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The Subset-Sum Problem

cryptanalysis employing a probabilistic approach

@ KU Leuven, 22.09.2016 – 13.30

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1 The Subset-Sum problem

- Motivation
- Historical Remarks
- Easy and Hard Instances
- Evolution of Algorithms
- Technique 1 - Meet in the Middle
- Technique 2 - Enlarge Number Set
- Applications

Outline

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Definition 1 (Subset-Sum)

$$\text{Given } n, S, a_1, a_2, \ldots a_n \in \mathbb{N}, \text{ find } I \subseteq [n] : \sum_{i \in I} a_i = S. \tag{1}$$

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  - worst-case instances are computationally intractable

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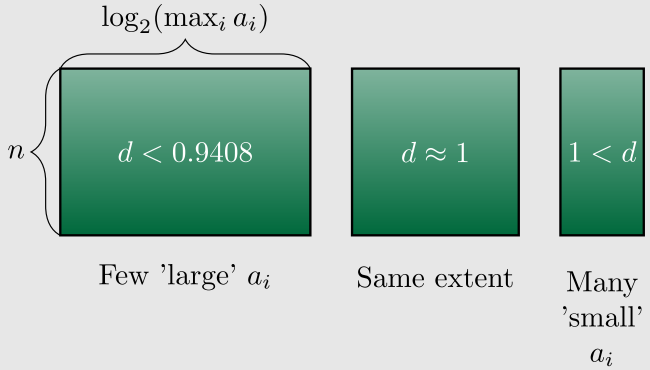

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  3. Finding x given (a, S) is (assumed to be) computationally hard.

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Table: Expected time and space requirements of algorithms solving Eq. (1).

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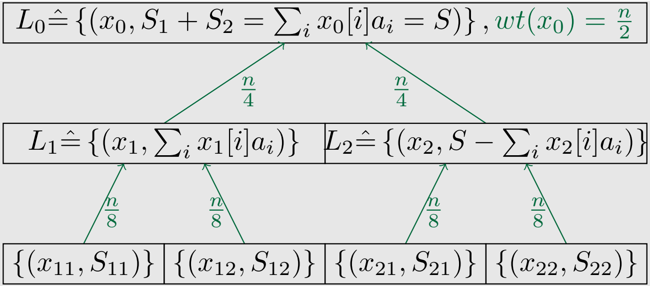

Figure: Schröppel-Shamir: Combining disjoint sub-problems of smaller weight.

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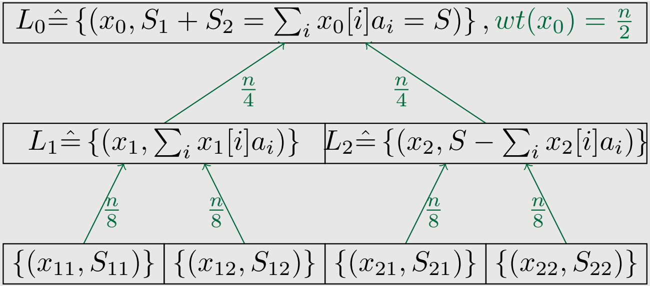

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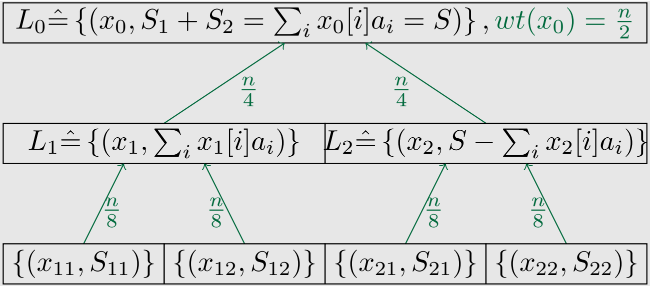

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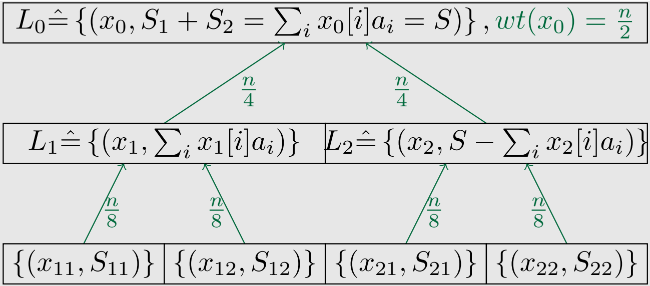

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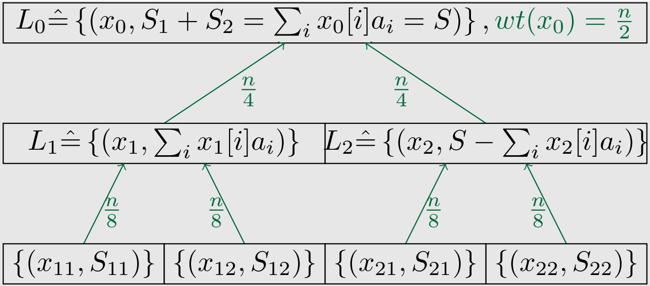

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- Merge L_1, L_2 to solutions $(x_0, S) \in L_0$ of the Subset-Sum problem.

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Technique 2 - Enlarge Number Set

$$\boxed{L_0 \hat{=} \left\{(x_0, \sum_i x_0[i]a_i = S_1 + S_2 = S)\right\}, wt(x_0) = \frac{n}{2}}$$

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$$\boxed{L_1 \hat{=} \left\{(x_1, \sum_i x_1[i]a_i)\right\}, wt(x_1) = \frac{n}{4}}$$

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- Speed-ups if $x_1[i], x_2[i] \sim \mathcal{D}(\{-1, 0, 1\})$ w.r.t. distribution $\mathcal{D}$.

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Setup: A preprocessed length n text T is stored in the cloud.

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Setup: A preprocessed length n text T is stored in the cloud.
Given: A pattern P of length $m \leq n$, find all locations of P in T.

Applications

- These cryptanalytic methods are meta-techniques
- Applicable to lattice- or code-based $\mathcal{NP}$-`complete` problems

Example 2 (Outsourcing a database to the cloud [1])

Setup: A preprocessed length n text T is stored in the cloud.
Given: A pattern P of length $m \leq n$, find all locations of P in T.
Goal: Cloud learns no information about text T and pattern P.

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Outsourced pattern matching.
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QUESTIONS?

Thank you for your attention!

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