State-Level Secrets

When Theory Meets Practice for Journalists Working with Encrypted Documents

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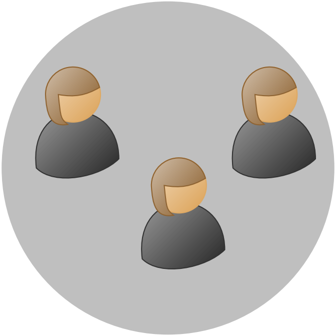
(t, n)-Threshold Schemes and Journalism

$(2, 3)$-Threshold Scheme Example



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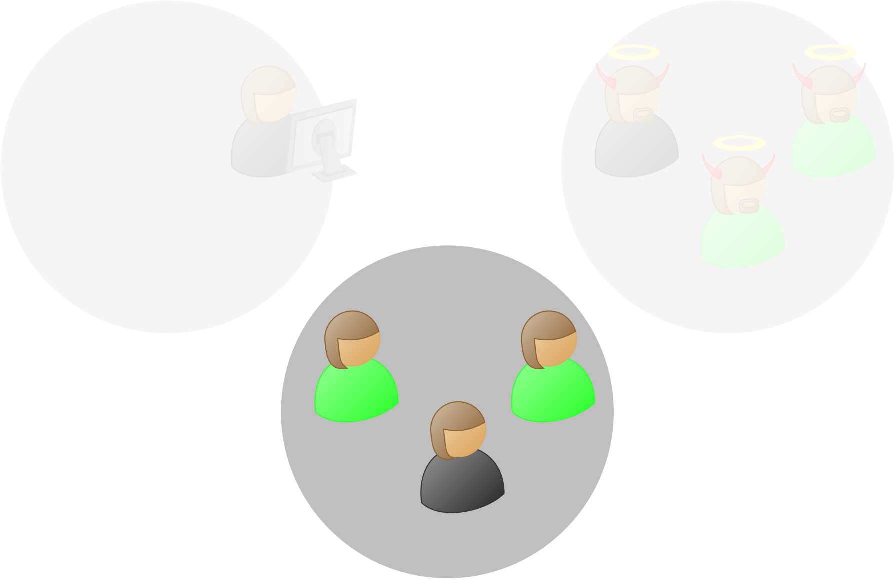

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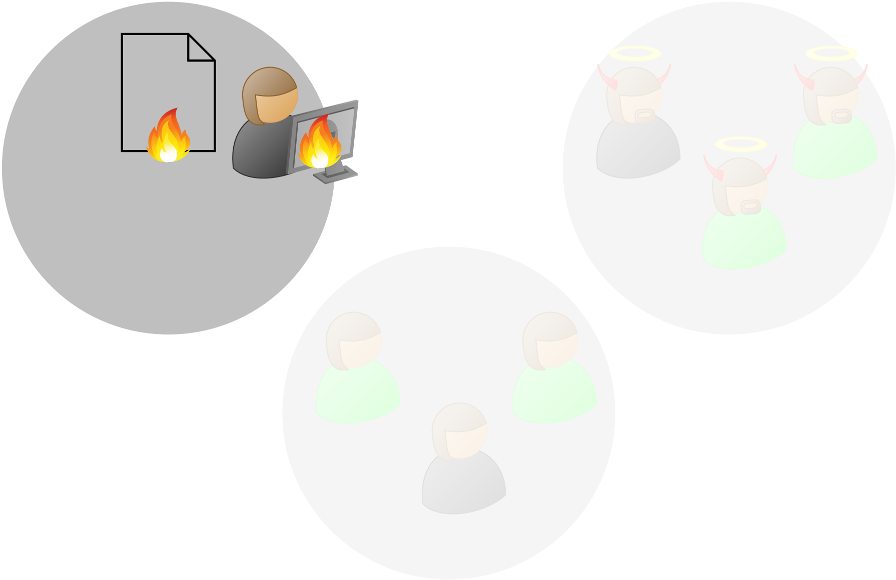

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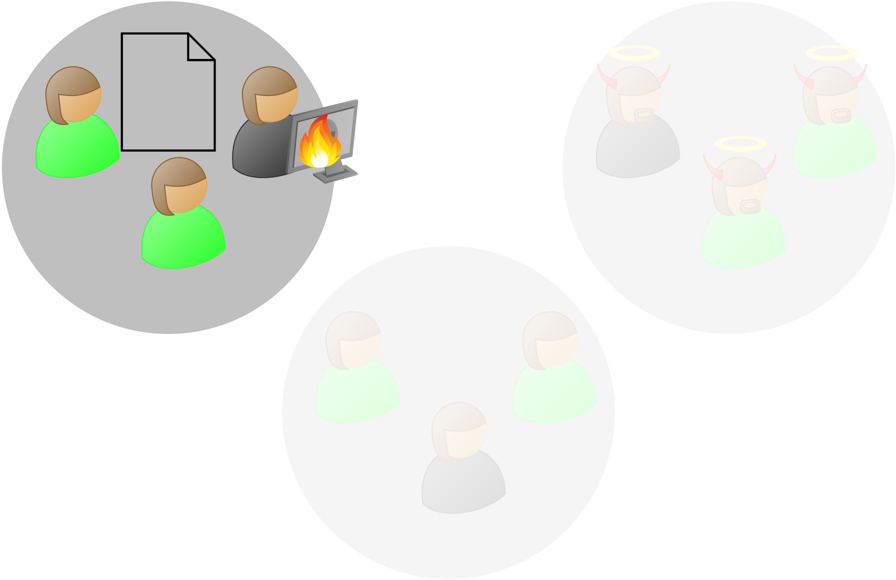

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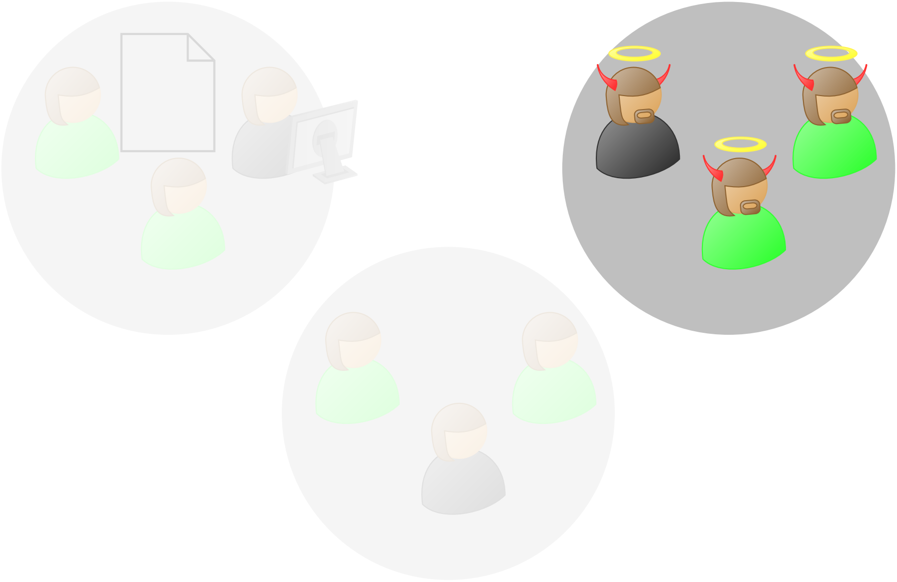
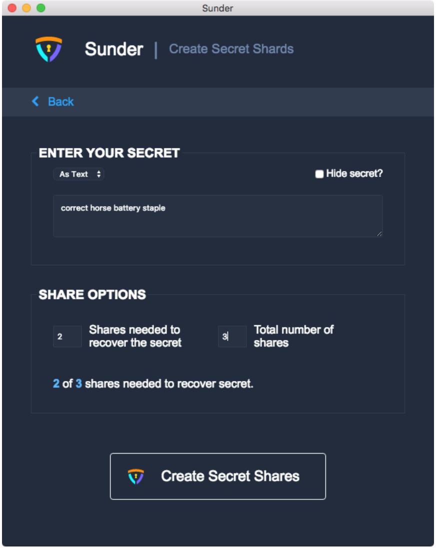


Freedom of the Press Foundation and Sunder



ENTER YOUR SECRET

As Text

□ Hide secret?

correct horse battery staple

SHARE OPTIONS

2 Shares needed to recover the secret

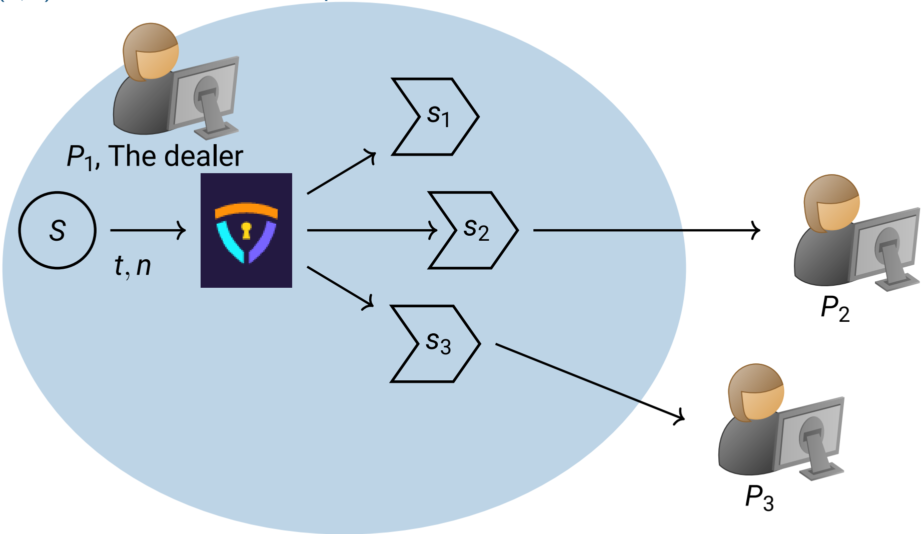
3 Total number of shares

2 of 3 shares needed to recover secret.

github.com/freedomofpress/sunder

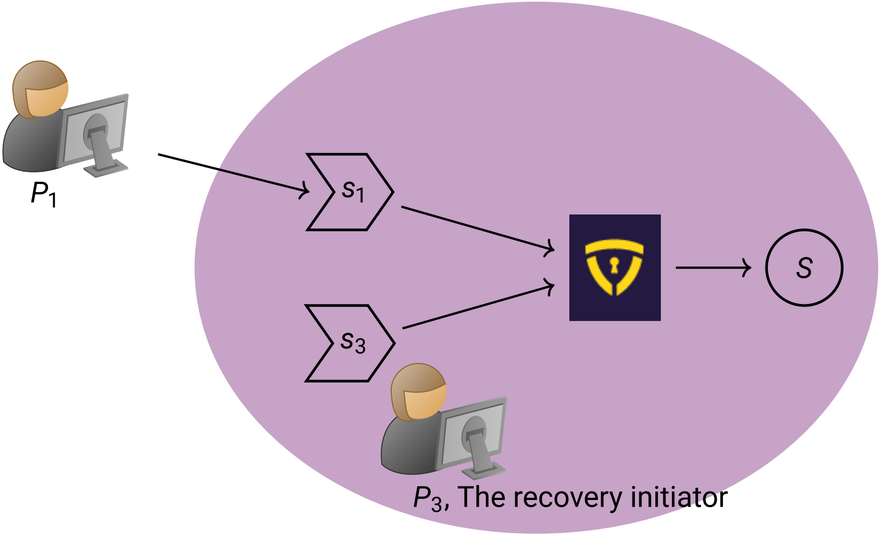
Basic Secret Sharing as a Protocol: Generation and Distribution

$(2, 3)$-Threshold Scheme Example



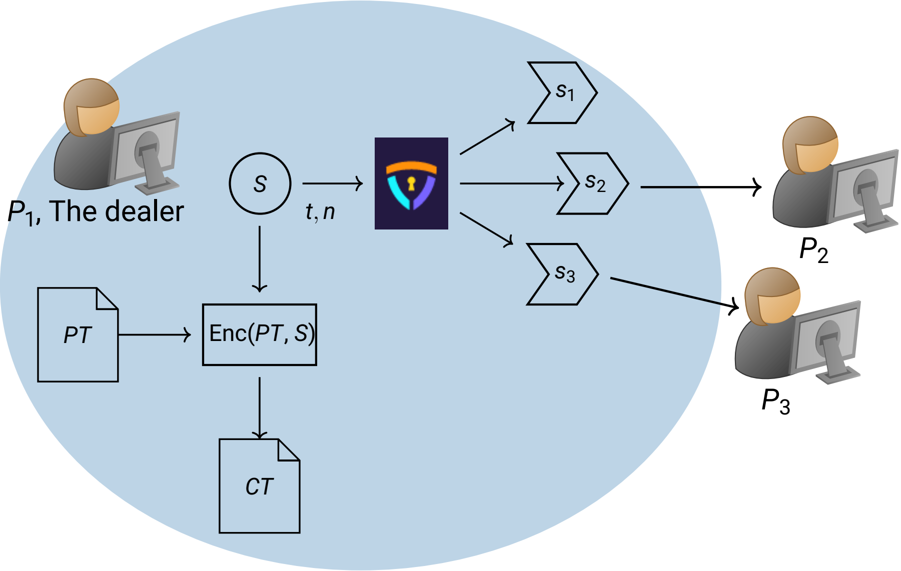
Basic Secret Sharing: Reconstruction

(2, 3)-Threshold Scheme Example



Expanded Secret Sharing: Generation and Distribution

$(2,3)$-Threshold Scheme Example



Expanded Secret Sharing: Generation and Distribution

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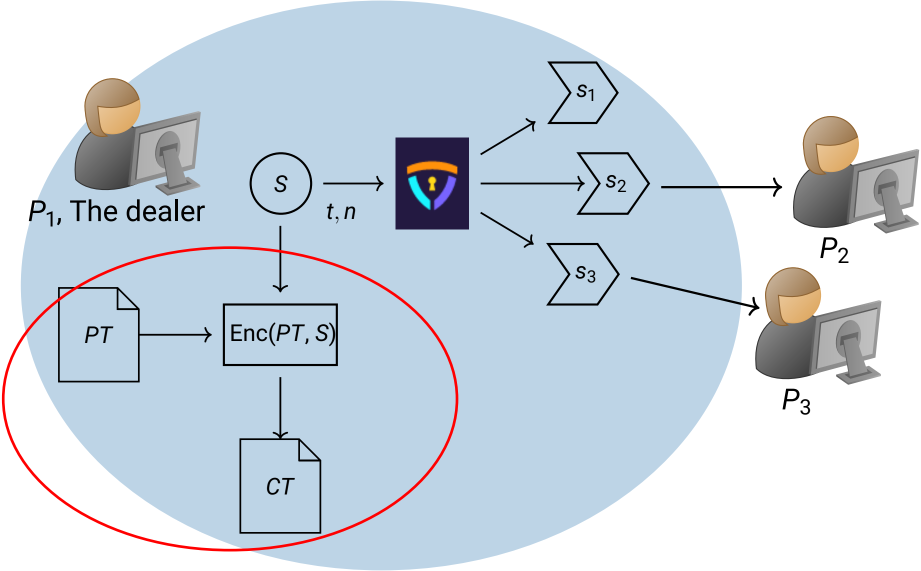
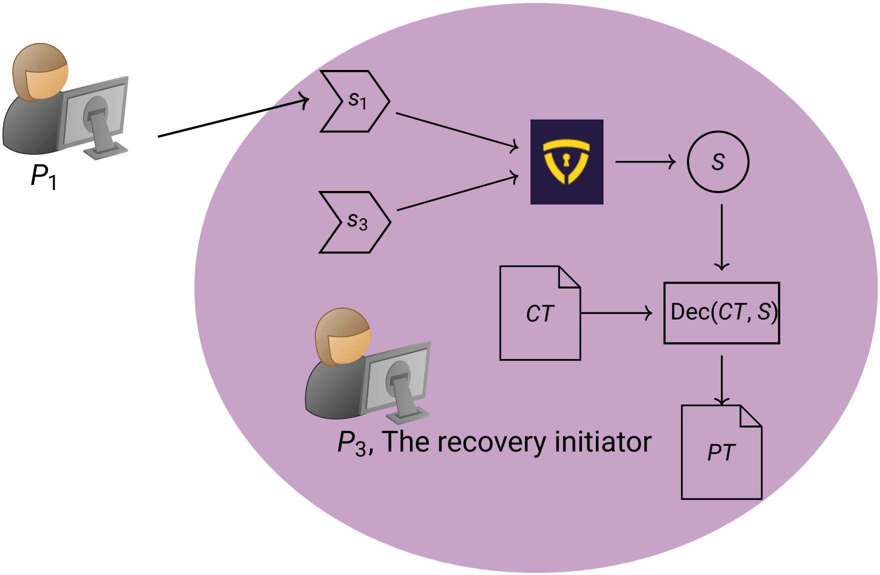


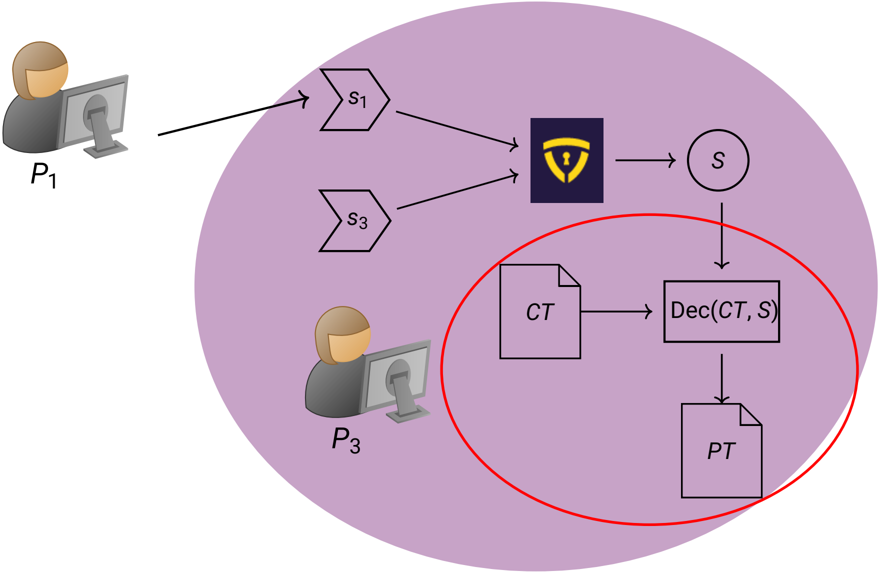
Expanded Secret Sharing: Reconstruction

$(2, 3)$-Threshold Scheme Example



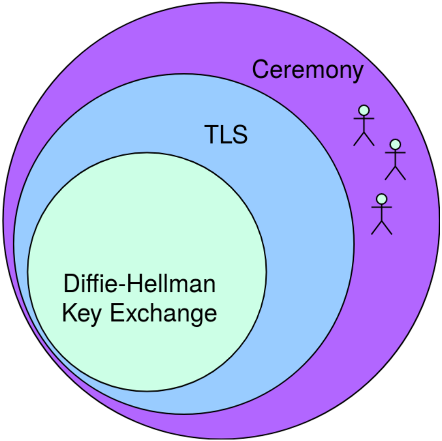
Expanded Secret Sharing: Reconstruction

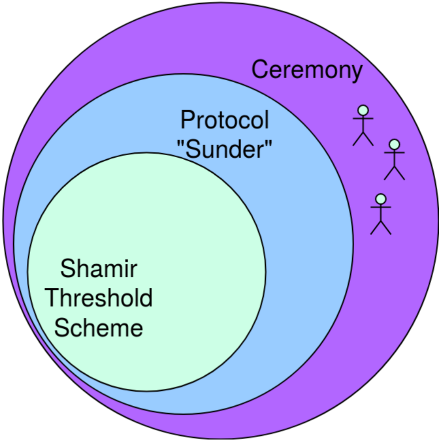
$(2, 3)$-Threshold Scheme Example



Ceremonies and Security

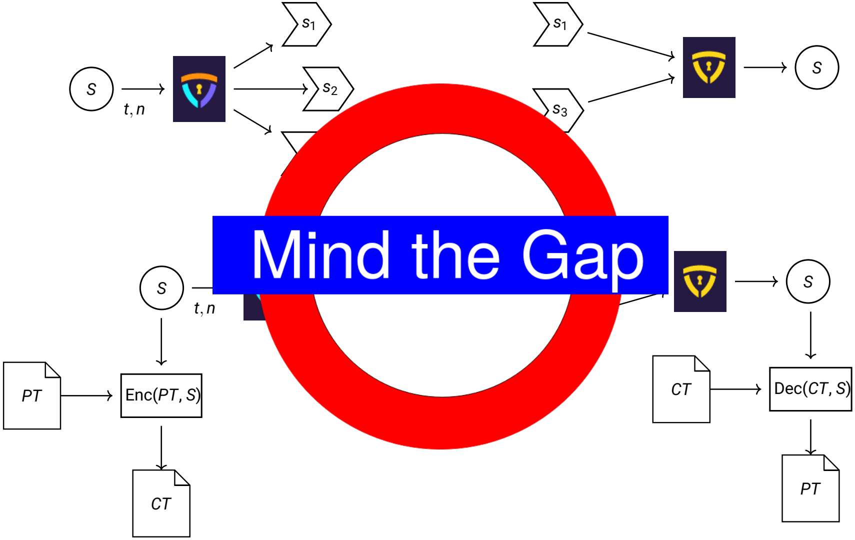
Layers of Security Analysis





C. Ellison, Ceremony Design and Analysis, 2007.

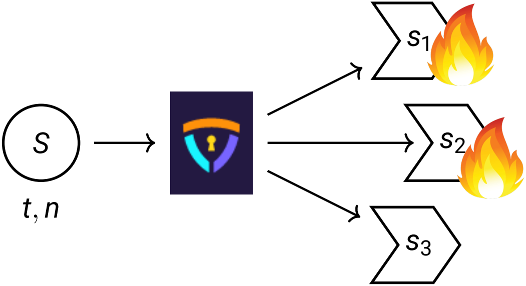
Protocol and Ceremony Security



Gaps and Improvements: Base

Share Loss: Gaps

Protocol

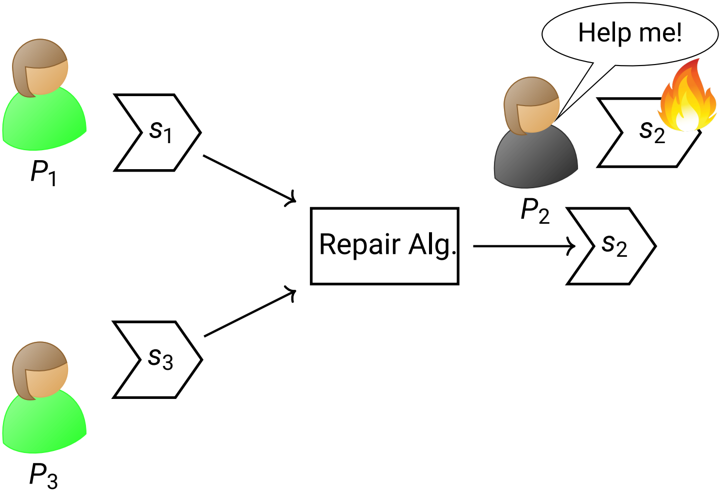


Loss of $n - t - 1$ shares renders the secret unrecoverable.

Attackers can destroy or perform a denial of service attack against shares.

Share Loss: Improvements

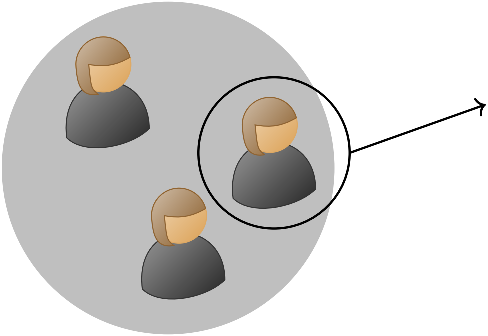
Protocol: (2,3)-Threshold Scheme Example



Laing, Stinson, A Survey and Refinement of Repairable Threshold Schemes, 2018.

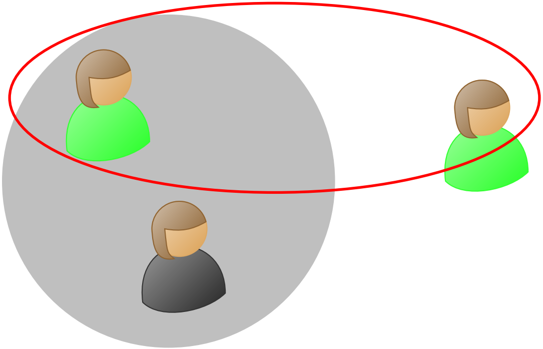
Organizational Turnover: Gaps

Protocol



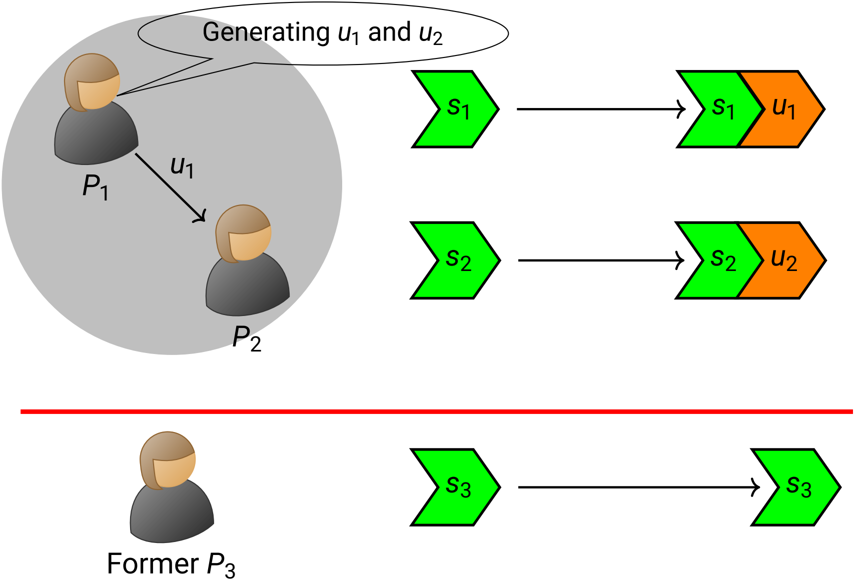
Organizational Turnover: Gaps

Protocol



Organizational Turnover: Improvements

Protocol



Generating u_1 and u_2

P_1

u_1

P_2

s_1 → s_1 u_1

s_2 → s_2 u_2

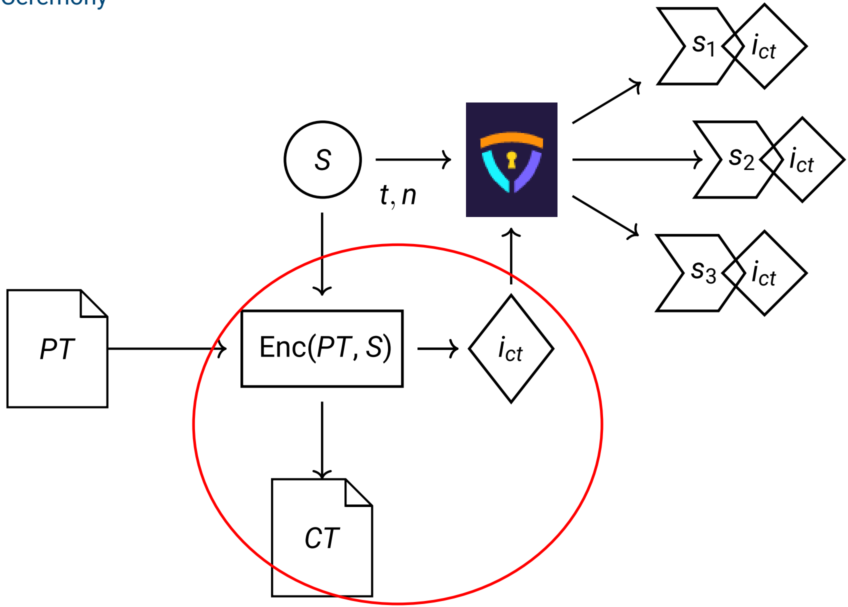
Former P_3

s_3 → s_3

Gaps and Improvements: Extended

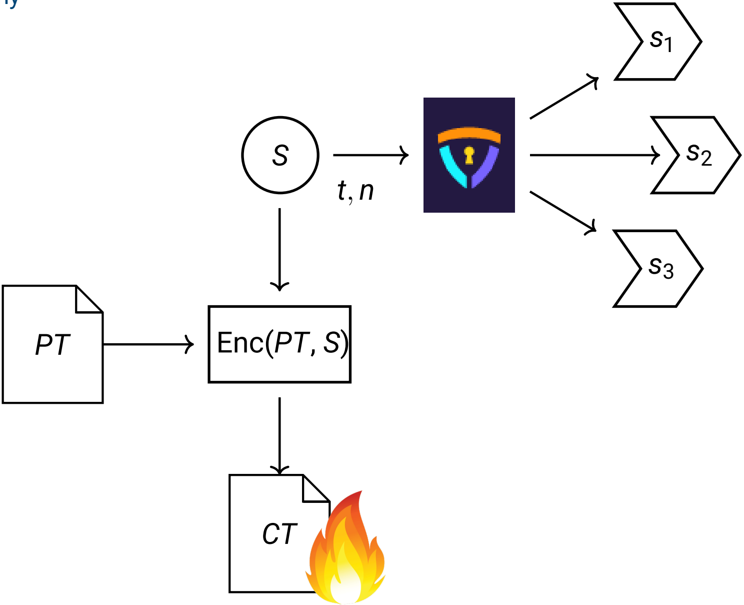
Integrity for Ciphertext: Gaps and Improvements

Ceremony



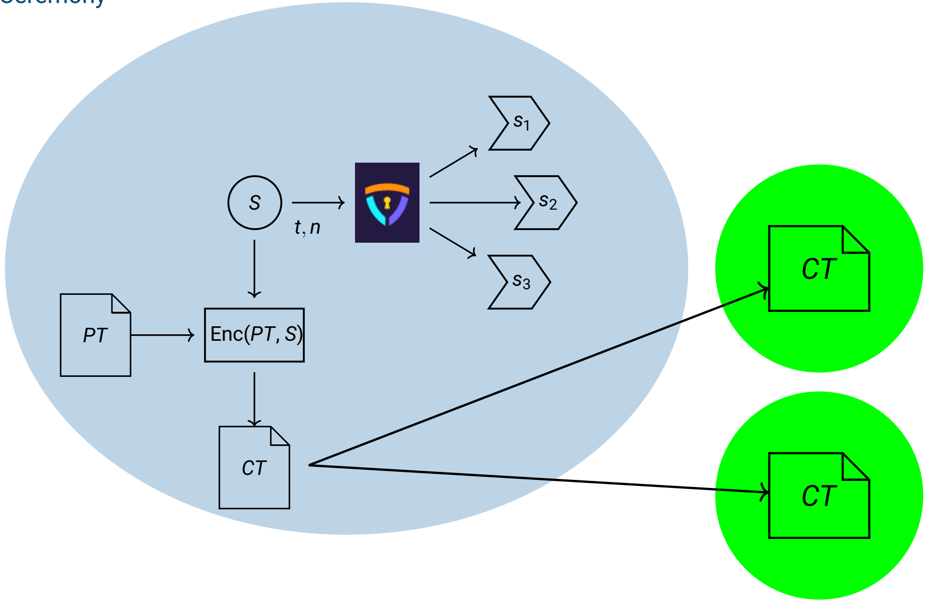
Redundancy for Ciphertext: Gaps

Ceremony



Redundancy for Ciphertext: Improvements

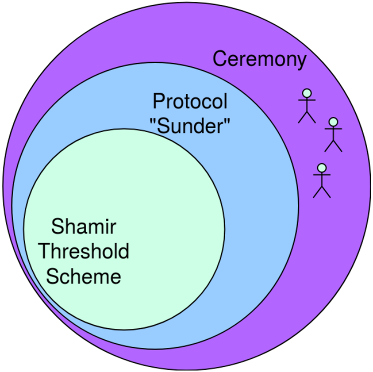
Ceremony



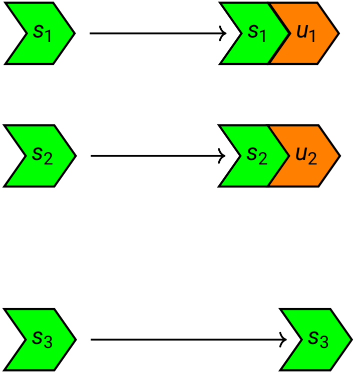
Ongoing and Future Work

Current Work

Complete Ceremony Analysis



Updating Shares Functionality



Future Work

- Adding implementations of repairing algorithms for lost shares
- Designing schemes to limit dealer trust

Takeaways

- Secret sharing schemes are not suitable for real-world use as-is
- Actionable improvements for gaps found in integrity, confidentiality, authenticity, and availability
- Ceremony analysis identifies gaps between user responsibility and security expectations

Thank You!

Watch for our paper at crysp.uwaterloo.ca