Further HCI

Alan Blackwell and Luke Church

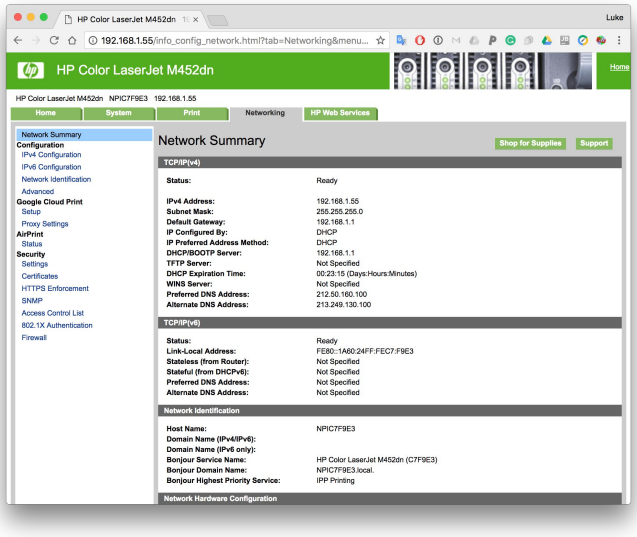
Overview of the course

- **Theory driven approaches to HCI**
- Design of visual displays
- Goal-oriented interaction
- Designing smart systems (guest lecturer)
- Designing efficient systems
- Designing meaningful systems (guest lecturer)
- Evaluating interactive system designs
- Designing complex systems

Lecture 1:
Theory driven approaches to HCI

What is a theory in HCI? Why take a theory driven approach to HCI?

Why theory in HCI?



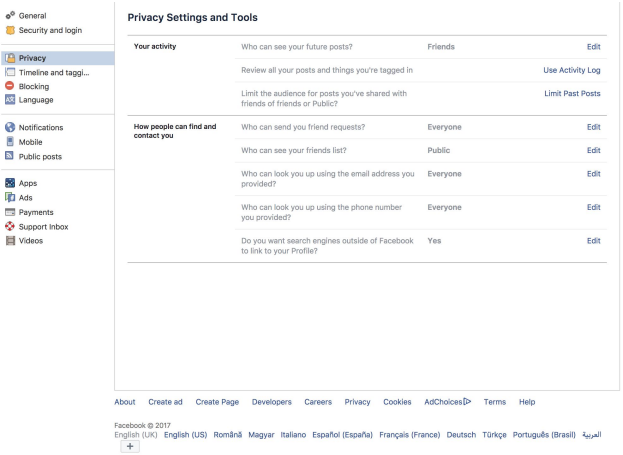
Installing a family printer in 2017

How would you design this?

Is this a good UI?

How do we know?

Could we improve it?



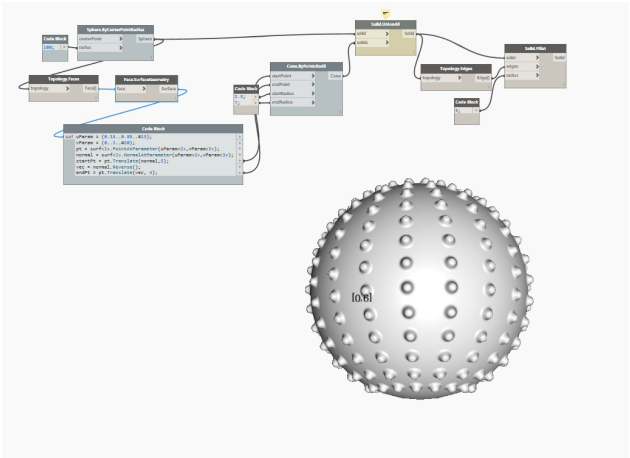
Facebook privacy in 2017

How would you design this?

Is this a good UI?

How do we know?

Could we improve it?



Visual Programming in 2017

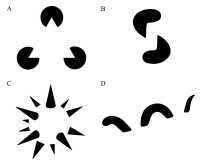
How would you design this?

Is this a good programming language?

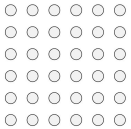
Derived from: http://dynamoprimer.com/en/05_Geometry-for-Computational-Design/5-6_solids.html

Theories give a *critical perspective*

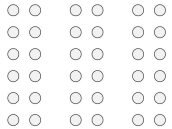
Reminder of a theory:
Gestalt theory of perceptual organisation

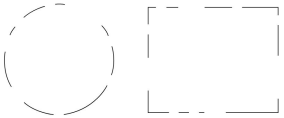


Continuity



Similarity

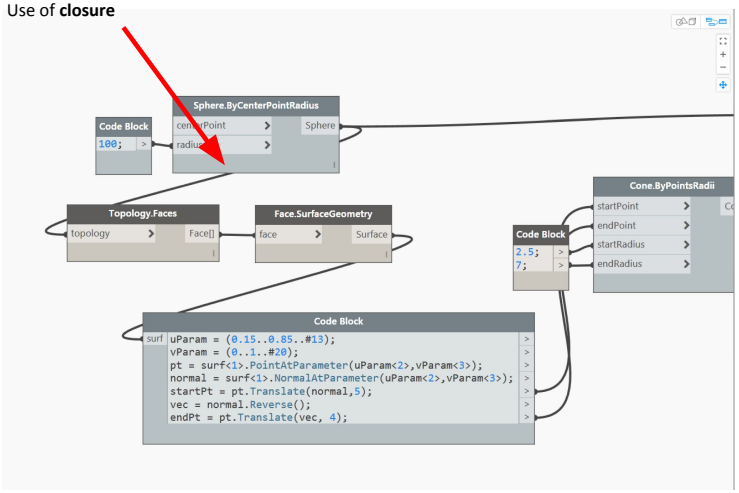




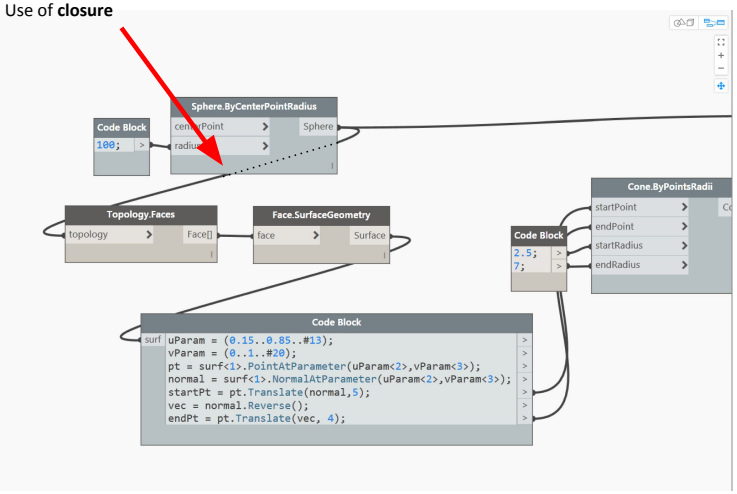
Closure

Images from: https://en.wikipedia.org/wiki/Gestalt_psychology

Use of **closure**

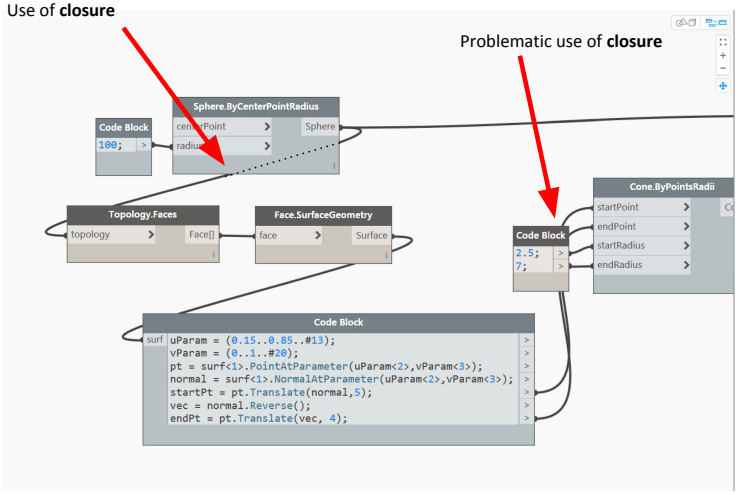


Use of **closure**

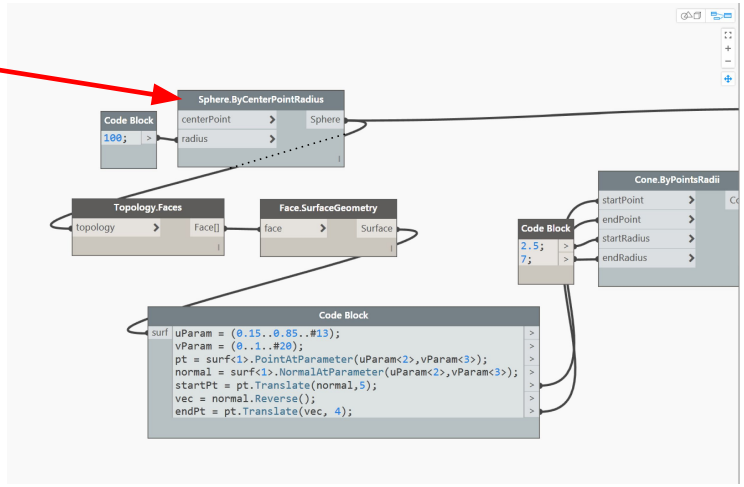


Use of **closure**

Problematic use of **closure**

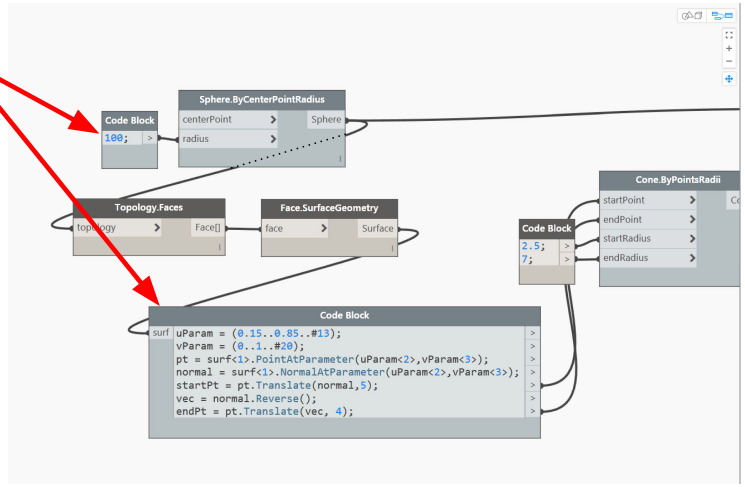


No use of **continuity**



Problematic
Similarity

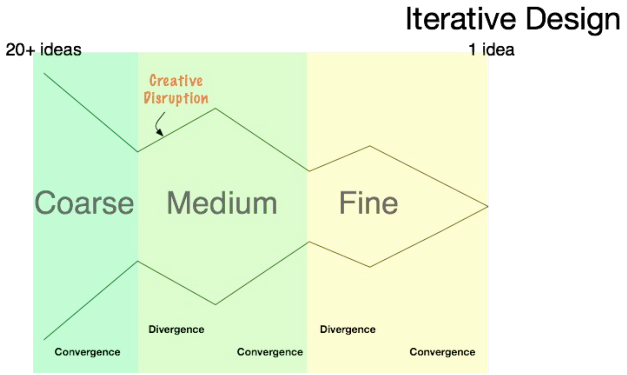
Do users think these are the same?



Summary of gestalt theory application

- Took a candidate design (Dynamo UI)
  - Predicted some properties that probably work well
  - Predicted some properties that might cause problems
- Over the course of the lectures you'll many theories like this
- How do we make use of critique?

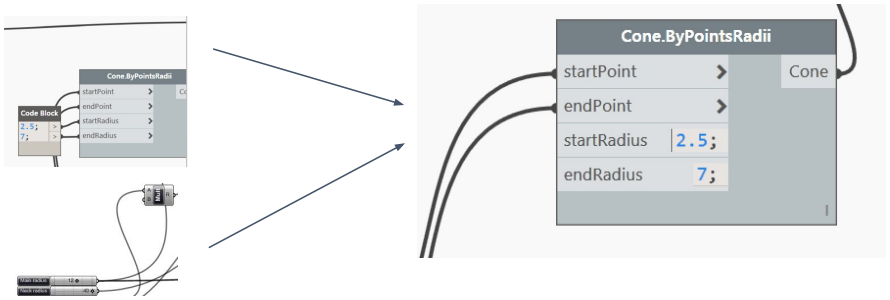
Critique your way to a design



Derived from Pugh '56

Example of convergence

- Merge features from two candidate designs to produce a better one
- Discard ideas that poorly fit the desired outcome

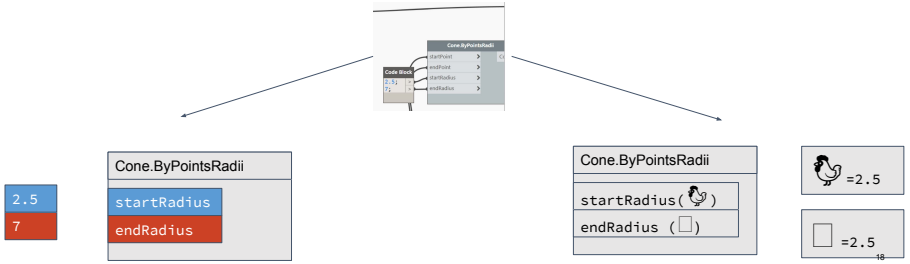


Grasshopper image: http://www.rhino3dhelp.com/wp-content/uploads/2010/02/jk-0x0.png

Example of divergence

- Generate new designs from existing one
- Use any creative technique, e.g. 'gestalt swapping', 'reduction to absurdity' or exploring metaphors

(e.g. what happens if we replace connectedness with similarity)



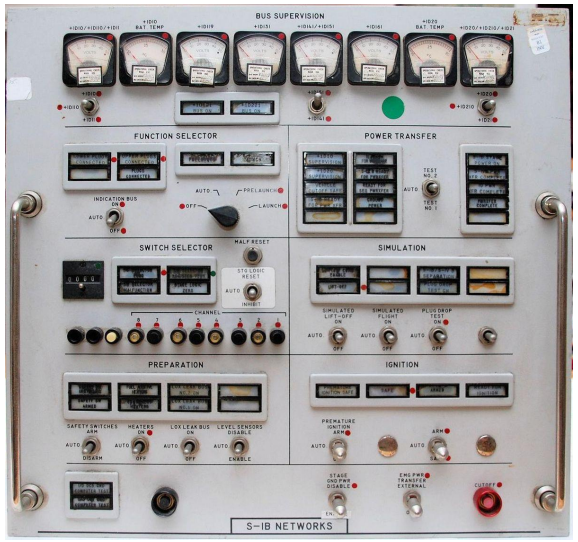
(Variables as emoji from Seymour, Kasibatla and Warth, 2017)

Why theory in HCI?

- We've interested in making interaction with computers faster, more productive, more creative, more social, more fun, somehow 'better'.
- Theories give us ways of criticising proposed designs and toolkits for inventing new ones

Three waves of HCI

- First wave (1980s):
  - Theory from Human Factors, Ergonomics and Cognitive Science
- Second wave (1990s):
  - Theory from Anthropology, Sociology and Work Psychology
- Third wave (2000s):
  - Theory from Art, Philosophy and Design



Apollo-Soyuz controls 1975

How would you design this?

Is this a good UI?

How do we know?

Could we improve it?

Photo: Jonathan H. Ward 2009

First wave: HCI as engineering "human factors"

- The "user interface" (or MMI "man-machine interface") is a separate module, designed independently of the main system.
- Design goal is efficiency (speed and accuracy) for a human operator to achieve well-defined functions.
- Use methods from cognitive science to model users' perception, decision and action processes and predict usability.

An information system

How would you design this?

Is this a good UI?

How do we know?

Could we improve it?

Photo: ZeeNews India, 2017

Second wave: HCI as social system

- The design of complex systems is a socio-technical experiment
  - Take account of other information factors including conversations, paper, and physical settings
- Study the context where people work
  - Use Ethnography and Contextual Inquiry to understand other ways of seeing the world
- Other stakeholders are integrated into the design process
  - Prototyping and participatory workshops aim to empower users and acknowledge other value systems

Blood bag radio

How would you design this?

Is this a good UI?

How do we know?

Could we improve it?

Photo: Dunne & Raby, 2009

Third wave: HCI as culture and experience

- Ubiquitous computing affects every part of our lives
  - It mixes public (offices, lectures) and private (bedrooms, bathrooms)
- Outside the workplace, efficiency is not a priority
  - Usage is discretionary
  - User Experience (UX), includes aesthetics, affect,
- Design experiments are speculative and interpretive
  - Critical assessment of how this is meaningful

Specialist topics not covered here:

- Graphics and VR - elsewhere in CS Tripos
- Digital media studies - CRASSH
- Game design - Anglia Ruskin University
- Social network analysis - elsewhere in CS Tripos
- Computer music - elsewhere in CS Tripos
- Security - elsewhere in CS Tripos
- Educational technology - Faculty of Education
- Information Systems - Judge Business School

Alternative perspectives

- Positive computing (e.g. Calvo & Peters 2014)
  - Wellbeing, flow, empathy, mindfulness, altruism
- Inclusion and accessibility (e.g. CWUAAT #1-9)
  - physical and sensory capabilities, ageing, low income and human rights
- Feminist utopianism (e.g. Bardzell 2010)
  - Diagnostic critique of hegemonic research and practice, combined with practice-led participatory processes of anticipation that amplify marginalized voices

Supervisions

- 2 supervisions after lecture 4 and lecture 8, recommend completing all the lectures before the last supervision

Textbooks

- Preece, Sharp & Rogers *Interaction Design: Beyond human-computer interaction* 4th Edition 2015
  - Practical professional methods, with good summary of theory
- Carroll (Ed.) *HCI Models, Theories and Frameworks: Toward a multidisciplinary science* 2003
  - Expert introductions to different theoretical traditions

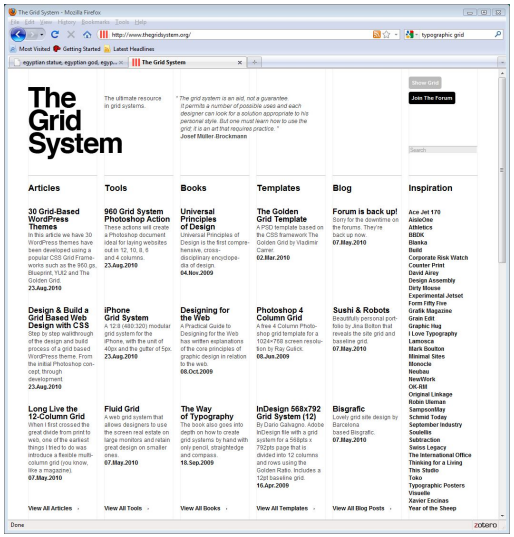
Exam structure

- 2 of the 8 questions in Paper 7 focus on Further HCI
  - Candidates answer 5 questions out of 8

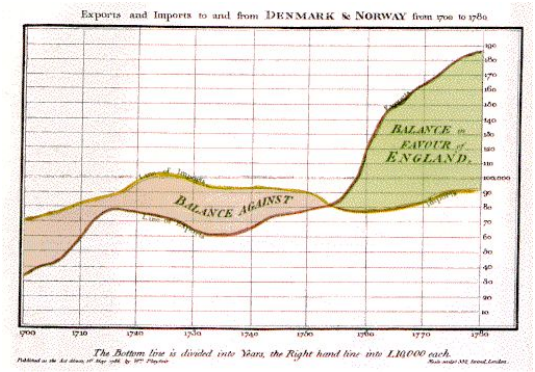
Further HCI

Lecture 2: Visual representation

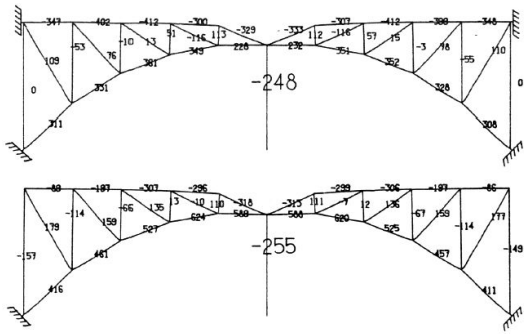
TYPOGRAPHY AND TEXT

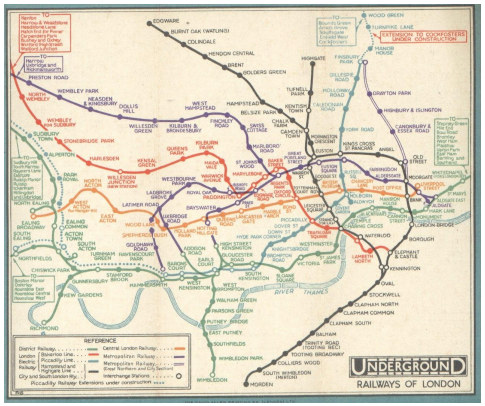


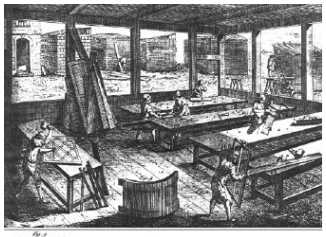
MAPS AND GRAPHS

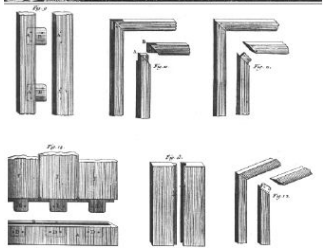


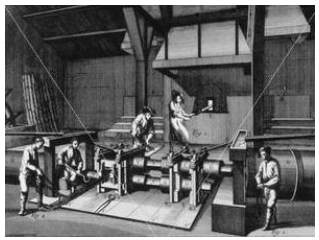
SCHEMATIC DRAWINGS

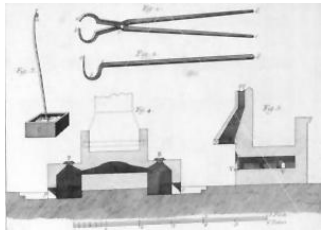












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NODE-AND-LINK DIAGRAMS

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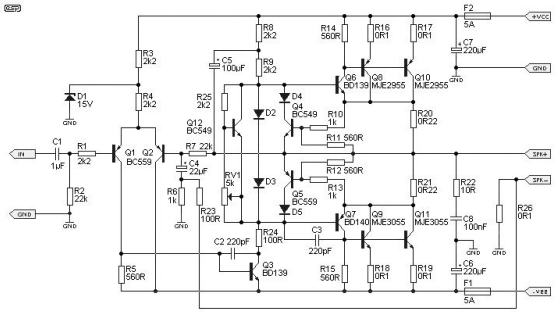

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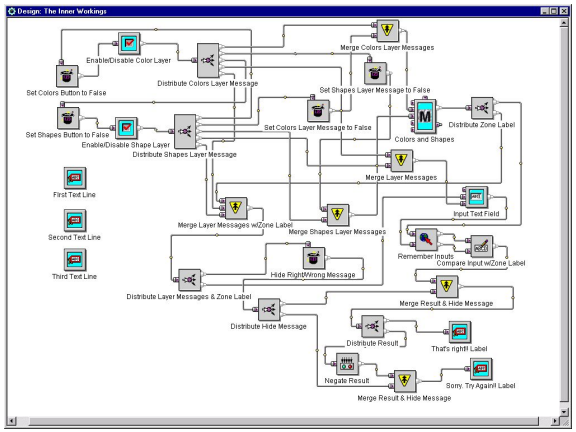

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ICONS AND SYMBOLS

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VISUAL METAPHOR

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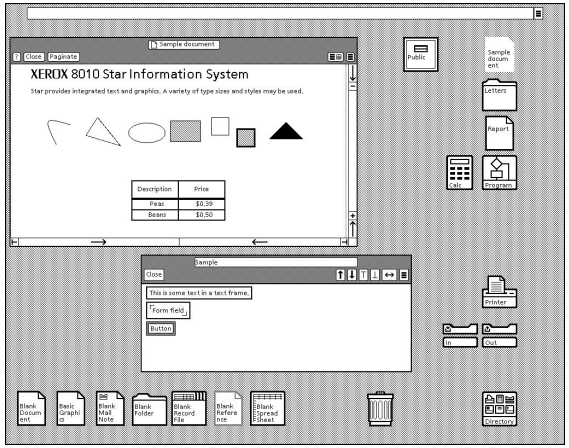

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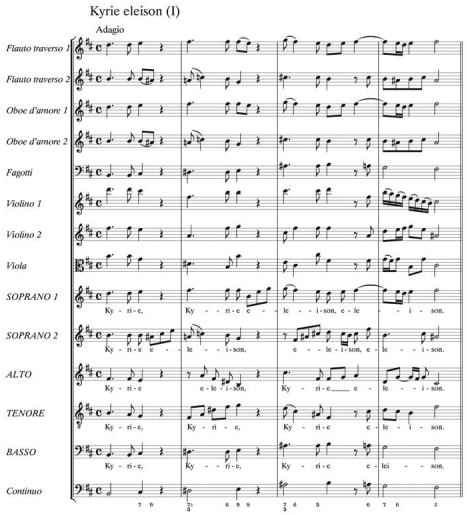
Public Family Room
Door to Public Study
Door to Public Safe
Door to Public Study
Bob Clock
Door to Public Mouse Hole
GeoSafari for Bob
Bob Financial Guide
Bob Address Book
Bob E-Mail
Bob Household Manager
Bob Letter Writer
Bob Checkbook

PICTURES

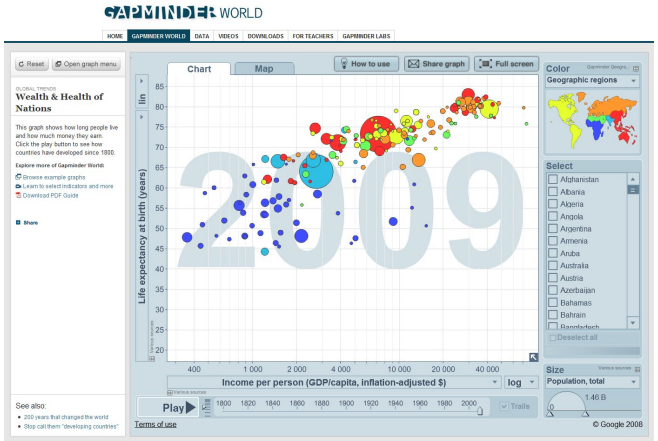
UNIFIED THEORIES OF VISUAL REPRESENTATION

	Graphic Resources	Correspondence	Design Uses
Marks	Shape Orientation Size Texture Saturation Colour Line	Literal (visual imitation of physical features) Mapping (quantity, relative scale) Conventional (arbitrary)	Mark position, identify category (shape, texture colour) Indicate direction (orientation, line) Express magnitude (saturation, size, length) Simple symbols and colour codes
Symbols	Geometric elements Letter forms Logos and icons Picture elements Connective elements	Topological (linking) Depictive (pictorial conventions) Figurative (metonym, visual puns) Connotative (professional and cultural association) Acquired (specialist literacies)	Texts and symbolic calculi Diagram elements Branding Visual rhetoric Definition of regions
Regions	Alignment grids Borders and frames Area fills White space Gestalt integration	Containment Separation Framing (composition, photography) Layering	Identifying shared membership Segregating or nesting multiple surface conventions in panels Accommodating labels, captions or legends
Surfaces	The plane Material object on which the marks are imposed (paper, stone) Mounting, orientation and display context Display medium	Literal (map) Euclidean (scale and angle) Metrical (quantitative axes) Juxtaposed or ordered (regions, catalogues) Image-schematic Embodied/situated	Typographic layouts Graphs and charts Relational diagrams Visual interfaces Secondary notations Signs and displays

ANALYSIS EXAMPLES



	Graphic Resources	Correspondence	Design Uses
Marks	Shape	Conventional (arbitrary)	Mark position identify category (shape)
Symbols	Geometric elements Letter forms Connective elements	Topological (linking) Acquired (specialist literacies)	Texts Definition of regions
Regions	Alignment grids White space	Containment Separation	Segregating and nesting multiple surface conventions in panels Accommodating labels
Surfaces	Material object on which the marks are imposed (paper)	Metrical (quantitative axes) Juxtaposed and ordered (regions)	Musical score



	Graphic Resources	Correspondence	Design Uses
Marks	Size Colour	Mapping (quantity, relative scale)	Mark position identify category (colour) Express magnitude (size)
Symbols	Geometric elements Connective elements	Topological (linking)	Diagram elements Visual rhetoric
Regions	Alignment grids	Containment Separation Framing (composition)	Segregating or nesting multiple surface conventions in panels Accommodating labels, captions or legends
Surfaces	Display medium (web browser)	Metrical (quantitative axes) Image-schematic?	Graphs and charts

Lecture 3:
Goal-oriented interaction

Using cognitive theories of planning, learning and understanding to understand user behaviour, and what they find hard.

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- **Goal-oriented interaction**
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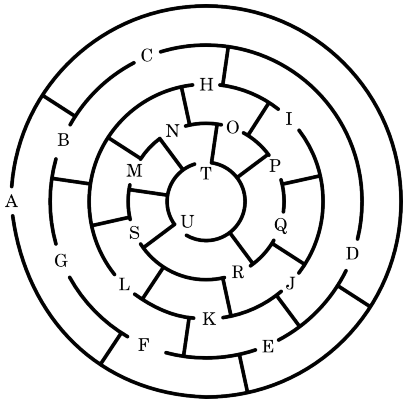
- Designing complex systems

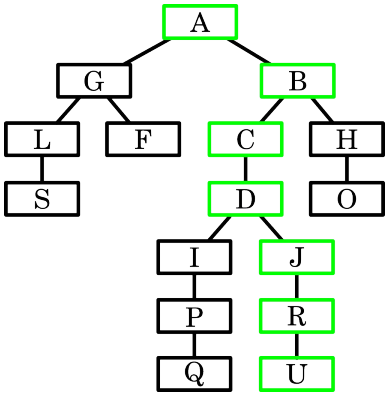
A *Metatheory* (in first-wave HCI): User interaction can be modelled as search

Reminder from Prolog course: problem solving using graph search



From Rice & Beresford

Turn the problem into a graph



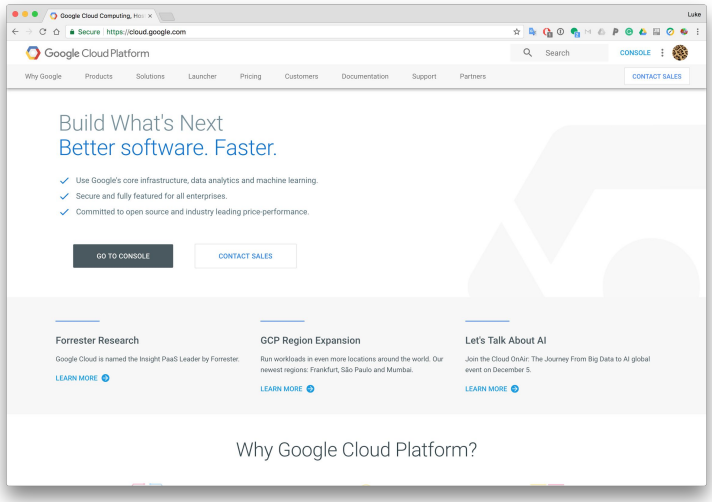
Encode as Prolog facts to solve

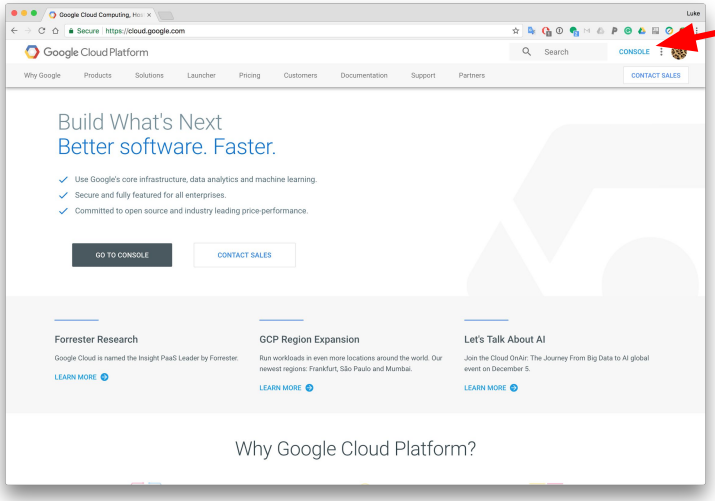
```
route(a,g).
route(g,l).
route(l,s).
...
travel(A,A).
travel(A,C) :- route(A,B),travel(B,C).

solve :- start(A),finish(B), travel(A,B).
```

```
start(a).
finish(u).
```


HCI example of a User Goal:
Find out how much did my use of Google Cloud Platform cost me last month?




Google Cloud Platform
CONSOLE
Why Google
Products
Solutions
Launcher
Pricing
Customers
Documentation
Support
Partners
CONTACT SALES
Build What's Next
Better software. Faster.
Use Google's core infrastructure, data analytics and machine learning.
Secure and fully featured for all enterprises.
Committed to open source and industry leading price-performance.
GO TO CONSOLE
CONTACT SALES
Forrester Research
Google Cloud is named the Insight PaaS Leader by Forrester.
LEARN MORE
GCP Region Expansion
Run workloads in even more locations around the world. Our newest regions: Frankfurt, São Paulo and Mumbai.
LEARN MORE
Let's Talk About AI
Join the Cloud OnAir: The Journey From Big Data to AI global event on December 5.
LEARN MORE
Why Google Cloud Platform?

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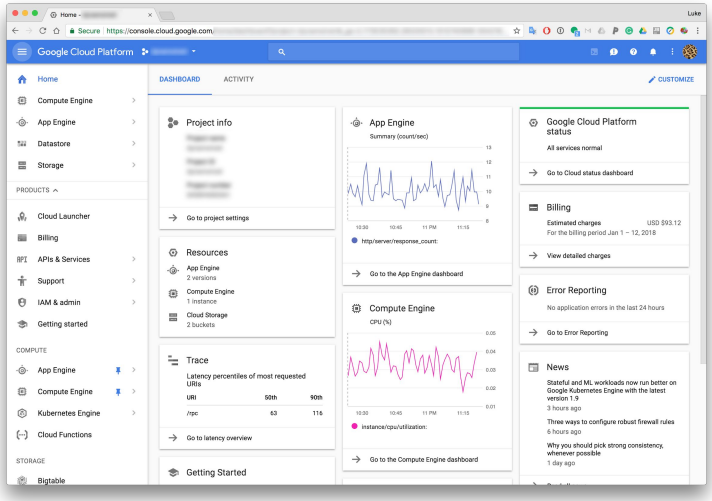
Google Cloud Platform
Home
Compute Engine
App Engine
Datastore
Storage
PRODUCTS
Cloud Launcher
Billing
APIs & Services
Support
IAM & admin
Getting started
COMPUTE
App Engine
Compute Engine
Kubernetes Engine
Cloud Functions
STORAGE
Bigtable
DASHBOARD
ACTIVITY
CUSTOMIZE
Project info
Go to project settings
App Engine
Summary (count/sec)
Go to the App Engine dashboard
Google Cloud Platform status
All services normal
Go to Cloud status dashboard
Billing
Estimated charges
USD $93.12
For the billing period Jan 1 – 12, 2018
View detailed charges
Error Reporting
No application errors in the last 24 hours
Go to Error Reporting
Resources
App Engine
2 versions
Compute Engine
1 instance
Cloud Storage
2 buckets
Compute Engine
CPU (%)
Go to the Compute Engine dashboard
Trace
Latency percentiles of most requested URIs
Go to latency overview
News
Getting Started

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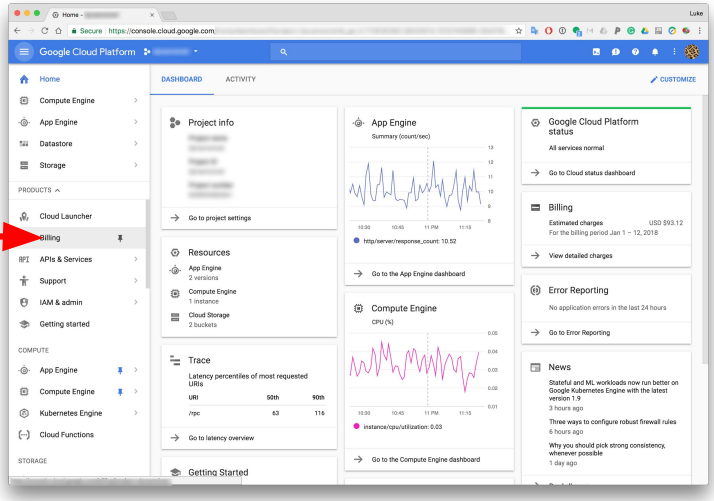
Google Cloud Platform
Billing
DASHBOARD
ACTIVITY
CUSTOMIZE
Project info
App Engine
Google Cloud Platform status
Billing
Error Reporting
Resources
Compute Engine
Trace
News
Getting Started

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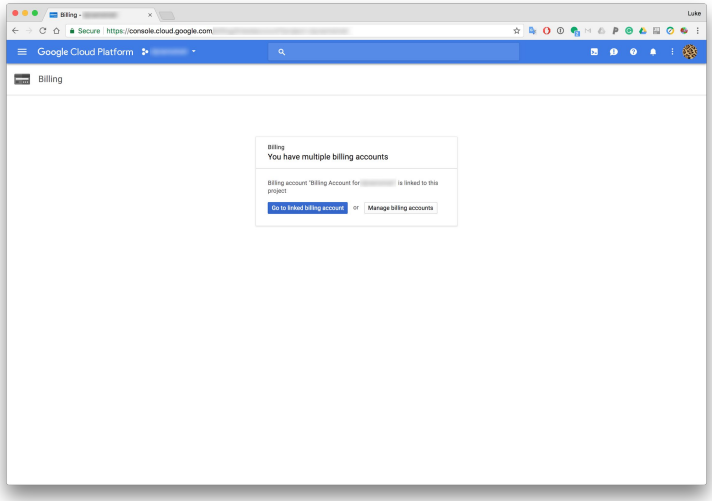
Google Cloud Platform
Billing
You have multiple billing accounts
Go to linked billing account
Manage billing accounts

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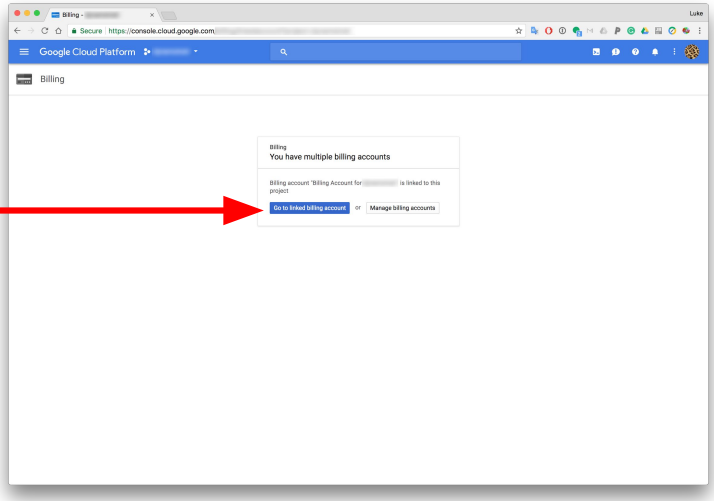
Google Cloud Platform
Billing
You have multiple billing accounts
Go to linked billing account
or
Manage billing accounts

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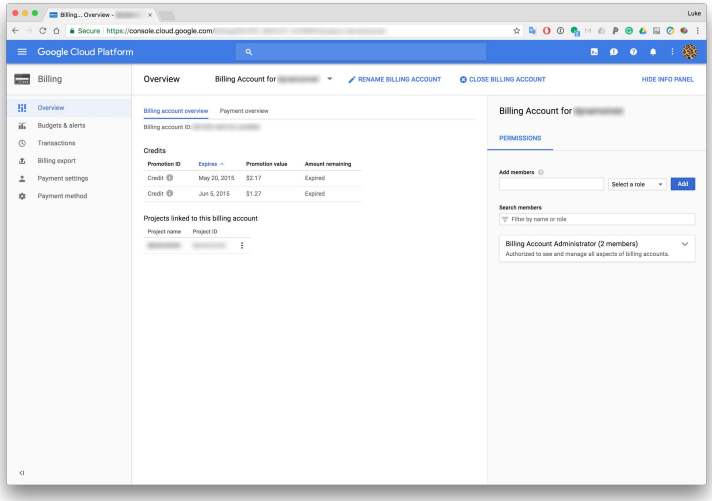
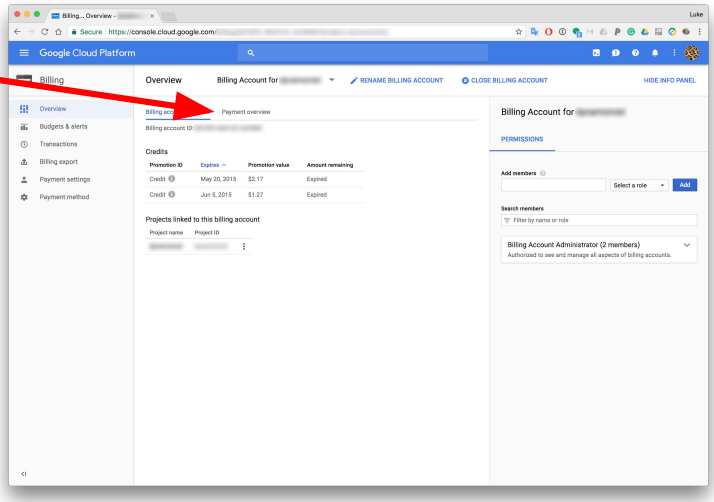

Google Cloud Platform
Billing
Overview
RENAME BILLING ACCOUNT
CLOSE BILLING ACCOUNT
HIDE INFO PANEL
Billing account overview
Payment overview
Credits
Projects linked to this billing account
PERMISSIONS
Add members
Search members
Billing Account Administrator (2 members)

74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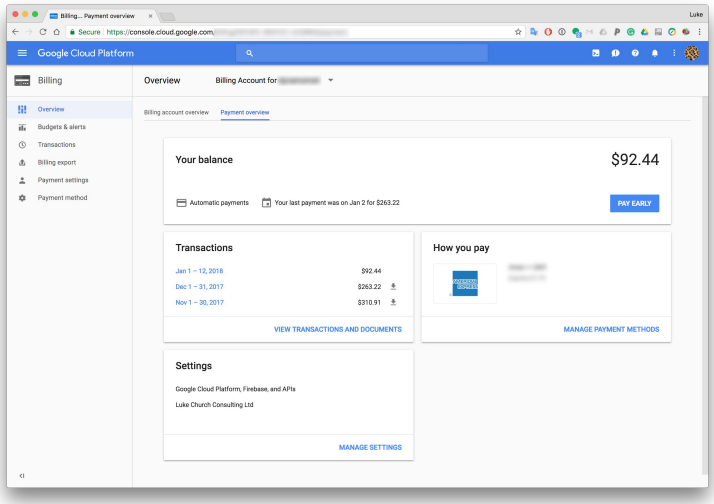
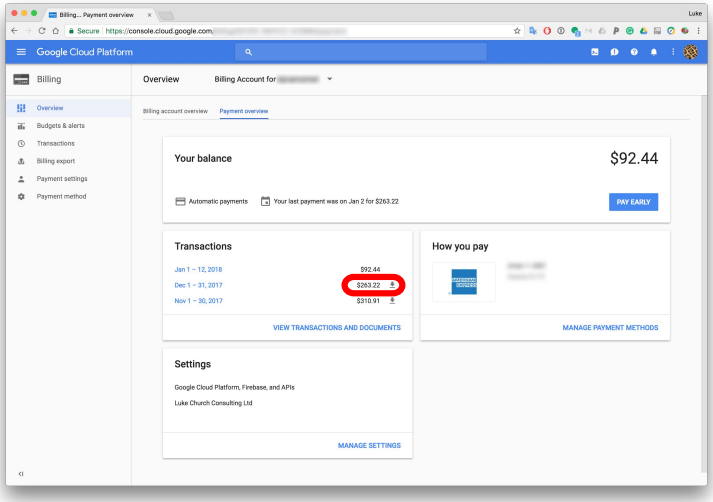
75


Google Cloud Platform
Billing
Overview
Billing account overview
Payment overview
Your balance
$92.44
Automatic payments
PAY EARLY
Transactions
VIEW TRANSACTIONS AND DOCUMENTS
How you pay
MANAGE PAYMENT METHODS
Settings
MANAGE SETTINGS

76



77

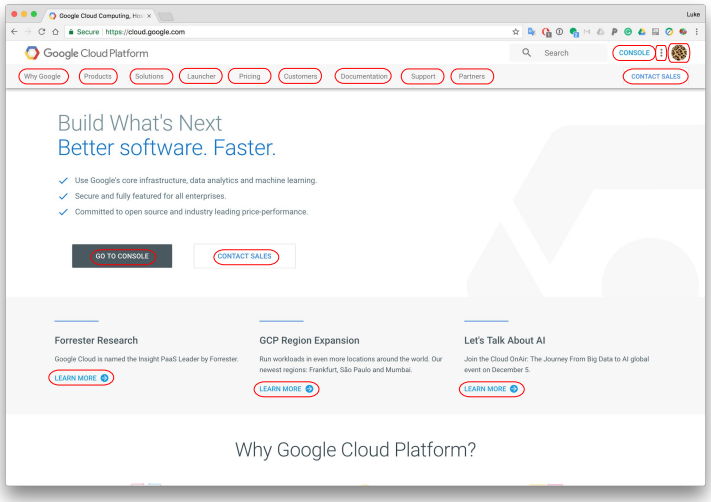
What search algorithm is being used here?

78

Breadth first/Depth first?

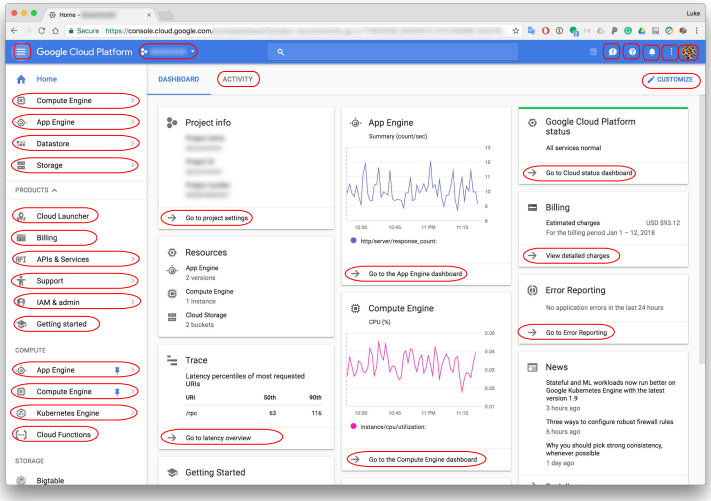
79

Click targets



80

Click targets

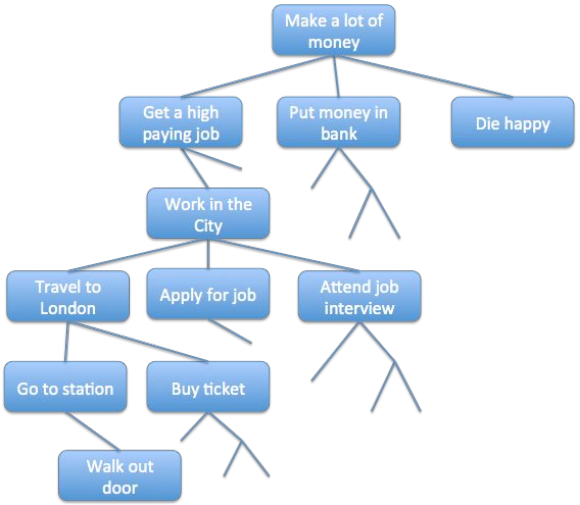


Human problems as AI search

My ultimate goal: Make a lot of money

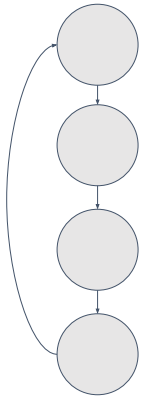
Some nodes in the search tree that must be arranged in order:

- Get a high paying job
- Save the money
- Work in the City
- Attend a job interview
- Apply for a job
- Travel to London
- Buy a train ticket
- Go to the station ...



Reminder from Part 1a:
Cognitive Walkthrough

[Simplified] Cognitive Walkthrough



Goal

Availability

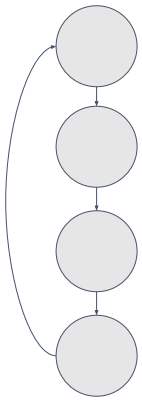
Match

Feedback

See:
https://www.colorado.edu/ics/sites/default/files/attached-files/93-07.pdf

For a detailed description

Finding your bill?

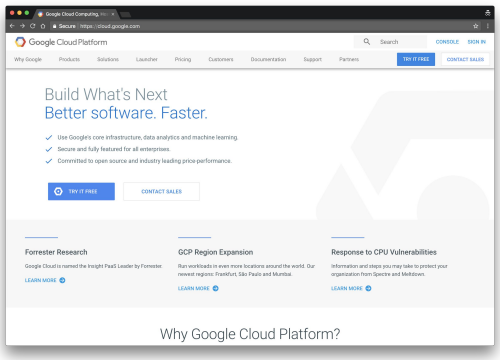


Goal

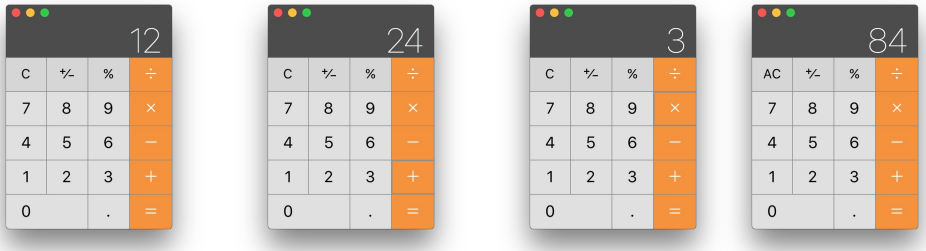
Availability

Match

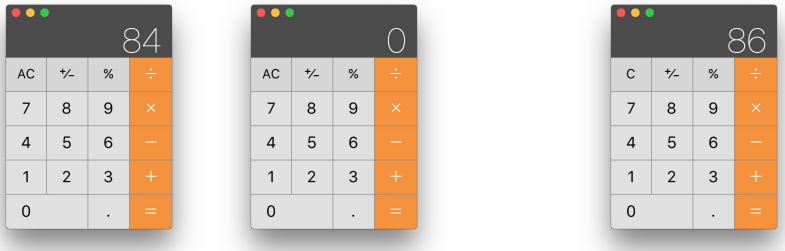
Feedback



The cost of thinking:
Heuristics and Biases



12 + 24 * 3 Enter



Enter Esc + 2

“eh?”

How many times should the user press Esc?

Classical theories of metareasoning

- Optimal search
  - Find the best possible solution within stated constraints on resources
- Bounded rationality
  - Computation is one of the constraints
- Satisficing
  - Find a satisfactory solution within computation constraints

Neuro-economic models of reasoning

- Behavioural economics, popularly known as “Nudge”
- Original basis in “prospect theory” (Kahneman & Tversky)
  - General theory of decision making
  - Construct a utility model, based on outcome of possible actions
  - Weight estimated values by likelihood
  - Choose action with optimal utility
  - May include future value discounting
- In practice, the optimisation is more likely to involve satisficing, due to reasoning with bounded rationality constraints
  - In Kahneman’s terms “thinking fast and slow”

Bounded rationality in humans

- Apply *heuristics* rather than searching for optimal plan
  - Availability heuristic - reason based on examples easily to hand
  - Affect heuristic – base decision on emotion rather than calculating cost / benefit
  - Representativeness heuristic - judge probability based on resemblance
- Apply *biases* to ensure estimation error within tolerable bounds
  - Loss aversion - losses hurt more than gains feel good
  - Expectation bias - researchers (even in HCI) find results they expected
  - Bandwagon effect - do what other people do
- And many others!

Behavioural economics in programming

- “Attention Investment theory” of abstraction use
  - Automation requires abstract specification
    - e.g. defining a regular expression for search and replace
  - Benefit of automation is saving time and concentration in future
  - But abstract specification (programming) takes time and concentration!
    - And powerful abstractions (programs) can go wrong powerfully
  - User may prefer repetitive manual operations - safe and incremental
- So utility function will compare future saving of attention from programming vs costs of concentrating on a risky strategy
  - Biases such as loss aversion will apply
  - Bounded rationality will apply, since deciding what to do takes even more concentration

The limitations of goal based HCI

It assumes the user doesn't make mistakes

- Would need a cognitive model of why error occurred
  - Information loss due to cognitive limitations
  - Incorrect mental model
  - Misleading design
- Need description of user journey that accounts for problem identification, diagnosis, debugging, testing, iteration etc

It assumes the user has the right goal

- Persuasive design is a field of HCI that addresses goal formation
- Applications:
  - Reduce energy consumption
  - Promote exercise
  - Manage diet and nutrition
  - Smoking cessation
- May include "nudge" to account for biases
  - But paternalistic / patronising

It assumes the user knows what the goal is

- Not true when the purpose is an experience (third wave HCI)
- Not true in "exploratory design"

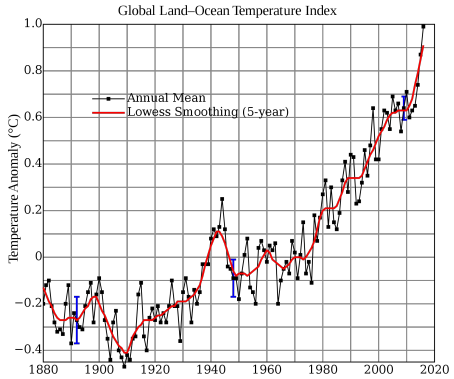
- More attention to this later in the course
- Some problems can't be decomposed into actions
- Sometimes actions have side effects

Wicked problems

Including material provided by Steven Tanimoto

A Wicked Problem:

Slowing climate change



By NASA Goddard Institute for Space Studies - http://data.giss.nasa.gov/gistemp/graphs/, Public Domain, https://commons.wikimedia.org/w/index.php?curid=24363898

More Wicked Problems

- Stopping the spread of antibiotic-resistant diseases
- Halting nuclear proliferation
- Ending homelessness in Cambridge
- Avoiding species extinction
- Colonizing Mars

Rittel-Webber Characteristics 1-5 of 10

1. There is no definitive formulation of a wicked problem
2. Wicked problems have no stopping rule
3. Solutions to wicked problems are not true-or-false, but good-or-bad
4. There is no immediate and no ultimate test of a solution to a wicked problem
5. Every solution to a wicked problem is a “one-shot operation”; because there is no opportunity to learn by trial-and-error, every attempt counts significantly

Rittel-Webber Characteristics 6-10 of 10

6. Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan
7. Every wicked problem is essentially unique
8. Every wicked problem can be considered to be a symptom of another problem
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution
10. The planner has no right to be wrong

Discuss with your supervisor:
"How might you design software to help solve wicked problems?"

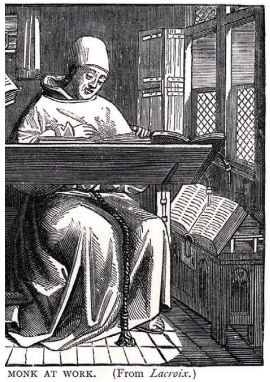
Solution principles for

Next-Generation Text Entry Summary

Per Ola Kristensson
Department of Engineering
University of Cambridge

Principles of intelligent text entry

1. Letters simplified to line marks
2. Common word stems compressed into simple line marks or dots
3. Common word stems identified by word frequency analysis of the book of psalms

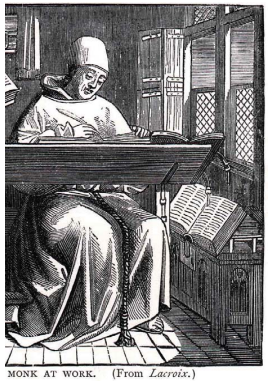


MONK AT WORK. (From *Lacroix.*)

Kristensson, P.O. 2009. Five challenges for intelligent text entry methods. *AI Magazine* **30**(4): 85-94.

Principles of intelligent text entry

- In other words:
  1. Optimise speed by minimsing the amount of information users have to articulate
  2. Exploit redundancies in natural languages by creating a language model



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Kristensson, P.O. 2009. Five challenges for intelligent text entry methods. *AI Magazine* **30**(4): 85-94.

Hey, Professor Touchscreen, keep your fingers off our Qwerty keyboards

There aren't many inventions from the 19th century that remain in

Ever since it was first produced in 1873, we have stuck with it. First on clunky, mechanical typewriters with their pleasing chika-chip-cha-chip-DING-ziiiiiiip, then with electronic word processors and computers. Even now, touchscreen

The typewriter keyboard was designed to stop keys jamming

their funky new KALQ board, which has all the vowels

order. But this meant that the mechanical levers, attached

composer), developed in the Thirties. Crucially, this version allows your fingers

that would cause snapped fingers with a Qwerty board.

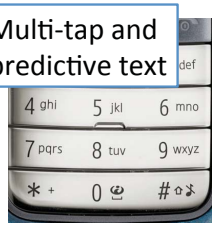
And if it's supersonic typing you are after, you should have seen the old stenographers at work at the Old Bailey, who used strange machines that worked like pianos – they struck chords

Why do nearly all text entry methods fail?

Mainstream mobile text entry methods

Graffiti

Multi-tap and predictive text



Touchscreen keyboards

Gesture keyboards

Physical thumb keyboards

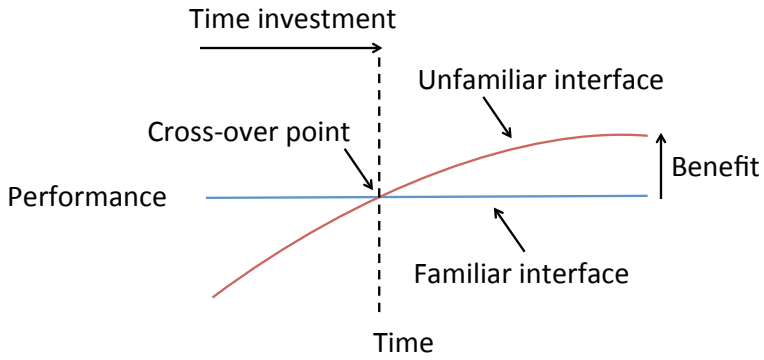
Mainstream mobile text entry methods

- Entry and error rate
- Learning curve, familiarity and immediate efficacy
- Form factor, preparation time and comfort
- User engagement
- Visual attention and cognitive resources
- Privacy
- Single vs. multi-character entry
- Specification vs. navigation
- One-handed vs. two-handed
- Task integration
- Robustness
- Device independence
- Computational demands
- Manufacturing and support cost
- Localisation
- Market acceptance

Mainstream mobile text entry methods

- **High effective entry rate**
  - Among the fastest of their generation
- **High familiarity and high immediate efficacy**
  - Either extremely easy-to-learn or very similar to existing technology (or both)

The cross-over point



Solution principles

- From closed to open-loop
  - Avoid the need for a visual feedback loop
- Continuous novice-to-expert transition
  - Avoid explicit learning
- Path dependency
  - Avoid redesigning the interaction layer
- Flexibility
  - Enable users to compose and edit in a variety of styles without explicit mode switching
- Efficiency
  - Let users' creativity be the bottle-neck

Conclusions

- A text entry method likely to be adopted by users is probably similar to existing solutions and at least as fast
- It is still possible to make progress by focussing on supporting few behavioural principles:
  - From closed to open-loop
  - Continuous novice-to-expert transition
  - Path dependency
  - Flexibility
  - Efficiency

Kristensson, P.O. 2015. Next-generation text entry. *IEEE Computer* **48**(7): 84-87.