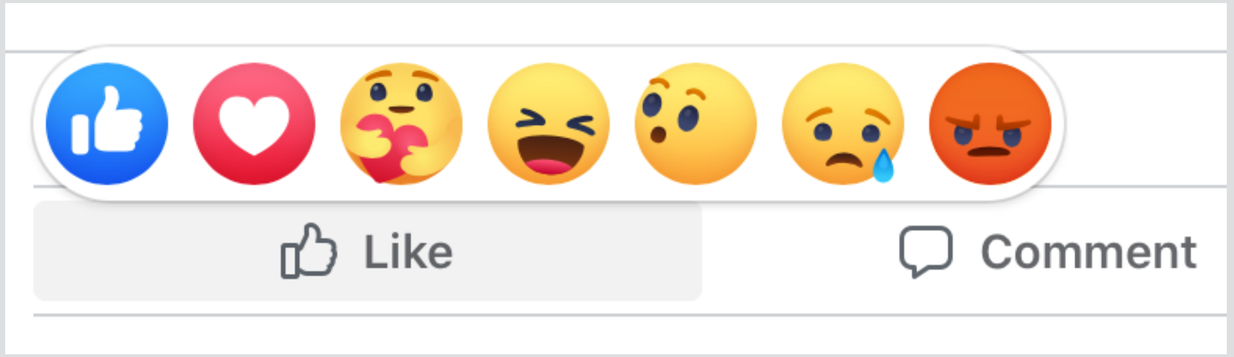
zoom


View
Rebecca Jackson
Daniel Jackson
Rebecca Jackson raised hand
Mute
Stop Video
Security
Participants
2
Chat
Share Screen
Polling
Record
Live Transcript
Breakout Rooms
Reactions
More
End


Mute
Hand
tighten
Mute
Hand

likes
in facebook

are angry reactions upvotes?



concept Upvote

purpose rank items by popularity

actions

upvote (u: User, i: Item)

...

concept Reaction

purpose convey emotion to author

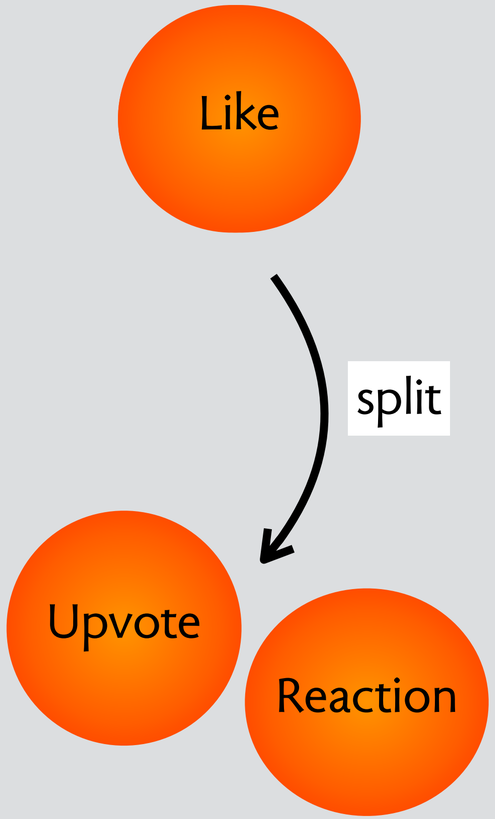
actions

reactAngry (u: User, i: Item)

...

unwanted sync?

a facebook split



event deletion
in google calendar

AS

Arvind Satyanarayan November 15, 2018 at 2:04 PM

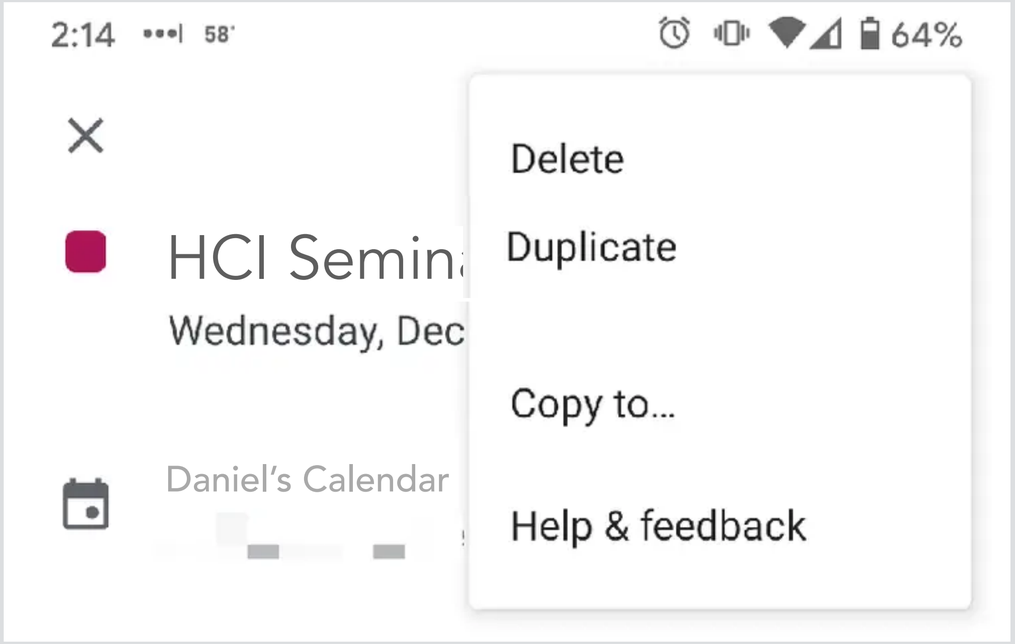
Re: TALK: Monday 11-19-2018 Kanit (Ham) Wongsuphasawat: No...

Cc: seminars@csail.mit.edu, HCI-Seminar@lists.csail.mit.edu

Details

This message is from a mailing list. Unsubscribe

Despite some erroneous messages sent to this list accidentally, Kanit's talk is happening! Please join us on Monday.



Canceling and deleting events in the Google Calendar mobile app is similar to on a desktop.

1. First, open Google Calendar.
2. Tap on the event you wish to cancel.
3. Press on the three dots in the top right corner of the event window.
4. Select Delete.
5. Tap Delete event. Google Calendar will send a cancellation email to the guests.

Mar 22, 2021

https://wpamelia.com › Blog

How to Cancel an Event in Google Calendar - Amelia booking ...

seminar announced as **email** to listserv with attached calendar event

↓

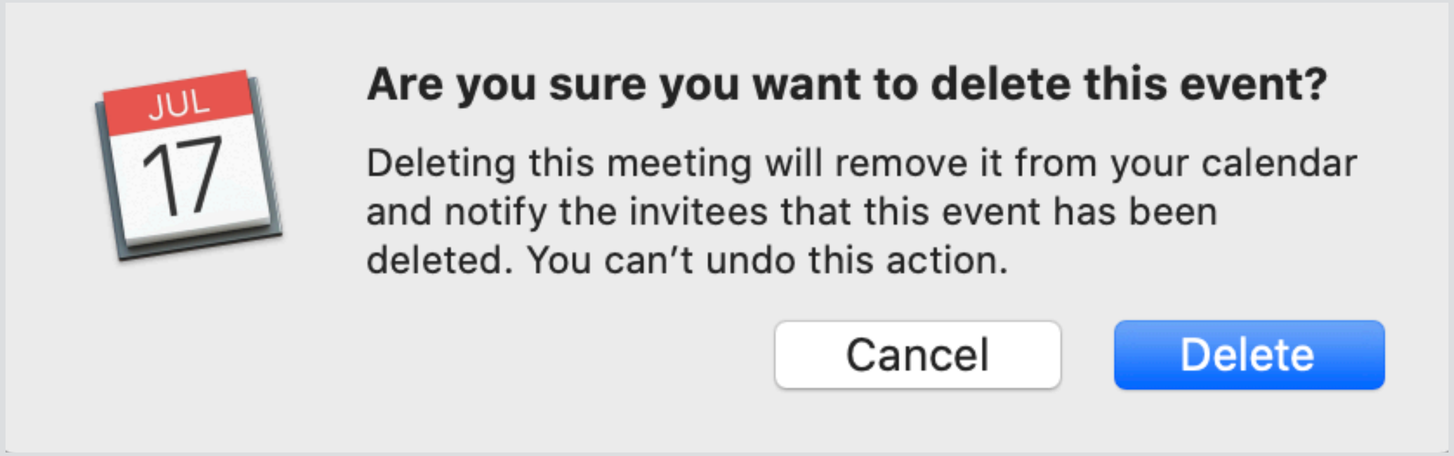
event **installed** automatically in user's calendar

↓

user **deletes** event from calendar

↓

cancellation email automatically sent to other invitees



a long time problem in iCal too

how to delete spam calendar events?

diagnosis?

concept calendar

purpose record engagements

actions

createEvent (…): Event

deleteEvent (e: Event)

…

concept invitation

purpose coordinate events

actions

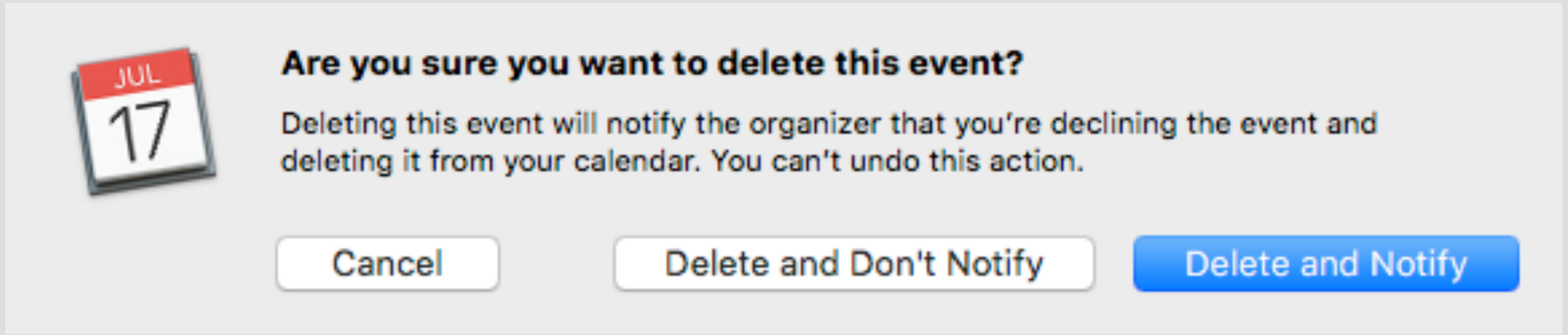
accept (e: Event)

decline (e: Event)

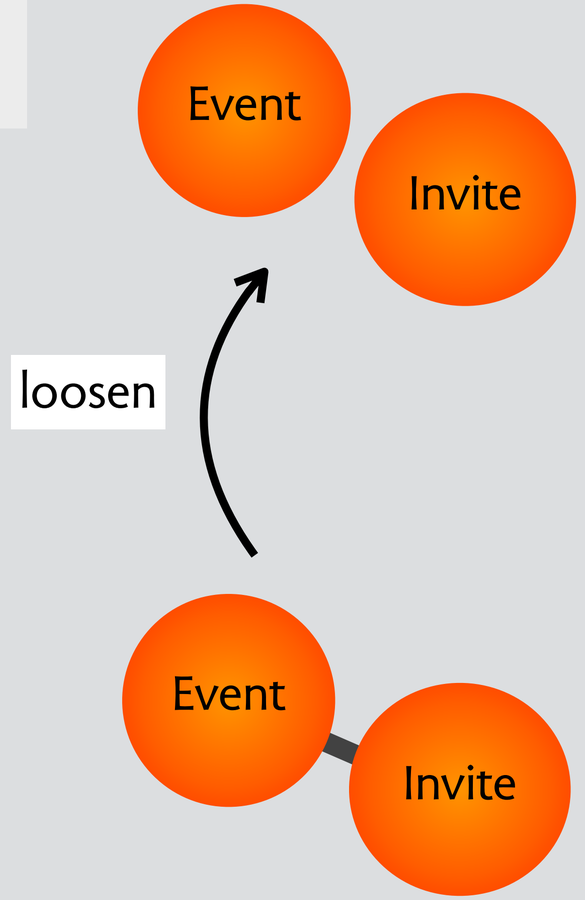
…

unwanted sync!

apple's solution



resolution to design problem
make sync optional



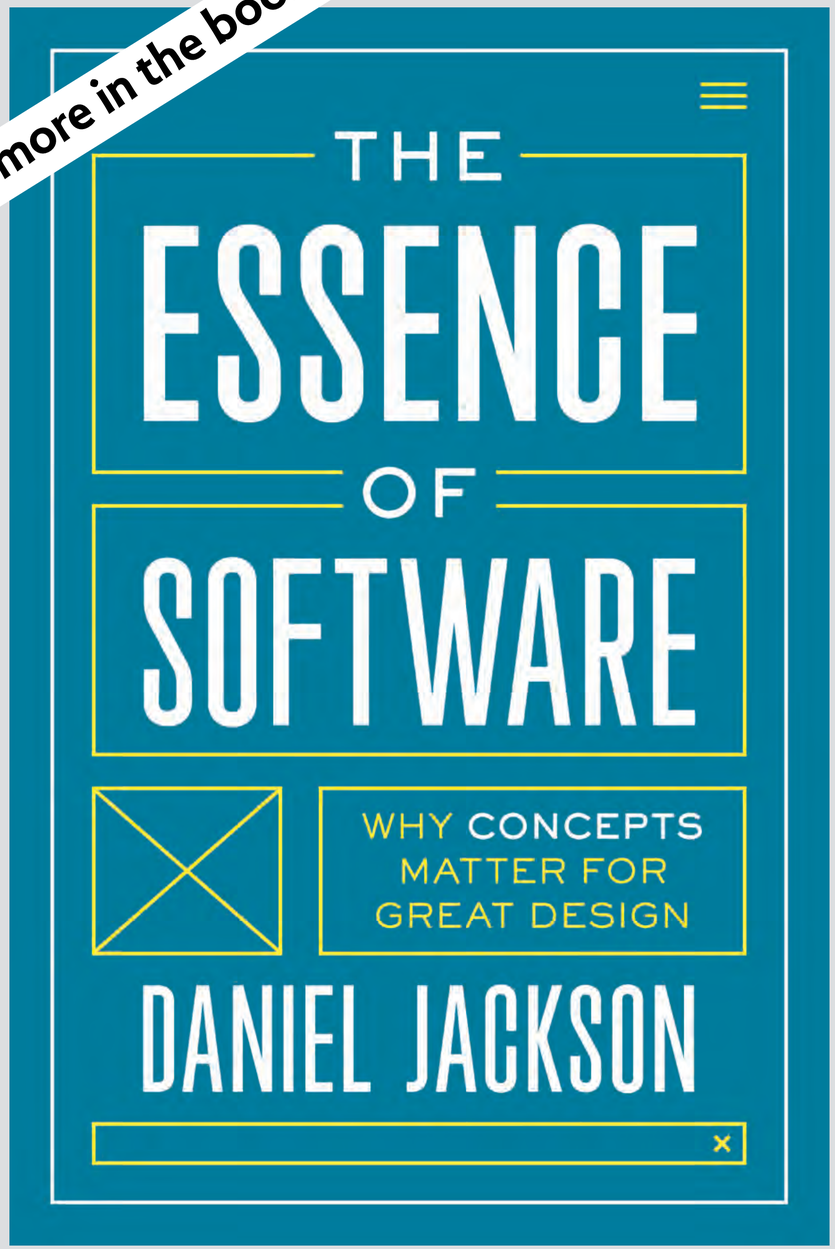
takeaways

structure your software design with concepts
inventory the concepts, identify the critical ones
see if you can describe them fully independently
then formulate interactions as synchronizations

apply design moves to explore new options
never a panacea, always a tradeoff

software concepts as patterns
only hinted at this, but equally important
don't reinvent the wheel!
express your design as sync of familiar concepts?

much more in the book



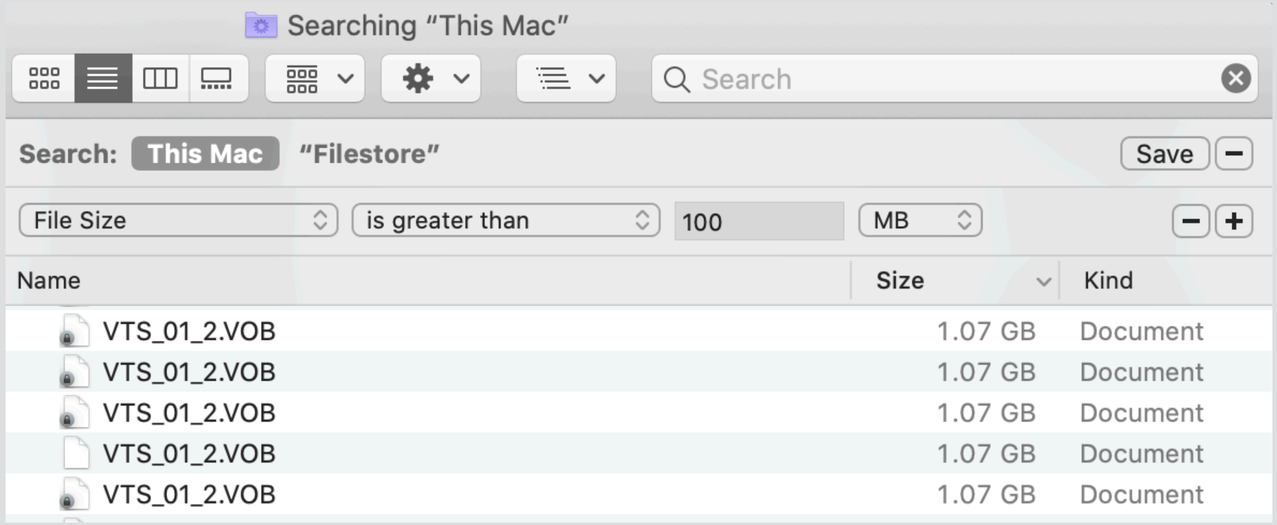
essenceofsoftware.com

newsletter
essenceofsoftware.com/subscribe

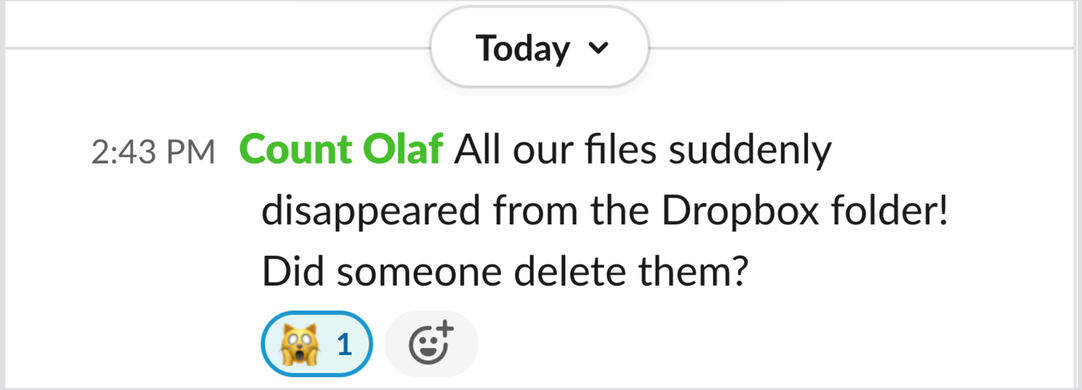
join the discussion
about concept design!
forum.softwareconcepts.io

unused
slides

Dropbox
& the case of the disappearing files



making space: list big files and delete the ones you don’t recognize



very unhappy colleagues

Quora

Search

Dropbox: Edit

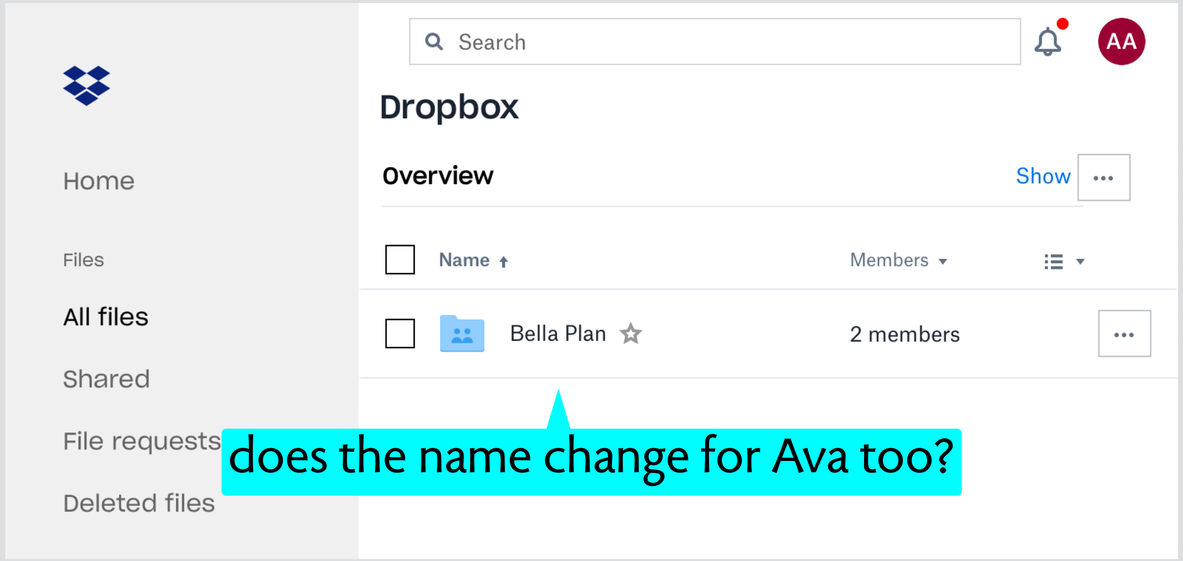
Someone accidentally deleted thousands of files in my company Dropbox: how can I quickly undelete them? Edit

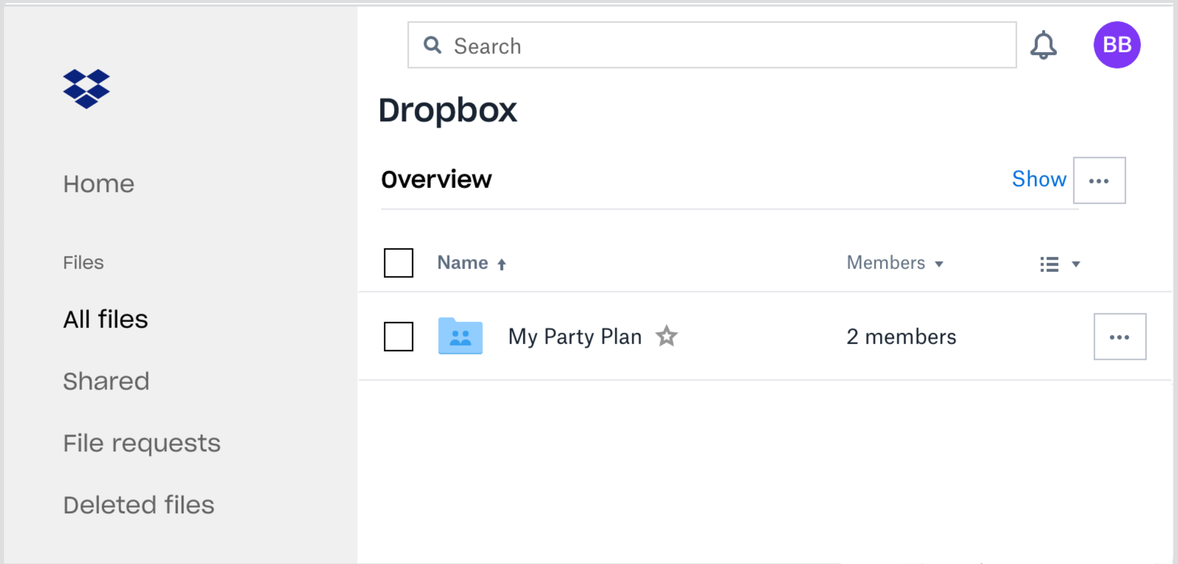
Add Question Details

Comment · Share · Report · Options

Ava is a party planner

Bella is having a party

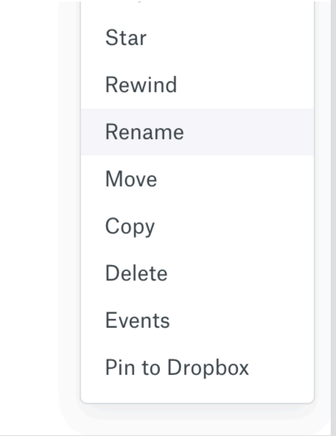




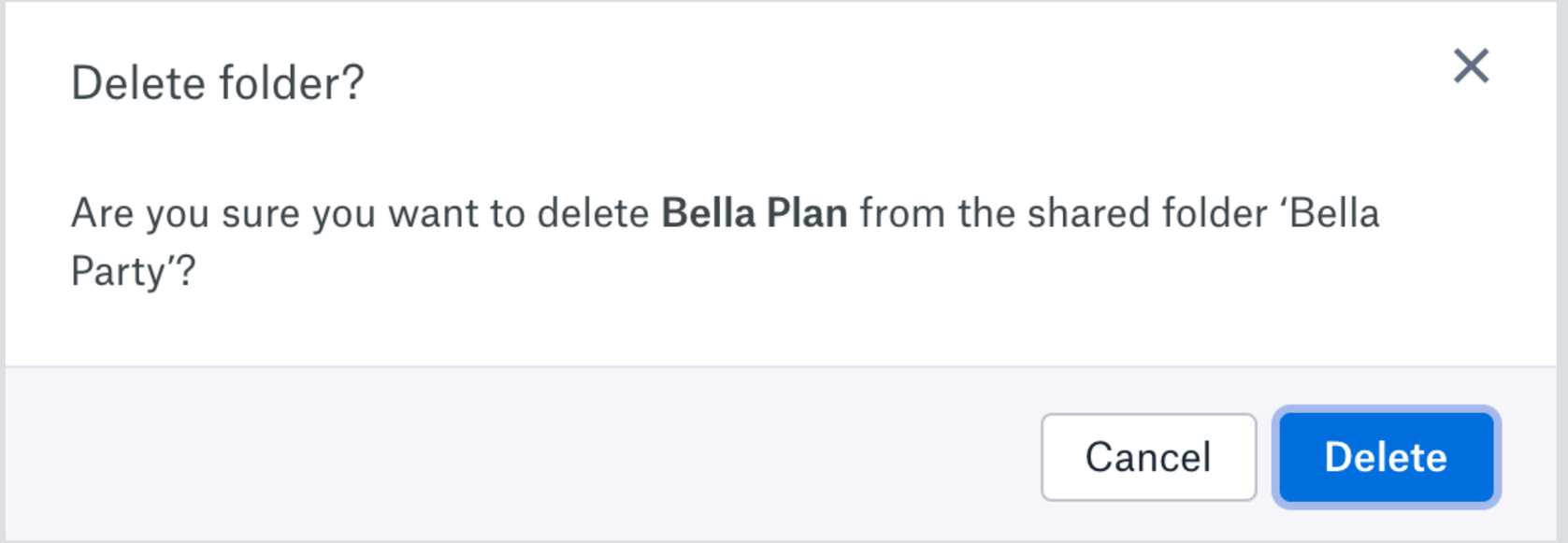
answer: it depends

if Ava just shares Bella Plan with Bella
and Bella renamed the folder, Ava sees no change

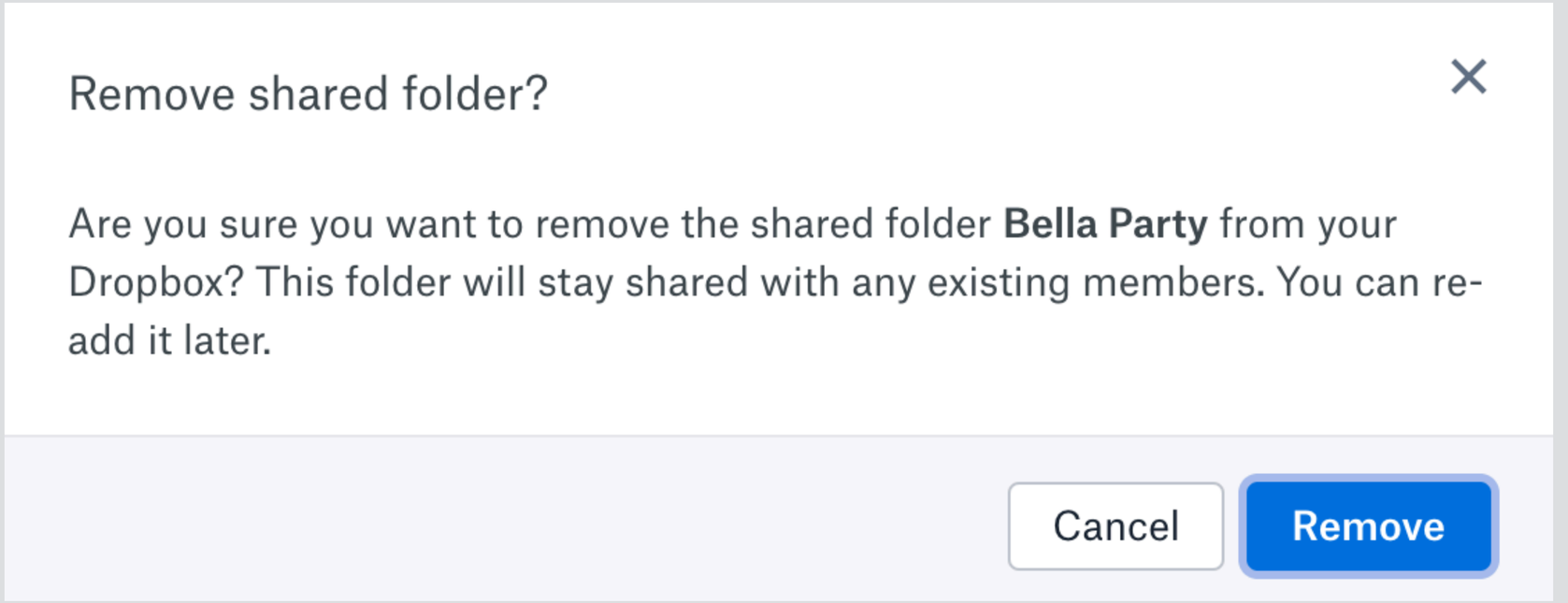
if Ava shared a folder containing Bella Plan
then Ava <u>does</u> see the change



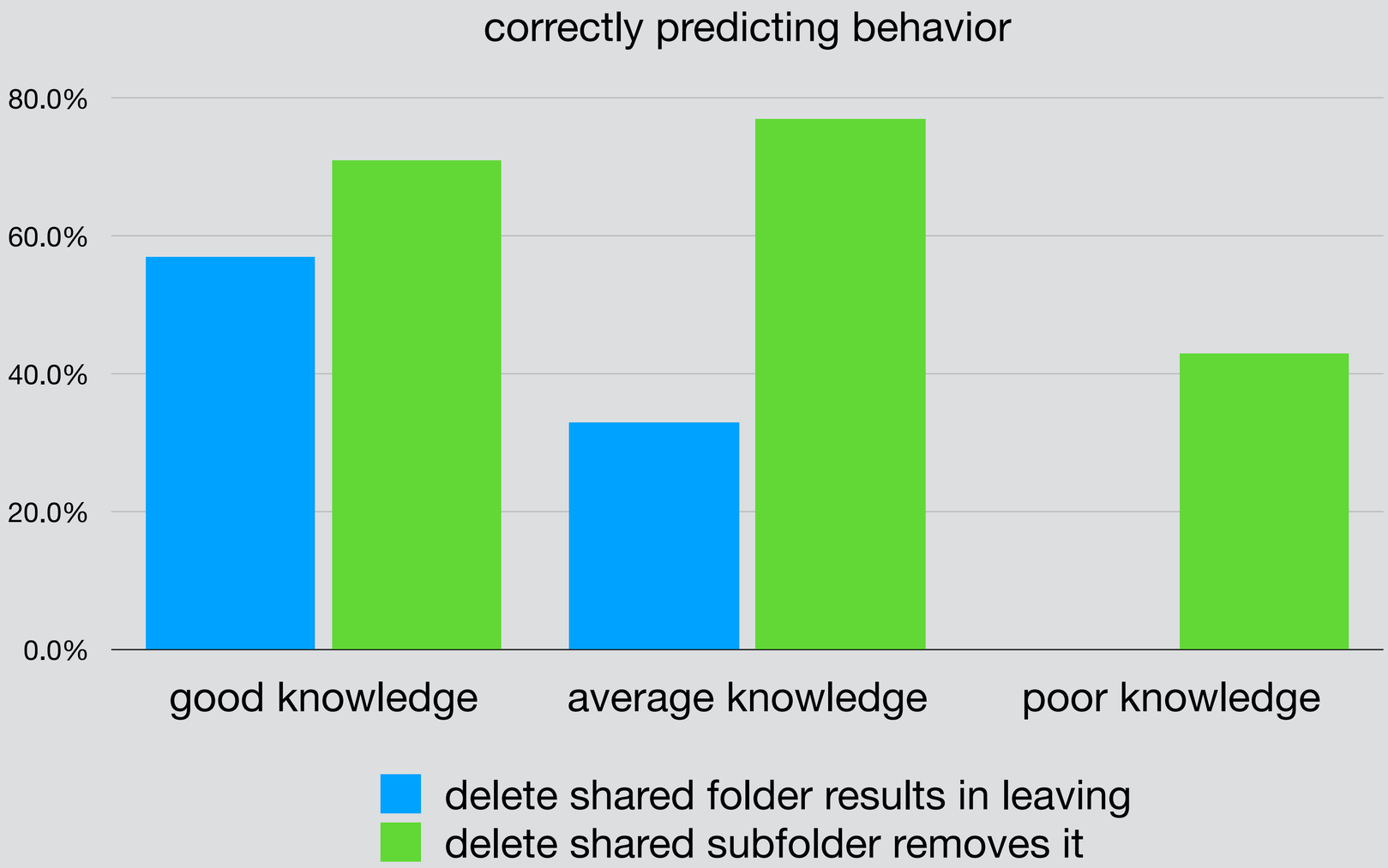
Bella deletes Bella Plan from shared folder Bella Party



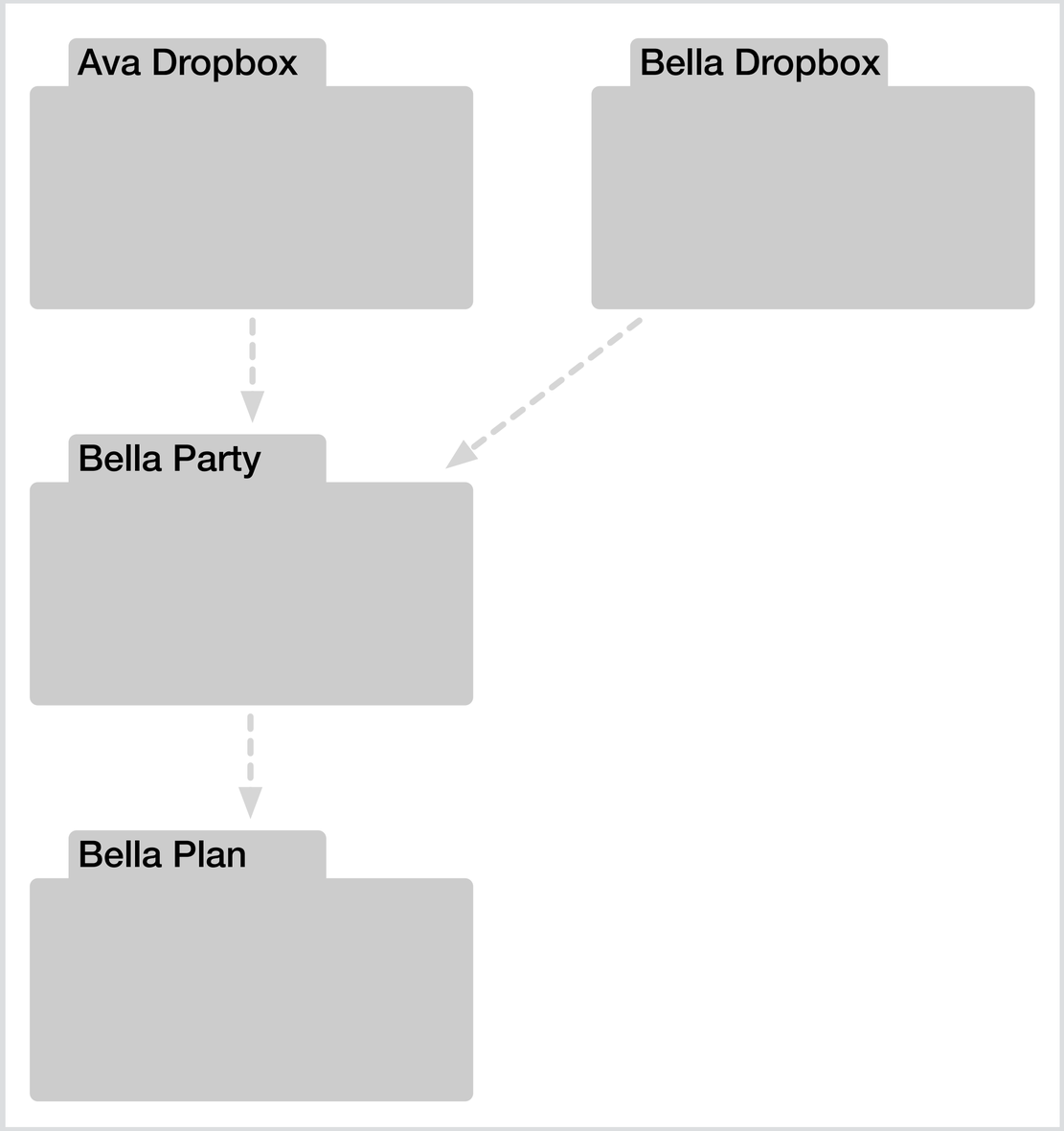
Bella deletes shared folder Bella Party



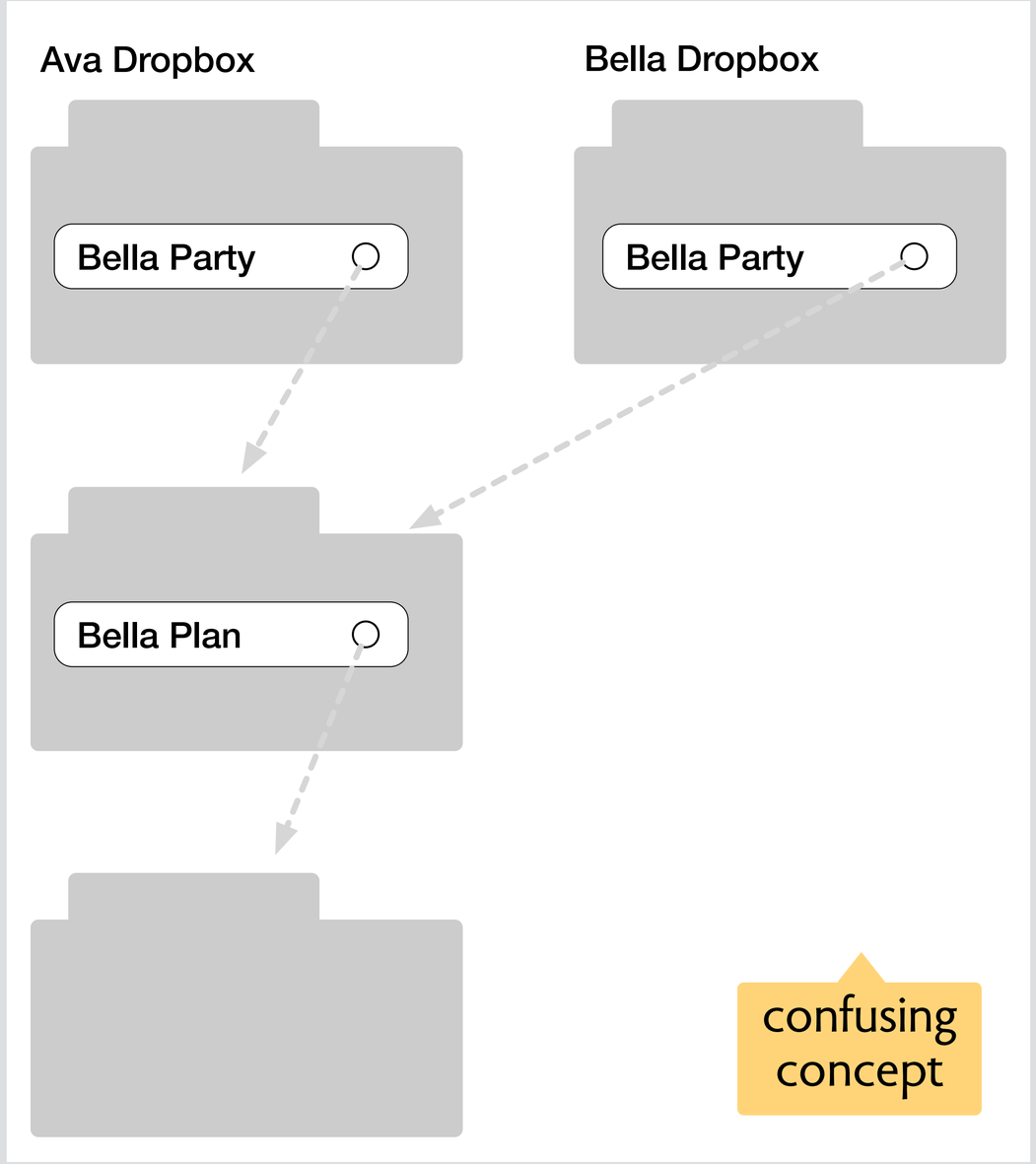
survey of dropbox users (MIT CS undergrads)



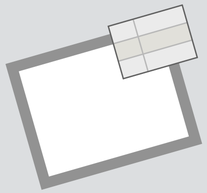
Kelly Zhang



how many users believe Dropbox is structured



how Dropbox is actually structured



concept metadata

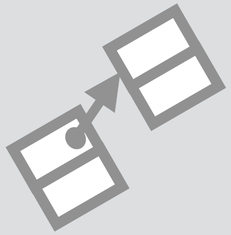
purpose tag items with properties for lookup

state

properties: Item -> set Property

key: Property -> one Key

val: Property -> one Val



concept unix directory

purpose organize items into overlapping categories

state

entries: Dir -> set Entry

name: Entry -> one Name

item: Entry -> one (File + Dir)

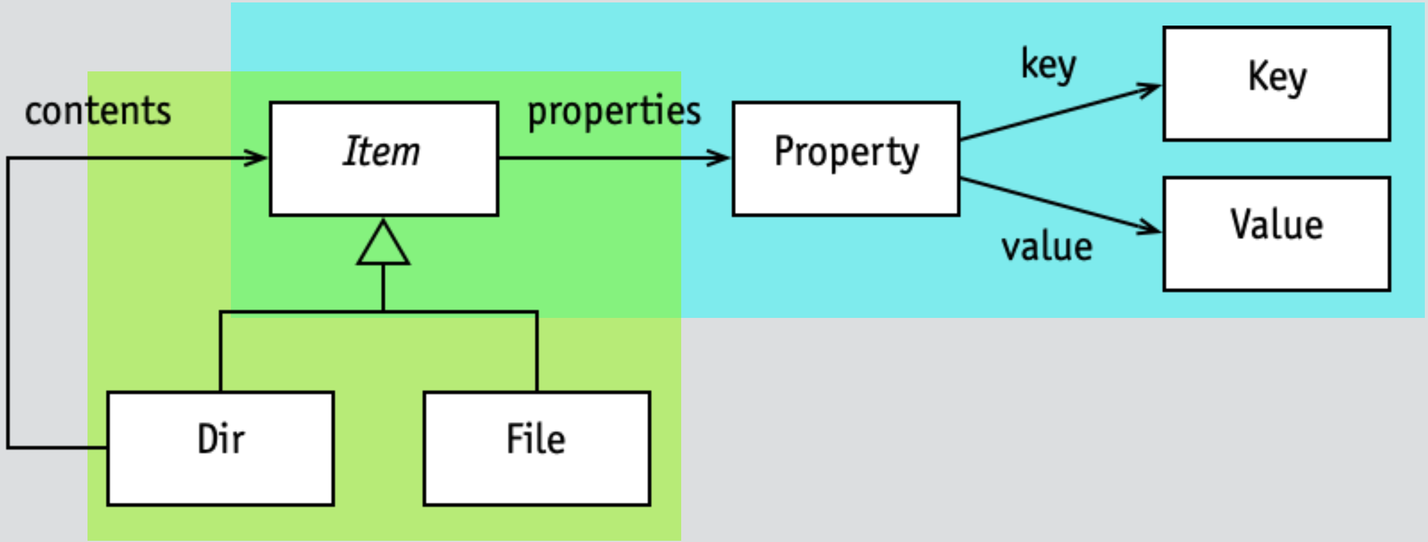
concept folder

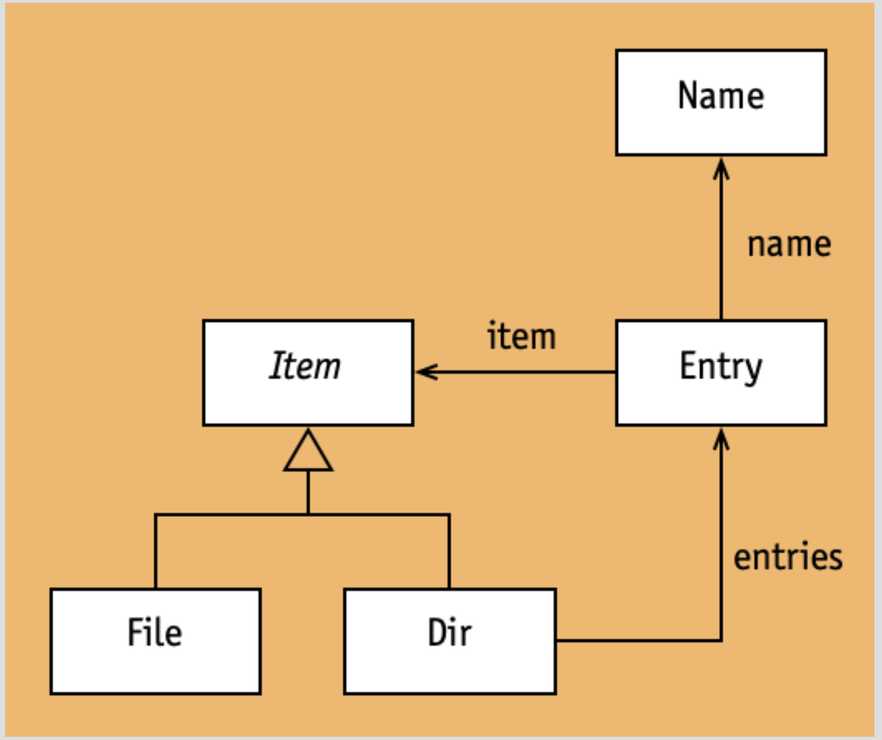
purpose organize items into disjoint categories

state

contents: Folder -> set (Folder + Item)

root: one Folder





Twitter
& the case of the surprised first lady

Andy Ostroy
@AndyOstroy

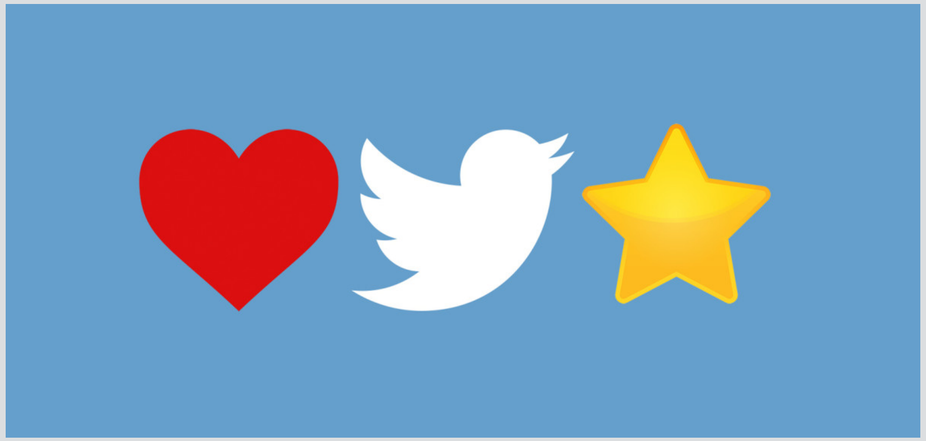
Seems the only #Wall @realDonaldTrump's built is the one between him and @FLOTUS #Melania #trump

8,221 8:15 PM - May 2, 2017

4,022 people are talking about this

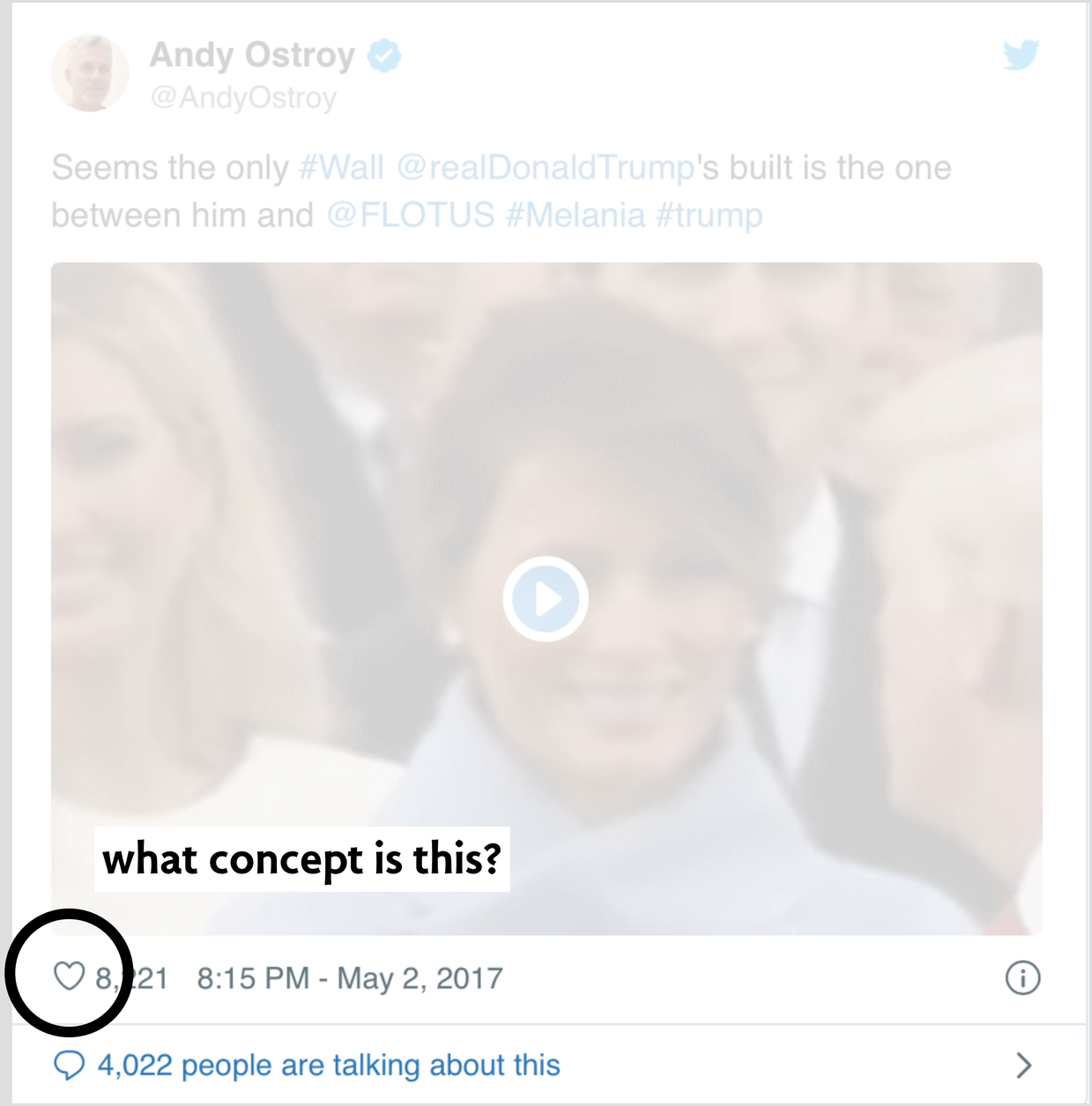
MELANIA TRUMP liked your Tweet

Seems the only #Wall @realDonaldTrump's built is the one between him and @FLOTUS #Melania #trump pic.twitter.com/XiNd2jiLUF



Nov 2, 2015: Twitter changes Favorite (Star) to Like (Heart)

We are changing our star icon for favorites to a heart and we'll be calling them likes... **We know that at times the star could be confusing, especially to newcomers**. You might like a lot of things, but not everything can be your favorite. *Twitter press release*



concept Upvote
purpose rank items by popularity

?

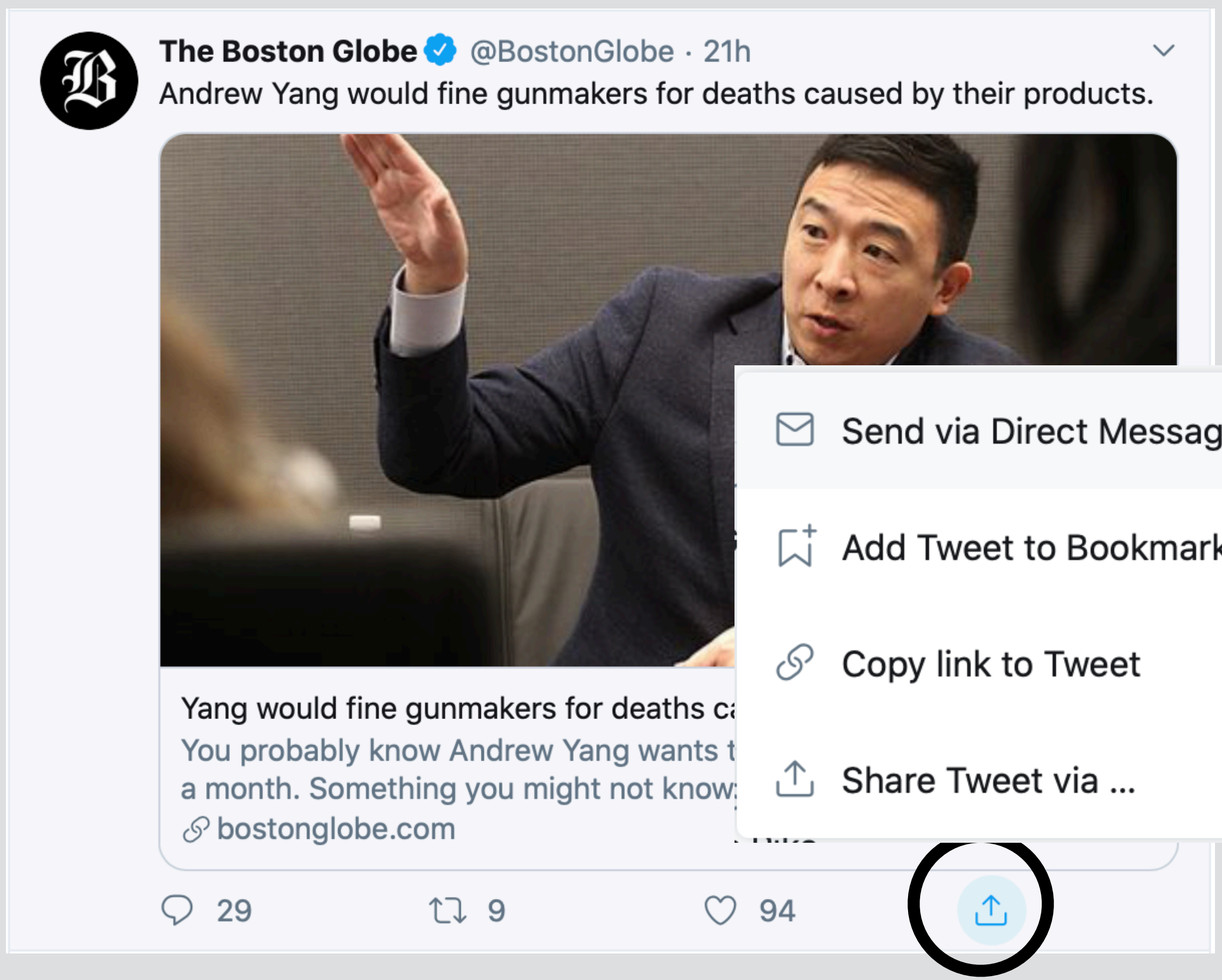
concept Bookmark
purpose save items to revisit

missing concept!

twitter adds a new concept (2018)

concept Upvote

purpose rank items by popularity



concept Bookmark

purpose save items to revisit

a new path
inspired by old ideas

user's model

designer's model

user interprets interface

interface designer conveys design

programmer implements design

user's model

psychology

interface design

designer's model

software engineering

user's model

classic usability research

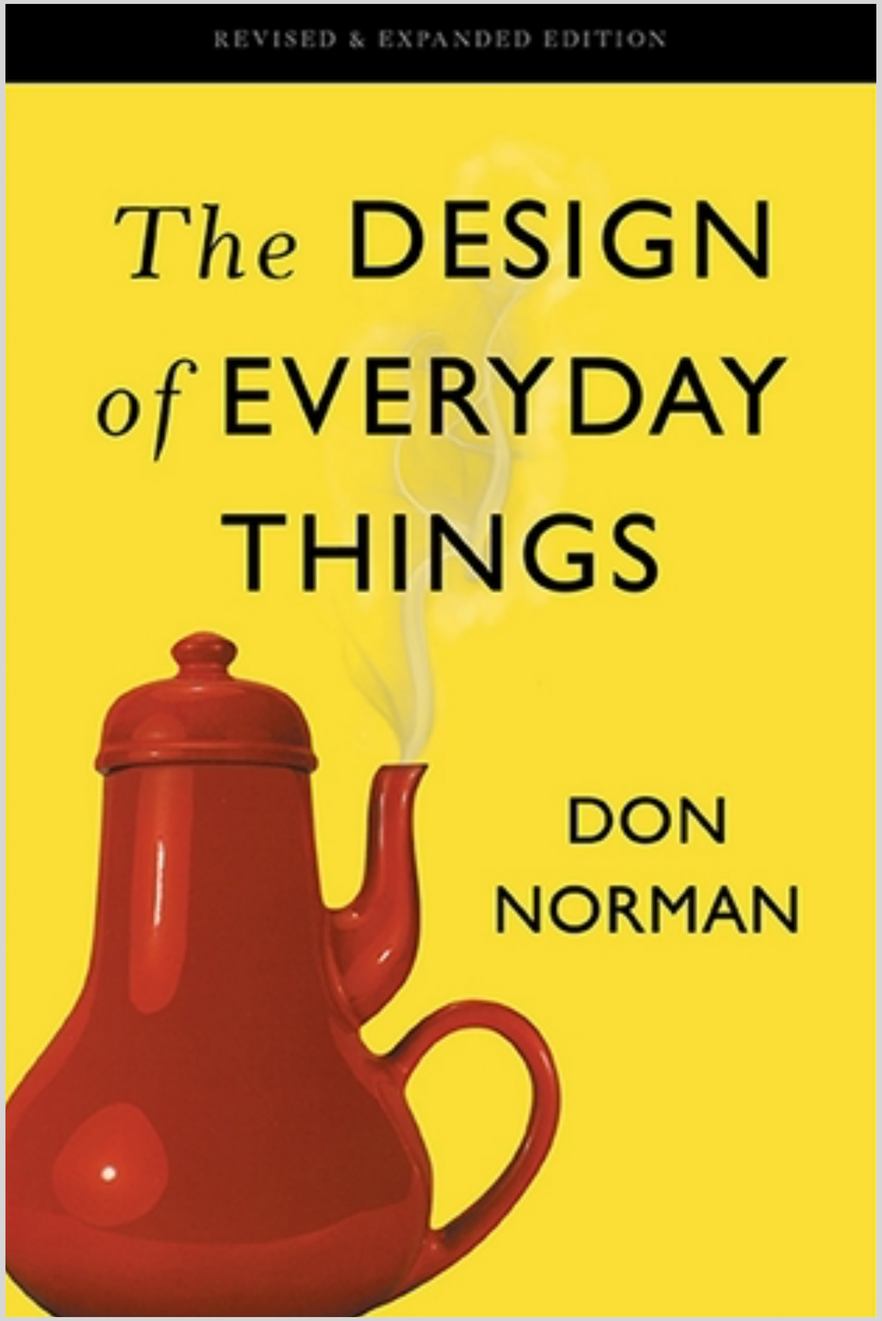
designer's model

user's model

go this way instead?

designer's model

but what if the system just does the wrong thing?



focus on faithful projection of design model
mapping, affordance/signifiers, gulfs

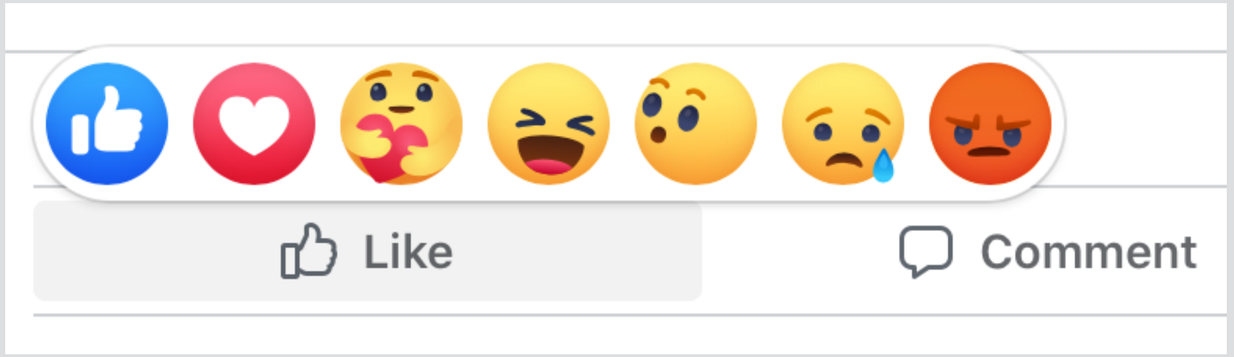
theory turned into practice through heuristics
8 Golden Rules (Shneiderman)
First Principles of Interaction Design (Tognazzini)
10 Usability Heuristics (Nielsen)

result: huge improvements in usability
anyone can design a great UI

If a simple model is not explicitly or implicitly provided, users formulate their own myths about how the system works... The system has to be designed with an **explicit conceptual model** that is easy enough for the user to learn.

Stuart Card & Thomas Moran (1986)

should facebook concepts be desynchronized too?



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concept Reaction
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reactAngry (u: User, i: Item)
...