towards a theory of conceptual design for software

Daniel Jackson · MIT

Onward, SPLASH · Pittsburgh · October 29, 2015
three software design problems
#1 email categories
<table>
<thead>
<tr>
<th>Primary</th>
<th>Social</th>
<th>Promotions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Google</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New sign-in from Chrome on Mac - New sign-in from Cr</td>
<td>12:30 pm</td>
<td></td>
</tr>
<tr>
<td>Keith Muhammad at DeMont.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DeMontrond Auto Group - 14101 North Freeway Housto</td>
<td>12:19 pm</td>
<td></td>
</tr>
<tr>
<td>AT&amp;T High Speed Internet.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT&amp;T High Speed Internet Service Activation - Your A1</td>
<td>10:37 am</td>
<td></td>
</tr>
<tr>
<td>Keith Muhammad at DeMont.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DeMontrond Auto Group - 14101 North Freeway Housto</td>
<td>Aug 26</td>
<td></td>
</tr>
<tr>
<td>betterbatonrougejobs.com</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Job Update -- 2015-08-26 - Looking For An Advantage W</td>
<td>Aug 26</td>
<td></td>
</tr>
</tbody>
</table>
category tab settings

Choose which message categories to show as inbox tabs. Other messages will appear in the Primary tab.
Like many Gmail users, I greeted the news of the introduction of tabs to the interface with a degree of anticipation -- now it was just a matter of waiting for the feature to roll out so I could try it for myself. Earlier today I was randomly signed out of my Gmail account, and after signing back in and checking the settings menus, I could see that tabs were now available to me. Excitement was short-lived, however; it quickly became apparent that this new feature is a disaster.
Why the Tabs Are So Confusing

The tabs do give you a convenient way to automatically sort your inbox according to Gmail's preset categories and get notifications at a glance for when new emails come in. However, the tabbed view introduces a new, not-so-clear element in Gmail called "categories."

The problem is, you already have labels that also match these categories. Gmail, for example, adds Social Updates, Promotions, and Forums as SmartLabels in the left menu. The "Notifications" SmartLabel corresponds to the Updates tab (I wonder why they didn't just call the tab Notifications), but **SmartLabels are not the same as Categories**. Gmail's pre-designed SmartLabel filters makes it seem like that, but they're really two different things.
Using labels

Labels help you organize your messages into categories – work, family, to do, read later, jokes, recipes, any category you want. Labels do all the work that folders do, but with an added bonus: you can add more than one to a message.
what you can’t do

associate tabs with labels
feature available only for categories

use tabs outside inbox
tabs disappear when you filter on a label
#2 camera settings
my camera fuji x100s
image quality setting
aspect ratio
image size setting
non-standard ratio + raw?
what you can’t do

non-standard aspect ratio + raw
even though raw images get nice nondestructive crop!
#3

texts & styles
what’s a font?
what you can’t do

define a style that italicizes
   Arno Regular to Arno Italic
   Futura Book to Futura Book Oblique
   Magma Light to Magma Light Italic
what kind of problems are these?

manifestations
constrained functionality
confusion & complexity

coding errors?
no, code seems to meet the spec

user interface design errors?
no, interfaces are clear and faithful to function
these are conceptual flaws

image size: a confusing concept

subfamily: a missing concept

categories: a redundant concept
what’s an app about?
what characterizes an app?

cancepts!

Apple Mail:
- Email Address
- Message
- Folder or Label

Microsoft Word:
- Paragraph
- Format
- Style

Twitter:
- Tweet
- Hashtag
- Following

Photoshop:
- PixelMap
- Layer/Mask
- Adjustment
concepts define classes

text editor
- line
- buffer

word processor
- paragraph
- format
- style

desktop publishing app
- stylesheet
- text flow
- page template

Just upgraded to the new Pages and can't find a way to link text boxes anymore like
http://www.macobserver.com/tmo/article/pages-linking-text-boxes
Am I missing something, or is it really not possible anymore?
where are Word’s concepts from?

Charles Simonyi: brought key concepts to Word from Xerox PARC
rich concepts have long journeys

Ginn & Co, since 1868

Apple Pages, 2005

Microsoft Word, 1983

Bravo, 1974
so what exactly is a concept?
a timer
a non-conceptual description

a precise semantics but no real meaning
a conceptual explanation

**purpose**
using this timer, you can program a light to be on at certain times each day

**data model**
the day's divided into time slots there's a set of slots called the **schedule** and a current time slot

**operational principle**
if you put a slot in the schedule, then when the time is in that current slot, the light will be on

**user interface**
each tab is a time slot the current time is where the arrow points

the concept!
the operational principle
a way to define & explain a concept

an archetypal scenario
separates essential from accidental aspects
shows how purpose is fulfilled
by combination of user & system actions

“if you pull a tab out, then when that time slot comes around, the light will go on”

Michael Polanyi
“if you change a style’s format, then all paragraphs of that style will change format accordingly”

“if you tag a photo, then all friends of the person tagged will be able to see the photo”

“if you select some files and they belong to a folder with keyboard focus, then pressing delete will move the files to the trash”
designing on purpose
design is driven by purpose

- purpose
- motivates
- fulfills?
- contrivance
- misfit
- not a counterexample
example: a photo wall

changeable wall display of prints

motivates

fulfills?

adhesive corners
not strong enough

not

not

not

not

not

not

corkboard tiles
damages prints

corkboard tiles
damages prints

corkboard tiles
damages prints

magnetic paint

magnetic paint

magnetic paint

magnetic paint

magnetic paint

magnetic paint

magnetic paint

✔
as implemented
refining the purpose with misfits

- adhesive corners
- corkboard tiles
- magnetic paint

- anticipated misfits
- unanticipated misfits

- strong enough
- no damage

motivates

fulfills?

changeable wall display of prints
Such a list of requirements is potentially endless... But if we think of the requirements from a negative point of view, as potential misfits, there is a simple way of picking a finite set.
concepts driven by purposes too

application purpose

purpose

purpose

purpose

motivates

fulfills?

motivates

fulfills?

motivates

fulfills?

concept

concept

concept

application
example: microsoft word

create & format documents

consistency within docs

provide structure

consistency across docs

motivates

motivates

motivates

style

paragraph

stylesheet

microsoft word
purposes, principles & misfits

**concept:** trash

**purpose:** allow undo of deletions

**operational principle:** if you delete a file, it moves to a special folder; you can restore from there, but emptying it removes contents for good

**misfit:** if you delete a file on an external drive, you cannot reclaim the space until you empty the trash, but then you’ll lose the ability to restore files deleted from the main drive

**misfit:** if you delete an old file and change your mind, you may not be able to find it again in the trash (if there are many deleted files and you forgot the file’s name)
the fundamental principle

in a well-designed system
each concept is motivated by one purpose
analyzing concepts
the ideal mapping

purposes

P1 \rightarrow C1

P2 \rightarrow C2

concepts
4 bad smells

- Unfulfilled purpose
  - P1 → C1

- Unmotivated concept
  - P1 → C1
  - P2

- Overloaded concept
  - P1 → C1

- Redundant concepts
  - P1 → C1
  - P2
  - C2
unfulfilled purposes

C1
user (Apple Mail, Gmail)
‘identify parties to communication’
weak search, no authentication

slide hierarchy (Powerpoint)
‘structure slides in a tree’
sections provide just one level

aspect ratio (Sony A7Rii, Canon 5D3)
‘take square image’
can’t view in finder or save setting

C2
binder (Preview, Acrobat)
‘maintain composite PDF doc’
can insert pages, but forgets source
unfulfilled purpose Apple Mail
unmotivated concepts

- **buffer** (emacs)
  - no reason not to save to file

- **stash** (Git)
  - addresses branching misfits

- **staging area** (Git)
  - what's it for?

- **boxing** (Java)
  - addresses primitives vs objects misfit
<table>
<thead>
<tr>
<th>Concept</th>
<th>Application</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>rating stars</strong></td>
<td>Lightroom</td>
<td>colors, flags, stars, oh my!</td>
</tr>
<tr>
<td><strong>rules &amp; searches</strong></td>
<td>Apple Mail</td>
<td>two ways to specify set of messages</td>
</tr>
<tr>
<td><strong>labels &amp; categories</strong></td>
<td>Gmail</td>
<td>two ways to classify messages</td>
</tr>
<tr>
<td><strong>text object &amp; text box</strong></td>
<td>Acrobat 10</td>
<td>document text too: all different</td>
</tr>
<tr>
<td><strong>permissions</strong></td>
<td>AFS</td>
<td>coexist with Unix permissions</td>
</tr>
<tr>
<td><strong>headline, title, caption</strong></td>
<td>IPTC</td>
<td>original purposes lost</td>
</tr>
</tbody>
</table>
redundant concepts apple mail
No one can serve two masters. Either you will hate the one and love the other, or you will be devoted to the one and despise the other. [Matthew 6:24]
overloaded concepts

- conference review
- feedback vs. selection
- call forwarding
- follow-me vs. delegate
- contact (Apple address book)
- shortcut vs. format addressee
- friends (Facebook)
- filter posts vs. limit access
- signature (Acrobat 9)
- digital vs. physical
- paper size (Epson printer driver)
- dimensions vs. source
overloaded concepts epson driver

result: can’t create custom size for front loading
also, page size presets in Lightroom hold feed setting
case studies
Gitless: a reworking of git

Gitless: a version control system

About Gitless

Gitless is an experimental version control system built on top of Git. Many people complain that Git is hard to use. We think the problem lies deeper than the user interface, in the concepts underlying Git. Gitless is an experiment to see what happens if you put a simple veneer on an app that changes the underlying concepts. Because Gitless is implemented on top of Git (could be considered what Git pros call a "porcelain" of Git), you can always fall back on Git. And of course your coworkers you share a repo with need never know that you're not a Git aficionado.

Check out the documentation to get started. If you are a novice user that never used any version control system the documentation should be enough to get you started. If you are a Git pro looking to see what's different from your beloved Git you'll be able to spot the differences by glancing through the Gitless vs. Git section.

Download

- Mac OS X Binary (.tar.gz)
- Linux Binary (.tar.gz)
- Source Code (.tar.gz)

For installation instructions see the readme file. After installation, you should be able to execute the gl command. The current Gitless version is 0.7 which was released on 4/2015 (release notes).
I enjoyed using Gitless

I found Gitless to be easier to learn than Git
I found Gitless to be easier to use than Git
I would continue using Gitless if I could

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Disagree Somewhat</th>
<th>Neutral</th>
<th>Agree Somewhat</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>9%</td>
<td>14%</td>
<td>14%</td>
<td>27%</td>
<td>27%</td>
<td>9%</td>
<td>64%</td>
</tr>
<tr>
<td>0%</td>
<td>18%</td>
<td>18%</td>
<td>27%</td>
<td>18%</td>
<td>18%</td>
<td>64%</td>
</tr>
<tr>
<td>18%</td>
<td>9%</td>
<td>5%</td>
<td>27%</td>
<td>9%</td>
<td>27%</td>
<td>73%</td>
</tr>
<tr>
<td>36%</td>
<td>18%</td>
<td>5%</td>
<td>9%</td>
<td>27%</td>
<td>18%</td>
<td>55%</td>
</tr>
</tbody>
</table>

Results of a user study
small survey of MIT Dropbox users

correctly predicting behavior

- Good knowledge: Dark blue, delete shared folder results in leaving
- Average knowledge: Blue, delete shared subfolder removes it
- Poor knowledge: Green

Kelly Zhang
conclusions
what else is in the paper?

concept dependence graphs

stylesheet

paragraph style

style

format

click style

character style

paragraph

text

concept idioms

<table>
<thead>
<tr>
<th>purpose</th>
<th>concept</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>consistency</td>
<td>achieve consistent formatting of a set of elements</td>
<td></td>
</tr>
<tr>
<td>style</td>
<td>achieve consistent structure and format of composite elements</td>
<td></td>
</tr>
<tr>
<td>master</td>
<td>consistency and time saving</td>
<td></td>
</tr>
<tr>
<td>stencil</td>
<td>use archetypal objects for consistency and time saving</td>
<td></td>
</tr>
<tr>
<td>style buffer</td>
<td>reformat another object like a previous one to save effort</td>
<td></td>
</tr>
<tr>
<td>preset</td>
<td>allow setting of many properties at once</td>
<td></td>
</tr>
<tr>
<td>organization</td>
<td>organize collection of items into a hierarchy</td>
<td></td>
</tr>
<tr>
<td>folder</td>
<td>organize collection of resources by simple path names</td>
<td></td>
</tr>
<tr>
<td>REST</td>
<td>group items so they can be treated as a single item</td>
<td></td>
</tr>
<tr>
<td>group</td>
<td>allow easy inclusion/exclusion of sets of items</td>
<td></td>
</tr>
<tr>
<td>layer</td>
<td>place items in stacking order for precedence</td>
<td></td>
</tr>
<tr>
<td>stack</td>
<td>allow items to be found later</td>
<td></td>
</tr>
<tr>
<td>selection</td>
<td>apply action in aggregate to many items at once</td>
<td></td>
</tr>
<tr>
<td>label</td>
<td>address one or more items with a shorthand name</td>
<td></td>
</tr>
<tr>
<td>alias</td>
<td>allow filtering of set of objects by their features</td>
<td></td>
</tr>
<tr>
<td>filter</td>
<td>describe an object with properties that have values</td>
<td></td>
</tr>
<tr>
<td>property</td>
<td>sort and search for items using associated data</td>
<td></td>
</tr>
<tr>
<td>metadata</td>
<td>keep past actions for audit, undo, visibility</td>
<td></td>
</tr>
<tr>
<td>navigation</td>
<td>provide temporary storage area for quick modification</td>
<td></td>
</tr>
<tr>
<td>buffer</td>
<td>provide shortcut entry into traversable document</td>
<td></td>
</tr>
<tr>
<td>cursor</td>
<td>access token</td>
<td></td>
</tr>
<tr>
<td>history</td>
<td>control access to a resource in an easy way</td>
<td></td>
</tr>
<tr>
<td>access</td>
<td>allocate resources efficiently and prevent conflicts</td>
<td></td>
</tr>
<tr>
<td>reservation</td>
<td>authenticate user with 'out of bound' channel unique to user</td>
<td></td>
</tr>
<tr>
<td>OOBA</td>
<td>communicate in discrete packets between endpoints</td>
<td></td>
</tr>
<tr>
<td>communication</td>
<td>message</td>
<td></td>
</tr>
<tr>
<td>posting</td>
<td>share a short communication by broadcast</td>
<td></td>
</tr>
<tr>
<td>notification</td>
<td>let a user know when something happens</td>
<td></td>
</tr>
<tr>
<td>community</td>
<td>mediate communications by preapproved relationships</td>
<td></td>
</tr>
<tr>
<td>friend</td>
<td>create subcommunity within larger community</td>
<td></td>
</tr>
<tr>
<td>clique</td>
<td>predicate relationship on approval</td>
<td></td>
</tr>
<tr>
<td>invitation</td>
<td>account</td>
<td></td>
</tr>
<tr>
<td>centralize user-specific information</td>
<td>karma</td>
<td></td>
</tr>
<tr>
<td>incentivize users to contribute to an online community</td>
<td>rating</td>
<td></td>
</tr>
<tr>
<td>crowdsource evaluation of items</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
contributions

the idea of concepts
a new-old view of software design

talking about concepts
purpose, misfit, operational principle

analyzing concepts
purpose-concept mapping, esp. overloading
A common view of software design

UI design
soft & human
about presentation

programming
hard & technical
about content
a better view of software design

conceptual design: essential concepts & behavior

representation design: organization & performance