Graphical passwords: some recent results

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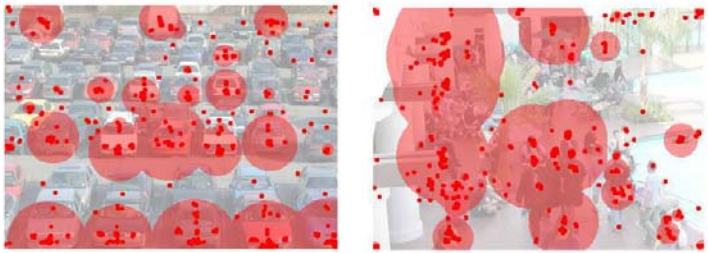
Context

- Textual passwords
  - Cheap, convenient, ubiquitous
  - Have long suffered usability problems
    - Due to limitations of human memory
- Graphical passwords
  - A picture is worth a thousand words
  - Hot topic in both security and HCI communities
  - Bonder ('96), Passfaces, Inkblot, Passpoints, etc.
  - Collective understanding: still in its infancy

PassFaces study [usenix'04]

- A sequence of k faces ⇨ password
- Permitting user choice
  - Password entropy far below theoretical optimum
  - Highly correlated with the race or gender of the user

PassPoints studies



- A ordered list of clicks ⇒ password
  - Inherent weakness: a random combination of spots ⇒ brute force attack
  - "Hot spots" ⇒ (≅) dictionary attacks [Usenix'07, SOUPS'07]

"Draw a Secret" [Usenix'99]

- One representative scheme; one of the few supporting both
  - **Authentication**: to verify the claimed identify of a user, and
  - **Key generation**: to use a password to generate a long crypto key
- Theoretical password space: DAS >> textual

"Draw a Secret"

- A password is a free-form drawing on a grid of size N × N
  - Sample: encoded as (2, 2), (3,2), (3,3), (2,3), (2,2), (2,1), (5,5) , (1,2), (1,3), (5,5)
  - Two secrets are the same if the encoding is the same;
- Determinants of password strength include
  - Stroke count (2)
  - Password length (8)
  - Grid size (4x4)

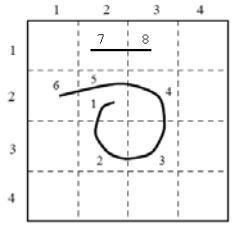


Figure 2: Input of a graphical password on a 4 × 4 grid. The drawing is mapped to a sequence of co-ordinate pairs by listing the cells in the order which the stylus passes through them, with a distinguished coordinate pair inserted in the sequence whenever the stylus is lifted from the drawing surface.

Problems with DAS

- Users tend to pick weak passwords that are vulnerable to *graphical dictionary attack*
  (Thorpe and van Oorschot [usenix'04])
  - Small stroke count,
  - Small password length,
  - Mirror symmetry
- Implication: this theoretically sound scheme is less secure in practice
  - 1-week recall (pilot): avg strength of memorable passwords < 41.9 bits (vs. 8-character text pwd: 53 bits)

Grid selection as a solution

- Thorpe and van Oorschot [acsac04]
- How it works:

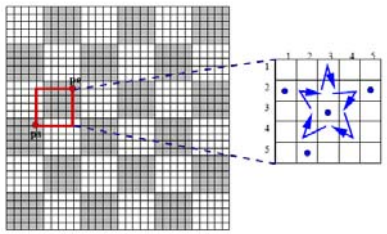
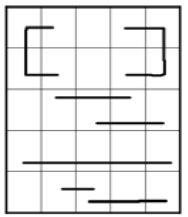
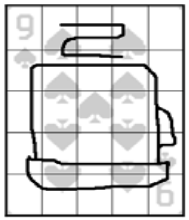


Figure 6. Grid selection: a user selects a drawing grid in which to draw their password.

- Adds up to 16 bits to the password space
- Unclear it works well as expected (no empirical study yet)

Intuition behind our solution

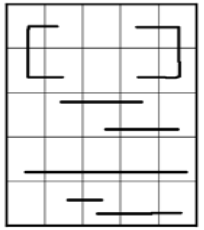




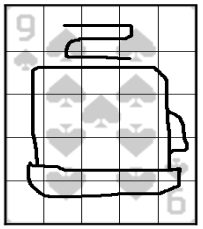
- In DAS, difficult to reconstruct a complex secret
  - E.g. people were able to remember what their drawings looked like, but failed to replicate them in the correct location (Goldberg et al [CHI'02])
- The cells in the grid all look alike!
  - What if recreation of a secret can be aided by something that reduces the confusion, e.g. a background image?

Our novel proposal

- Background Draw a Secret (BDAS):
  - Instead of creating a secret on an empty grid, a user choose a background image to be overlaid by the grid, and then create a secret as in DAS



DAS



BDAS

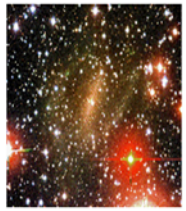
Empirical evaluations

- Design
  - Paper/transparency prototype
  - Drawing grid
    - 5x5
    - Same size as a popular PDA
  - Comparative study
    - DAS: grid printed on transparency
    - BDAS: choose one out of 5 images to be overlaid with grid
- Procedure
  - 46 participants
    - 26: non-technical
    - 32 M, 14 F
    - Age: 18-25 (one 50+)
  - Briefing & randomly assigned a group
  - Practice
  - Password creation
  - 5-minute recall
  - 1-week recall

What background image to choose?

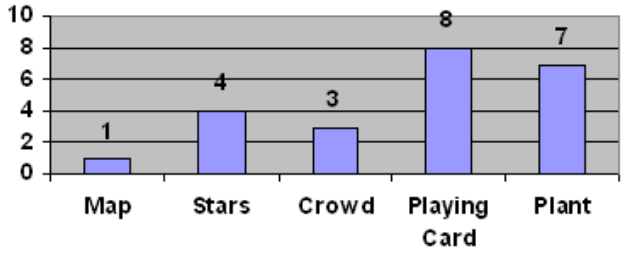
- Little guideline in literature at the time
- have meaningful content and rich details (Wiedenbeck et al SOUPS'05)
  - Easy to select spots
- Intuition
  - Not introduce obvious bias
  - Everyday images

Background images used



- Stars
- Map
- Plant
- Crowds
- Playing card
  - Low-detail

Results: background image choice



- Images dense with content (*map* and *crowd*) anticipated to be the most popular
  - This was clearly contradicted
  - Playing card: 33% of selections, plant: 30%

Results: password quality

- Complexity of secrets in each group (23 valid secrets/grp)
  - BDAS: larger stroke count (significantly different) and password length
  - BDAS: stronger by more than 10 bits

Group	Strokes				Password length			
	Avg.	S.d.	Max	Min	Avg.	S.d.	Max	Min
BDAS	7.22	2.21	12	4	21.43	7.76	37	6
DAS	5.30	2.44	10	1	18.26	9.19	42	6

- Symmetry: 43% (BDAS) vs 57% (DAS)
- Centering within the grid: 43% (BDAS) vs. 87% (DAS)

Results: 5-minute recall

- Recall rate
  - DAS: 100% (23/23); BDAS: 96% (22/23) [Fig10(a)]
- Complexity of successfully recalled secrets:

Group	Strokes				Password length			
	Avg.	S.d	Max	Min	Avg.	S.d.	Max	Min
BDAS	7.45	2.26	12	4	21.7	8.31	37	6
DAS	5.30	2.44	10	1	18.26	9.19	42	6

  - BDAS: larger stroke count (significantly different) and password length; avg strength: larger by more than 10 bits
  - BDAS: less symmetry and centering

Results: 1-week recall

- Recall rate
  - DAS = BDAS = 95% (20/21)
- Complexity of successfully recalled secrets:

Group	Strokes				Password length			
	Avg.	S.d.	Max	Min	Avg.	S.d.	Max	Min
BDAS	7.1	2.16	12	4	20.9	7.71	37	6
DAS	5	2.44	10	1	17.45	7.63	37	6

  - BDAS: larger stroke count (significantly different) and password length
  - Avg strength: <60 bits (DAS); >70.2 bits (BDAS)
  - BDAS: less symmetry and centering

On estimating BDAS passwords

- We used the method designed for DAS
  - Would the observed increase in BDAS pwd complexity not in fact indicate increased password security?
    - E.g. bias introduced by background images could reduce password security
  - Our answer: not only real increased security, but arguably also an underestimate

On estimating BDAS passwords

- No significant bias relevant to security, other than reduced symmetry and centering, was observed
- Strength figures were minimum estimates directly quoted, while off-scale estimate was not calculated.
- Didn't consider either symmetry or centering reduced by BDAS.
  - If considered, both could further increase estimate figures

Summary

- A simple idea: introducing background images into DAS
- Nice results
  - Much stronger passwords; just as memorable as their much simpler DAS counterparts.
  - The most exciting bit: A simple idea significantly enhances both usability and security simultaneously
- Numerous possibilities for future study

Ongoing and future work

- Larger scale of experiments with an actual implementation, participants of more diversified bgrd
  - DAS vs. BDAS
  - BDAS vs. textual passwords
- What will make good background images?
  - Effect of individual background image choices
- Shoulder surfing resistance
- Interference between multiple passwords
- Many more ...

Full paper: *Do background images improve "draw a secret" graphical passwords?* (CCS'07)

BDAS website:
http://homepages.cs.ncl.ac.uk/jeff.yan/bdas.htm

Thank You!

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