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Duress Authentication via Partially Homomorphic Encryption

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Overview

- **Duress Authentication:** An authentication system that allows users to send duress signals
- Might be used in places like banks as a sort of silent alarm
- Current systems have fatal flaws or require a third party to check all logins
- Current systems are either hard to use or easy to bypass
- We develop a new method to allow duress authentication
- Simple implementation by changing password storage method

Duress Adversaries

We consider adversaries who are physically forcing someone to reveal their password, whether via force, blackmail, or some other threat. In an attack this adversary:

- **Knows the system**
- **Compromises multiple administrators**
- **Monitors all network traffic**
- **Has full system access**
- **Can request as many responses from those they are attacking as they like**
- **Cautious – They will never perform an action that is sure to trigger a duress signal**

The Failings of Current Duress Systems

- Many claims to offer duress authentication
- Included in many US Patents, often as part of a larger system
- All include some flaw that makes them impractical or vulnerable
- They fall into two categories:
- **Two Passwords**: Each user has two passwords. One normal and one duress.
  - People struggle to remember passwords
  - Adversary can guess an win 50% of the time
- **Modified Passwords:** A user modifies their password in some predictable way
  - Type in a random number at the end – vulnerable to typos
  - Move first letter to the end – very obvious

`Securepassword123` → `ecurepassword123S`

A standard password transforms into an obvious duress signal

Our Requirements

For a useful duress password system we require the following features or properties

- **Easy to use:** The system should require minimal learning on the user's end, and should not require a large amount of memorization
- **Undetectable:** The system should not leak a duress signal to someone who does not have authorization to read it
- **Low false-positive rate:** We should ensure that false alarms are not a common occurrence
- **Low false-negative rate:** Adversaries should not be able to bypass the system
- **Spyware-resistant**: A system compromised by spyware before any signal is sent should not be able to reveal who sends a signal

The Keyword System

- Previously proposed by Atallah and Stefanov in 2010[2] – this provides a method for sending a duress signal that is easy for users.
- Don't memorize two passwords.
- Memorize a keyword from a dictionary
- Your assigned keyword is for non-duress logins
- *Any other* keyword is a duress signal
- Keyword dictionary should have high edit distance to avoid typos (e.g. birds)
- This system satisfies the easy-to-use and low false positive/negative rates

Partially Homomorphic Encryption

- Homomorphic encryption allows for operations to be performed on data *while it is encrypted*
- **Fully Homomorphic Encryption:** Any operation can be performed on encrypted data
  - Currently very inefficient!
- **Partially Homomorphic Encryption:** Only some operations can be performed
  - Limited, but efficient
  - E.g. $Dec_{sk}(Enc_{pk}(x) * Enc_{pk}(y)) = x*y$

A New Duress System

Given some partially homomorphic public-key cryptosystem with a homomorphism over a group G with operation • we are able to store extra information in a password file to handle duress signals

- We store **$Enc_{pk}(r_i)$, $Enc_{pk}(kw_i^{-1})$** in addition to the usual password data4
- Password storage now looks as shown below, with new additions in the green columns

Username	Salt	H(salt + pwd)	$Enc_{pk}(r_i)$	$Enc_{pk}(kw_i^{-1})$
alice	`dc433a1f34`	`8f8ff2239b`	`442d50f7e4`	`7f1eb7e075`
bob	`a734ac7cb6`	`72ff38eb2d`	`9c670ba400`	`8074ed62c9`
…	…	…	…	…

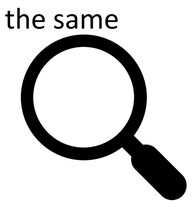
The Login Process

1. The user enters their password
   1. Check if H(pwd,salt) matches the stored data. If so continue, else reject
2. The user enters a keyword, kw'
   1. If kw' is not in the dictionary reject (probably a typo!)
   2. If it is, overwrite their password file record as follows
      1. **$Enc_{pk}(r_i) \leftarrow Enc_{pk}(r_i) \bullet (Enc_{pk}(kw_i^{-1}) \bullet Enc_{pk}(kw'))$**

- The overwriting process is key. If kw' == kw_i then the encrypted value does not change
- If kw' does not match kw_i, then **$Enc_{pk}(r_i)$** is overwritten with an incorrect value
- Randomization within the cryptosystem prevents attacker from telling if anything changed

Checking for Duress

- Some Duress Authority holds the private keys to the system
  - Ideally external e.g. police, alarm company, but can be in the same organization as well if desired
- Authority stores the correct r_i value for each user
- To check for duress, compare the r_i value with the stored value
  - A mismatch is a duress signal!
- Optionally – a global flag can be kept for quick polling as well
- At this point the duress response is up to the authority



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1. Modified from Randall Monroe's XKCD: Security https://xkcd.com/538/
2. Stefanov, Emil, and Mikhail Atallah. "Duress detection for authentication attacks against multiple administrators." *Proceedings of the 2010 ACM workshop on Insider threats*. ACM, 2010.

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