Privacy Protection for Social Media based on a Hierarchical Secret Image Sharing Scheme

September 23, 2019
ICIP 2019 – Taipei (Taiwan)

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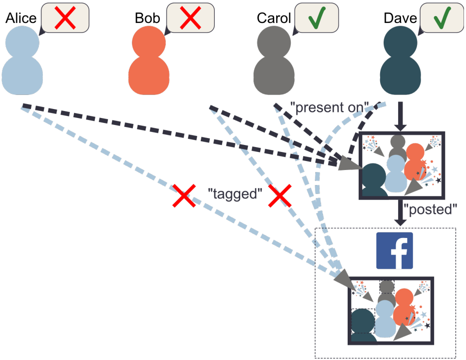
Multimedia content privacy issues

Social media

- 3.2 billion active users, *i.e.* 42% of global population
- 1,200 billion images taken per year
- 500 million images shared on Instagram and Facebook per day



Multiparty privacy conflict

Mainstream social media solutions

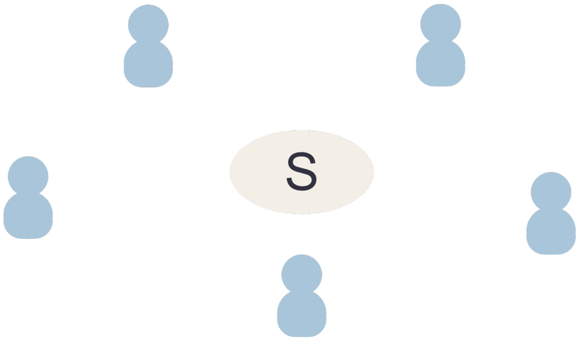
- *Tagging/Untagging*
- Report **inappropriate** content
- Ask the **owner** to remove content

Proposed solution

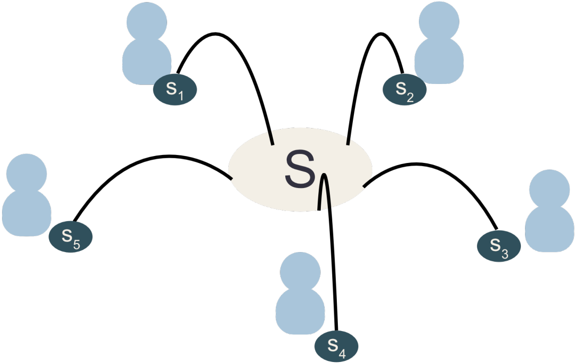
- Preserve privacy of users
- Negotiate **collectively**

J. M. Such and N. Criado. *Multiparty privacy in social media*. Communications of the ACM, vol. 61, no. 8, pp. 74–81, 2018.

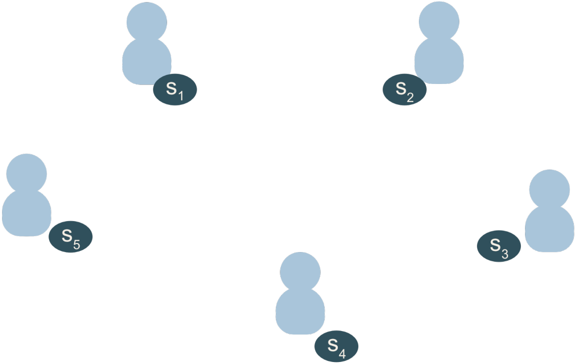
Secret Sharing



Secret Sharing

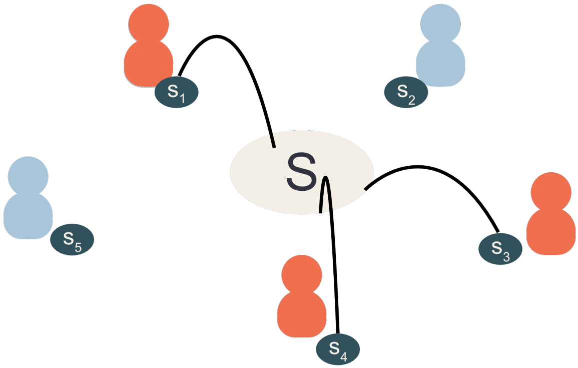


Secret Sharing



Secret Sharing

- For example, $k = 3$



Secret Sharing

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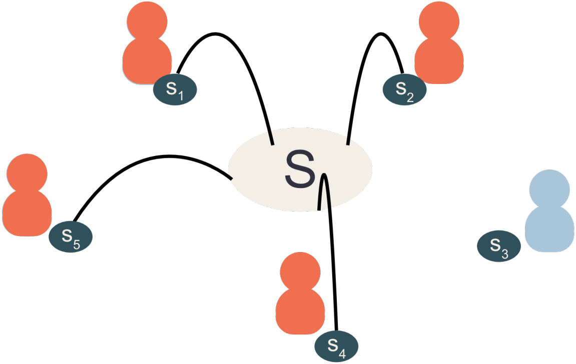
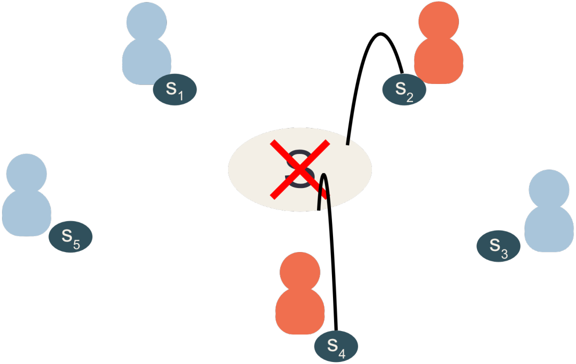


Secret Sharing

- For example, $k = 3$

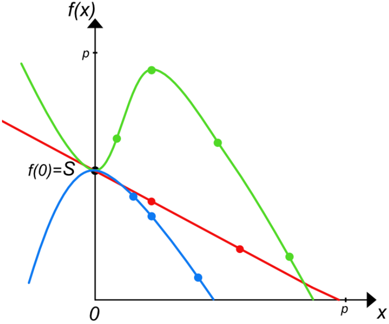


Secret Sharing

(k, n)-threshold scheme (Shamir, 1979)

Based on polynomial interpolation: $f(x) = \sum_{i=0}^{k-1} a_i \times x^i$

- Finite field $\mathbb{F}_p$ where p is prime
- $a_0 = S$ with $S \in \mathbb{F}_p$
- Share $s_j = (x_j, f(x_j))$ where $j \in \{1, ..., n\}$ and $x_j \in \mathbb{F}_p^*$

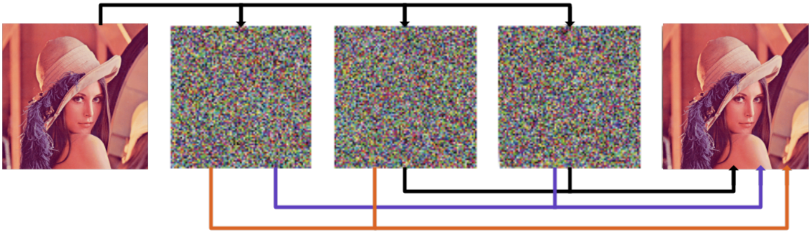


A. Shamir. *How to Share a Secret*. Communications of the ACM, vol. 22, no. 11, pp. 612–613, 1979.

Secret Sharing applied on images

Secret Image Sharing (Thien and Lin, 2004)

- Sharing pixel values
- Shares are images

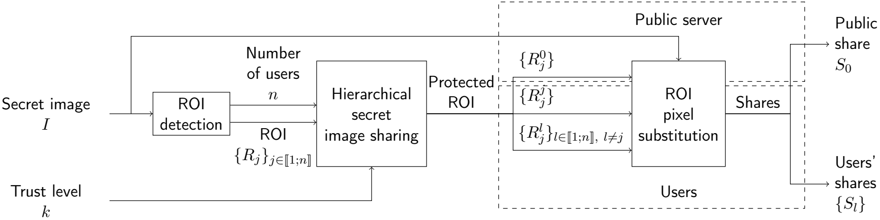


C.-C. Thien and J.-C. Lin. *Secret image sharing*. Computer & Graphics, vol. 26, no. 5, pp. 765–770, 2004.

S. Beugnon, W. Puech and J.-P. Pedeboy. *An efficient lossless* $(2, n)$ *secret image sharing based on Blakley's scheme*. 19th IEEE International Workshop on Multimedia Signal Processing, MMSP, October 16-18, 2017.

Outline

Sharing method overview



k-order polynomial generation

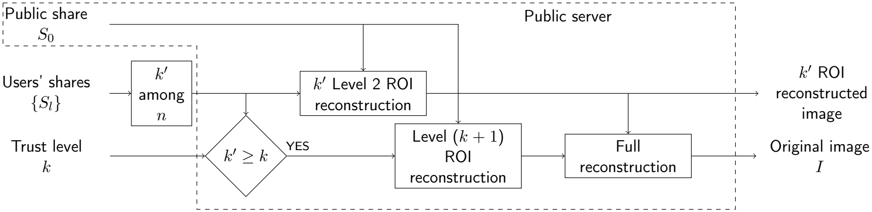
- Generation of a random sequence $a_0, a_1, \ldots, a_{k-1}$
- a_k set to s
- k-order polynomial: $f(x) = \sum_{i=0}^{k} a_i \times x^i$

Sharing method

3 scenarios for sharing s values from R_j

- For the public share S_0
  - Threshold 2
  - 1-order polynomial
  - $f^{(k+1-2)}(x_0) = f^{(k-1)}(x_0)$
- For the user x_j
  - Threshold 2
  - 1-order polynomial
  - $f^{(k+1-2)}(x_j) = f^{(k-1)}(x_j)$
- For the user x_l ($l \neq j$ and $l \neq 0$)
  - Threshold $k+1$
  - k-order polynomial
  - $f^{(k+1-(k+1))}(x_l) = f(x_l)$

Reconstruction method overview



Outline

Multiparty privacy conflict issues in social media

Hierarchical secret image sharing scheme for privacy protection

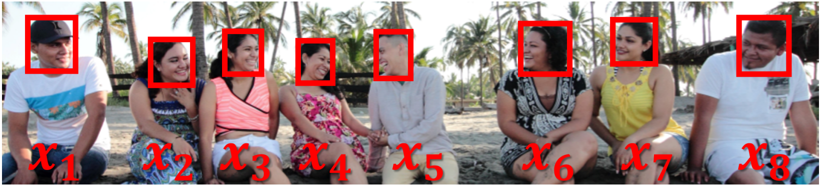
Experimental results

Conclusion and future work

Experimental results

Experimental setup

- Detection: social media tagging
- Parameters $k = 5$, $n = 8$ *Majority consensus*



Experimental results

Experimental setup

- Detection: social media tagging
- Parameters $k = 5$, $n = 8$ *Majority consensus*

- Public share S_0

Experimental results

- Using the share S_2 of user x_2 and the public share S_0

- Using the share S_4 of user x_4 and the public share S_0

Experimental results

- With user group $\{x_1, x_2, x_4\}$ and the public share S_0 $(< k = 5)$

- With user group $\{x_1, x_3, x_5, x_7, x_8\}$ and the public share S_0 $(\geq k = 5)$

Experimental results

Statistical analysis of shares

- High entropy (around 7.997 bits per pixel per channel)
- Low spatial correlation (around 0.0012)

Outline

Conclusion

- A new application case for Secret Image Sharing
- A new solution to resolve Multiparty Privacy Conflicts

Future work

Rendering improvement

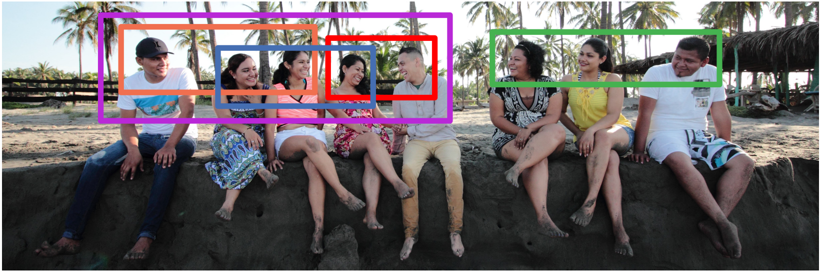
- Pixel masking
- Face edges instead of a bounding box

M.R. Anderson *et al. Brainwash: A Data System for Feature Engineering*. Cidr 2013

Future work

Hierarchical Secret Image Sharing for multigroups

- Use advanced privacy configuration
- Hierarchy among users
- Visible only for *friends*, *acquaintances*, *others*



Thank you for your attention!

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