# GNUnet-BOSS: A multiplicative secret sharing subsystem for GNUnet

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Course: Peer-2-Peer Systems & Security

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# Overview

1. Problem & motivation

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2. Related work
3. The project
4. Conclusion

# Secret sharing

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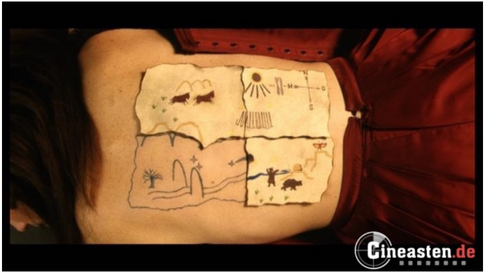
- splitting a secret up into parts that can be distributed and
- (when enough parts (*shares*, *shadows*) come together) reconstructed



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    - destroy the original secret.

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- You can scale a shared secret (multiply by a scalar value).
- And, if you are really courageous you can multiply shared secrets (with each other).

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- $n$ shares are distributed, but $t + 1$ suffice to recover the secret (while $t$ shares do not reveal it).
- Call this a $(t + 1, n)$-threshold scheme.

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Crypto-anarchy?!

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- Transformation-based approach to secure multi-party linear programming.
- Linear program is shared among parties and then transformed via distributed matrix multiplications, to be solved by a standard LP solver.
- There are also direct approaches (SMC version of the Simplex algorithm).

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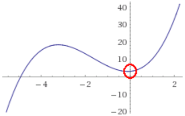

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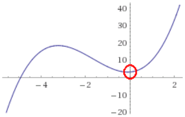


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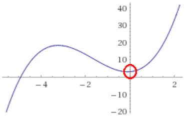


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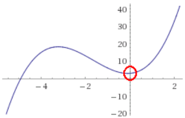


- Create $n$ shares by evaluating polynomial at $n$ distinct, non-zero points.
- With $t + 1$ such shares the polynomial is uniquely identified and can be recovered and evaluated at 0 to yield the secret.
- $t$ shares (or less) do not reveal anything about the secret.

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- Achieved by having the sharing party commit to the shares by publishing a special value.
- This is already implemented in GNUnet in the context of anonymous voting / distributed key generation / cooperative decryption. (Thank you, Florian!) – Remains to be seen how adaptable it is for our purpose.

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- Adding secrets: adding shares means adding polynomials. Adding polynomials means the constant coefficients are added.
- The same holds for scaling.
- Actually, it also holds for multiplication. But there is a problem. Any ideas?
- Multiplying polynomials increases the degree! We need to be able to reconstruct the secret from the polynomial, so choose $t = \left\lfloor \frac{n-1}{2} \right\rfloor$.

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- This can be done using a rather complicated and communication-heavy protocol.
- Our goal: make it (almost) transparent to the user of the GNUnet service by wrapping it in a simple API.

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- Assumption: The initiator has a list of potential participants which he/she passes to the service.
- A few (very general) message types `INIT`, `INFORM`, `REQUEST`.
- Keep protocol extensible by allowing message subtypes (initialize session / sharing / operation, etc.).

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- code cleanup & refactoring

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- Make some fundamental changes to the underlying secret sharing library.
- Adjust to allow applications to perform (specifically for the problem) optimized operations (e.g. matrix multiplication).
- Allow transference of shares.

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- How should client disconnects be handled? What about "partial" disconnects (only some nodes)?
- Communication complexity issues.
- Reconstruction requires trust. If I send you my share, can I be sure you will send me yours?
- All other problems we are too unimaginative to think of. Any ideas?

# That's it!

Thank you for your attention!

Questions, comments?

# The complete degree reduction protocol

Let $f$ `[i]` denote the share of the polynomial $f$ at point $x_i$ (owned by player $i$). Let $h(x)$ be the polynomial for which degree reduction should be performed.

1. $\forall i$. Player $P_i$ generates random polynomial $q_i$ with secret 0 and $\forall j$. shares $q_i$`[j]` with player $P_j$.
2. $\forall i, j$. Player $P_i$ sums up $q_j$`[i]` he received in the last step to obtain $q$`[i]`.
3. $\forall i$. Player $P_i$ computes $\beta_i = h'\texttt{[i]} = h\texttt{[i]} + q\texttt{[i]}$.
4. $\forall i, j$. Player $P_i$ shares $\beta_i$`[j]` with player $P_j$.
5. $\forall i, j$. Player $P_i$ computes $\delta_j\texttt{[i]} = A \cdot \beta\texttt{[i]}$ and restores $\delta_j$`[i]` to player $P_j$.
6. $\forall j$. Player $P_j$ computes $\delta_j$, his share of the reduced polynomial.

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