Challenge Questions: Authentication's Weakest Link?

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(joint work with David Aspinall)

Introducing Your Speaker

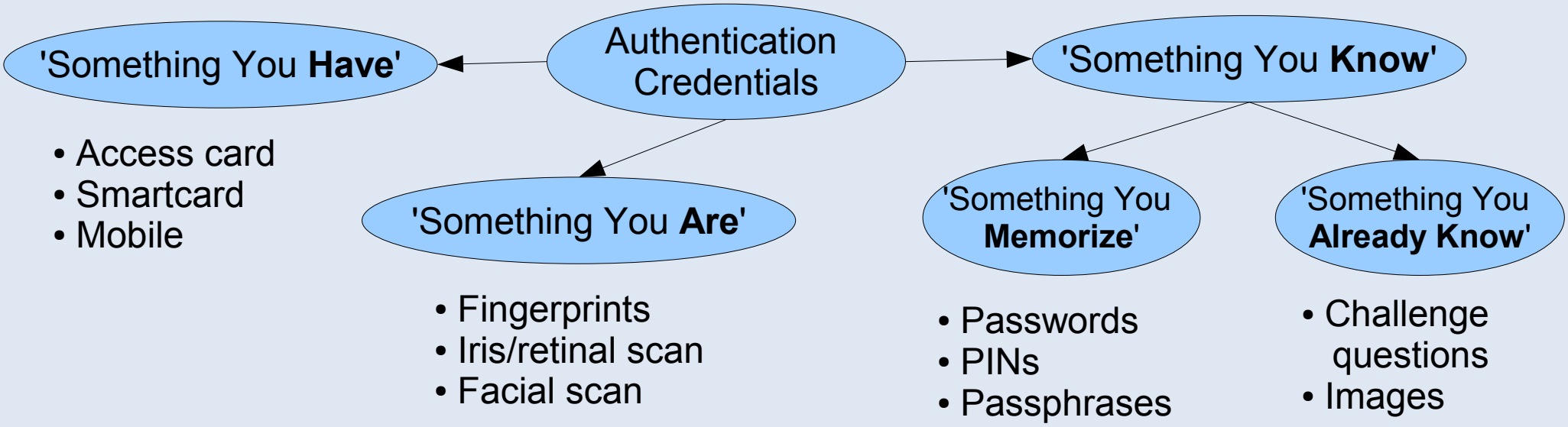
- Visiting Research Fellow till Sept 2009
  - EPSRC-funded project with David Aspinall
- Former Director of Innovation, and continue to work part-time, remotely for Canadian Government
- Worked in public and private sectors, and academia during past 10 years (focus on Applied Cryptography)
- In 2005, designed the Challenge Question Authentication Solution used by Canadian Government to authenticate appox 3 million citizens and businesses
- PhD, Carleton University, 1998

Outline

- The Scenario
- Challenge Question Research
- Our Research
- Experiments
- Security and Usability Analysis
- What Does it all Mean?
- Further Information

The Scenario (1 of 3)

- What are 'Challenge Questions?'
  - Type of 'authentication credential'
  - Users register Question & Answer
  - To authenticate later, user is posed Question and asked to provide Answer



The Scenario (2 of 3)

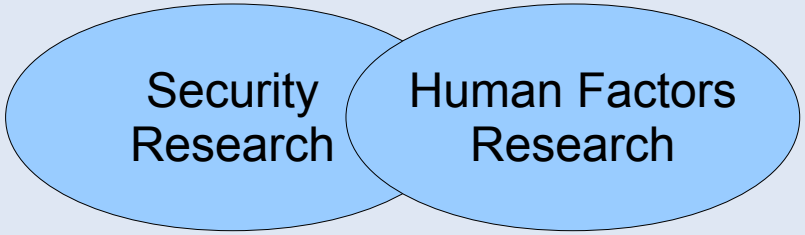
- Common Examples
  - 'What is my Mother's Maiden Name?'
  - 'What was the name of my first pet?'
  - 'What was the name of my primary school?'
- How do Challenge Questions support authentication?
  - The answers to the questions should be known only to the users that registered the questions, similar to how passwords should be uniquely known

The Scenario (3 of 3)

- How and why do we use Challenge Questions?
  - Almost exclusively as secondary/fallback authentication in case of lost primary credential
  - Often driven by desire to avoid costly help-desk calls
  - In some cases, 're-registration' is possible, but not always
    - Too expensive or takes too much time
    - Not all sites have a registration phase (that includes user identification with shared secrets)
  - So, some form of secondary authentication is desireable
    - Challenge Questions are today's ubiqutous choice
  - (And yes, they could be used as a primary credential as well)

Challenge Question Research (1 of 3)

- What is studied w.r.t. Challenge Questions?
  1. Security (Attacker's Point-of-View)
     - How difficult is it to determine the answers to the questions?
     - Demonstration of security often involves quantitative analysis
  2. Usability (User's Point-of-View)
     - How easy is it to choose questions?
     - How easy is it to remember the answers?
     - Demonstration of usability often involves qualitative research



Challenge Question Research (2 of 3)

- What has been studied w.r.t. Challenge Questions?
  - Early '90s usability studies referred to 'word pairs,' and 'associative' or 'cognitive passwords'
  - Focused on facts, opinions or interests. Studies [Haga *et al*.] suggested facts were easier to recall, but more easily guessable by friends or family
  - Early '00 analysis focused on tolerating users either forgetting or mistyping answers with secret sharing and error correction [Ellison *et al.*, Frykholm *et al*.]
  - Recent work [Rabkin, Jakobsson *et al*.] has focused directly on the insecurity of administratively-chosen challenge questions, and on specific questions ('Mother's Maiden Name')
  - Jakobsson *et al.* have published a novel solution based upon user preferences (binary), though more usability study is needed

Challenge Question Research (3 of 3)

- And while other forms of authentication have received more study, not all is transferable
  - 'Known' information risk is difficult to quantify
- A systematic analysis of the security and usability of challenge questions is lacking
- Basic facts regarding Challenge Questions aren't known

Our Research (1 of 2)

- Our goals are to answer the following:
  - Do users choose secure questions?
  - Do users choose memorable answers?
  - Can we lead *realistic* yet *ethical* authentication experiments?Investigation of security and usability of user-chosen challenge questions

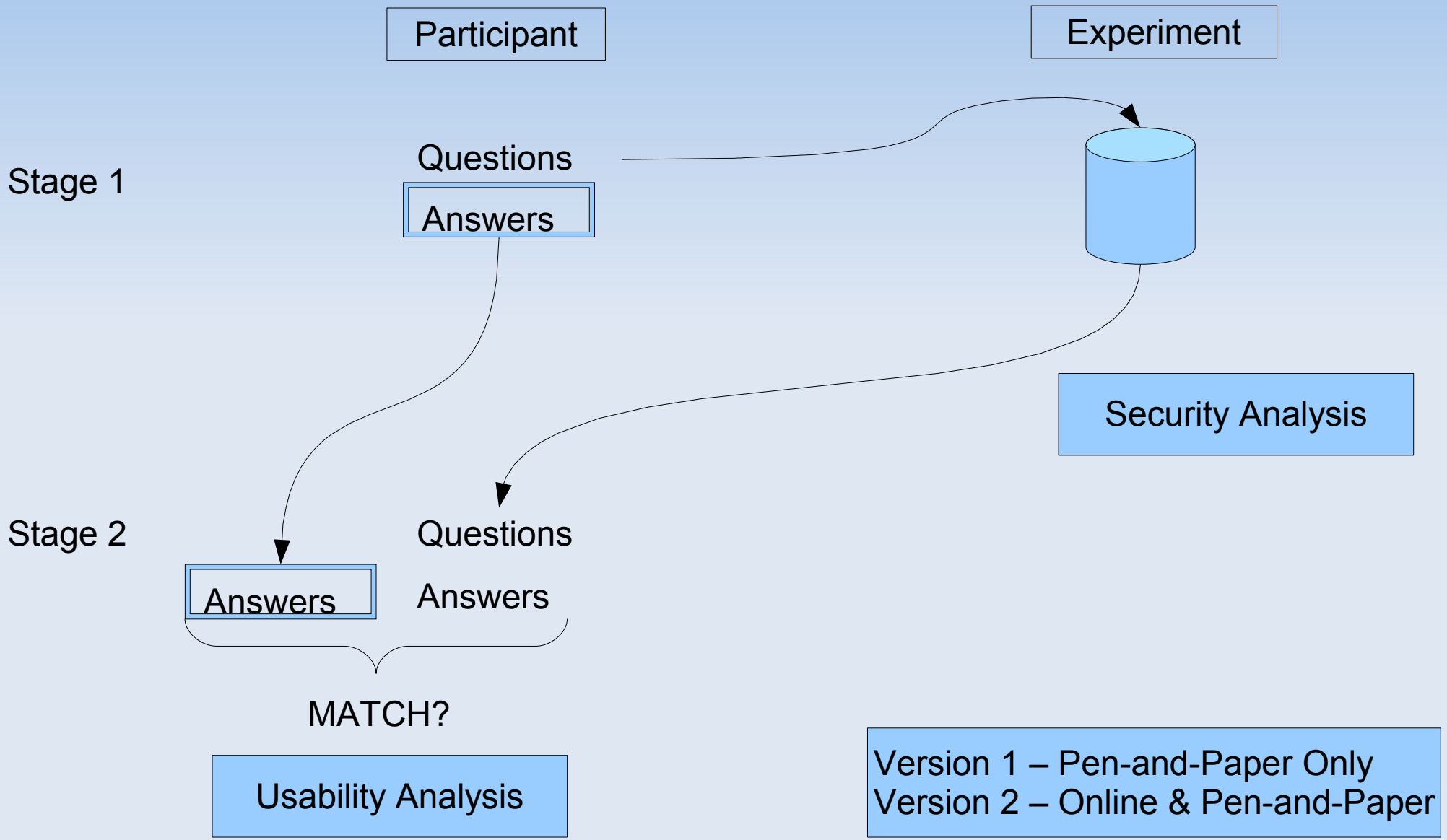
Our Research (2 of 2)

- Lead(ing) three experiments
  - HCI class – Oct/Nov 2008
  - Computer Security class – Jan/Feb 2009
  - Biology class – Jan/Feb 2009
- 170 participants submitted 500 questions
- The remaining slides review our preliminary results

Experiments (1 of 3)

- Collecting authentication data can be tricky
  - Users are consistently told to not reveal their authentication information
  - For our analysis, we'd like to see this information
  - Ethically, we could ask for their information
  - But will users give use 'real' information?
- Our solution
  - Pen-and-paper experiments where participants retain their authentication credentials
  - Participant self-assessments

Experiments (2 of 3)



Experiments (3 of 3)

- Participants use of 'real' Questions and Answers
  - We asked if participants would use same Questions and Answers in real applications (e.g. Banking)
  - Of the respondents (92%) indicating that they would likely re-use their questions, 61% indicated some influence from not submitting their answers
- Participants and personal privacy
  - We asked participants if they would be concerned if their friends or family members knew their Questions and Answers
  - More than two-thirds of the questions raised 'no concern' at all for participants with < 10% meriting strong concern

Security Analysis (1 of 7)

- Existing security analysis of Challenge Questions is limited, and extremely ad hoc
- There are no clear guidelines for choosing 'good' questions and answers
- We're attempting to follow a more systematic approach that will either
  - Provide some guidance for secure design, or
  - Recommend abandonment of the concept

Security Analysis (2 of 7)

Attack Methods	Information Available to Attacker
Blind Guess	Attacker knows the answer alphabet and probability distribution of the answer characters.
Focused Guess	Attacker also knows (or can guess) valid user identifiers and determine the challenge questions. From the questions the attacker can determine a set of possible answers and their probability distribution.
Site-Specific Guess	Attacker can also infer additional information about the user, including gender, age range, interests, place of residence, based upon the site at which the questions and answers were registered.
Personalized Guess	Attacker can also determine information specific to a targetted user.

Security Analysis (3 of 7)

- Blind Guess
  - Based upon our prelimary experiment results the average answer length is 7.95 characters
  - Unlike passwords, the alphabet for answers is just 26 lowercase letters (plus 10 digits in some cases)
  - With uniformly distributed answers, we have entropy (uncertainty) of 4.7*8=37.6 bits for 8-character answer
  - According to Shannon, for answers from English lang. we can reduce to 2.3*8=18.4 bits of uncertainty (approximately 350,000 answers)
  - For comparison, a uniformly chosen password (upper and lowercase, numbers) has approx. 6*8=48 bits of uncertainty

Security Analysis (4 of 7)

- Blind Guess (cont'd)
  - Use of a single question seems to provide insufficient protection against the simplest attack (Blind Guess)
  - Conclusion: Without knowledge of the questions, or personal details, attacks will succeed
  - Why? It's a numbers game.
  - For a targetted attack (online), some attackers will succeed
  - For a random attack (online), some accounts will be compromised
  - For an offline attack, all attackers would succeed

Security Analysis (5 of 7)

- Focused Guess
  - Knowing question gives further reduction in uncertainty (and questions are effectively public)
  - E.g. ”What was my first pet's name? (http://www.babynames.com/Names/Pets/ gives the top 200 names for dogs & cats)
  - Most questions suggest a small target answer space (see Table)
  - Some questions simply suggest very low entropy answers, e.g. ”What religion is my father?”, ”Favourite colour?”

Answer	**%**
Proper Name	45%
Place	22%
Name	15%
Number	6%
Time/Date	4%
Ambiguous	8%

Security Analysis (6 of 7)

- Site-Specific Guess
  - Dependent upon the site, one can sometimes learn the likely gender, age range, interests, place of residence of users
  - E.g. ”First album bought?”, ”Who is my favourite actor?”
- Personalized Guess
  - Only necessary once previous attacks have been exhausted
  - E.g., ”Mother's Maiden Name” is often easy to determine from public records

Security Analysis (7 of 7)

- User Perceptions of Security
  - We asked participants how difficult they believed it would be for (i) strangers, or (ii) friends/family to determine the answers to their questions
- Perceived effort of Stranger to Discover Answers
  - Very difficult (47%), Somewhat difficult (42%), Not difficult at all (11%)
- Perceived effort of Friend/Family to Discover Answers
  - Very difficult (11%), Somewhat difficult (36%), Not difficult at all (53%)

Usability Analysis (1 of 3)

- Usability often refers to 'usable interface design'
- For usable authentication, similar principles apply
  - The user should be able to understand and execute their task
  - We're dealing specifically with information
- In this case, we're more concerned with mental capabilities, e.g., processing, memory

Usability Analysis (2 of 3)

- Applicability
  - Users have sufficient information to provide an answer to a question
  - E.g., 'What was my first pet's name?'
  - Relevant to administratively-chosen questions (not user-chosen)
- Memorability
  - Users can consistently recall the original answer to a question over time
  - Precise recall, 'blank'
- Repeatability
  - Users can consistently and accurately repeat the original answer to a question over time
  - E.g., 'Favourites' change over time, 'Street' versus 'Avenue'

Usability Analysis (3 of 3)

- Our initial results suggest some difficulty with perfect recall of answers
  - 15% of respondents in our first experiment gave either a completely different, or slightly different answer
  - Comments suggest that 'complicated answers' and allowance of free-form answers may be culprit
  - Further results indicate high incidences of recall (perhaps due to our participant population - students)

What Does it All Mean? (1 of 3)

- Our preliminary results indicate that relying upon only a single question-answer is insecure
- Some Candidate Recommendations
  - Require multiple questions at authentication
  - Dynamically assess Questions and Answers at registration
  - Use fixed-form answers (e.g., drop-down menus)

What Does it All Mean? (2 of 3)

- Next Steps
  - Third experiment ends tomorrow
  - Complete our security assessment (vs user perception) by aligning to Attack Model
- Other 'Lessons Learned'
  - 'Prizes' not necessarily sufficient for participation
  - Require much larger groups for meaningful usability results

What Does it All Mean? (3 of 3)

- Looking ahead ...
  - Study the impact of our recommendations
  - Investigate use of 'more recent' information for authentication (not 'original' answers)
  - More study of Jakobsson's 'preferences' solution
  - Use of images, or image-elicited passwords

Further Information

- Project web site
  - http://homepages.inf.ed.ac.uk/mjust/KBA.html
- Email
  - mike.just@ed.ac.uk