Attack-Defense Trees

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https://www.mdr.de/sachsen/dresden/dresden-radebeul/kunstraub-kunstsammlungen-dresden-100.html, 02.01.2020

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- More complex security measures are followed by more sophisticated attacks - an endless race

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- How can newly discovered attacks be efficiently and systematically documented?

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- Tree-like representation of an attack scenario

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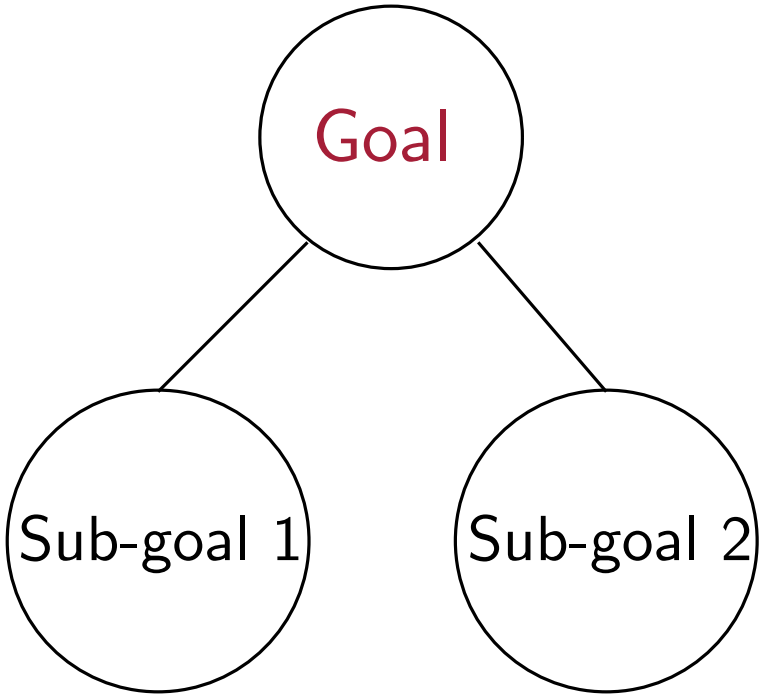

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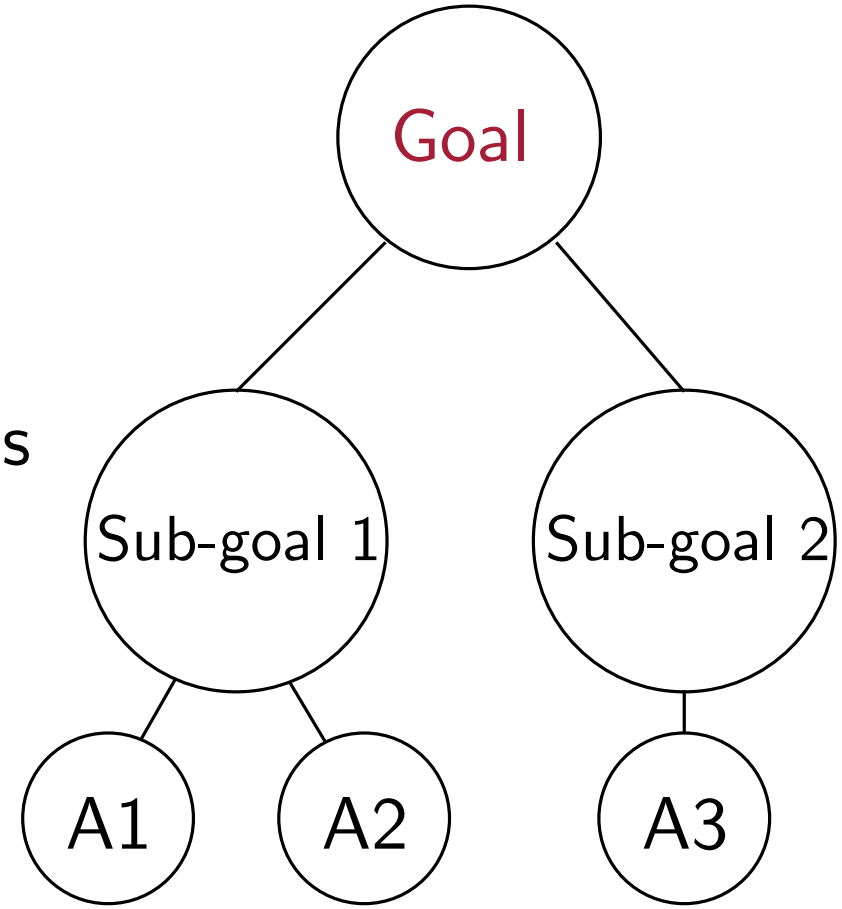
- Root represents attacker's goal
- Children nodes represent sub-goals
- Leaves represent the basic attacks executed by the attacker



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- An extension of the model is necessary for qualitative analysis
  - Attack-defense scenario portrayed as game between a proponent p and an opponent o

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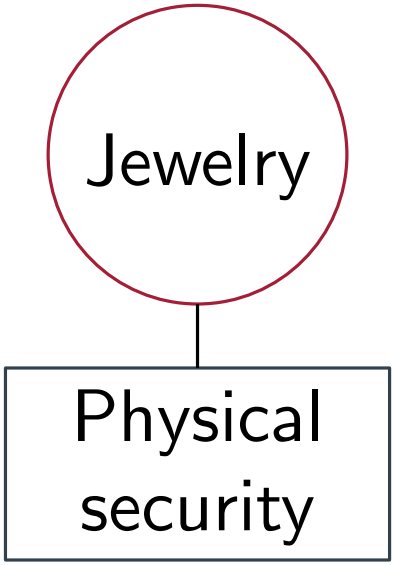

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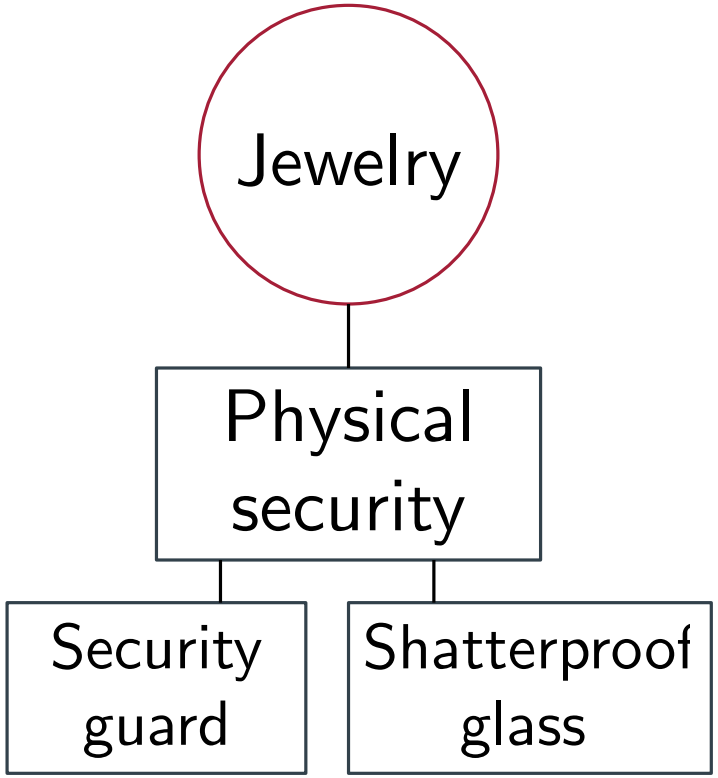

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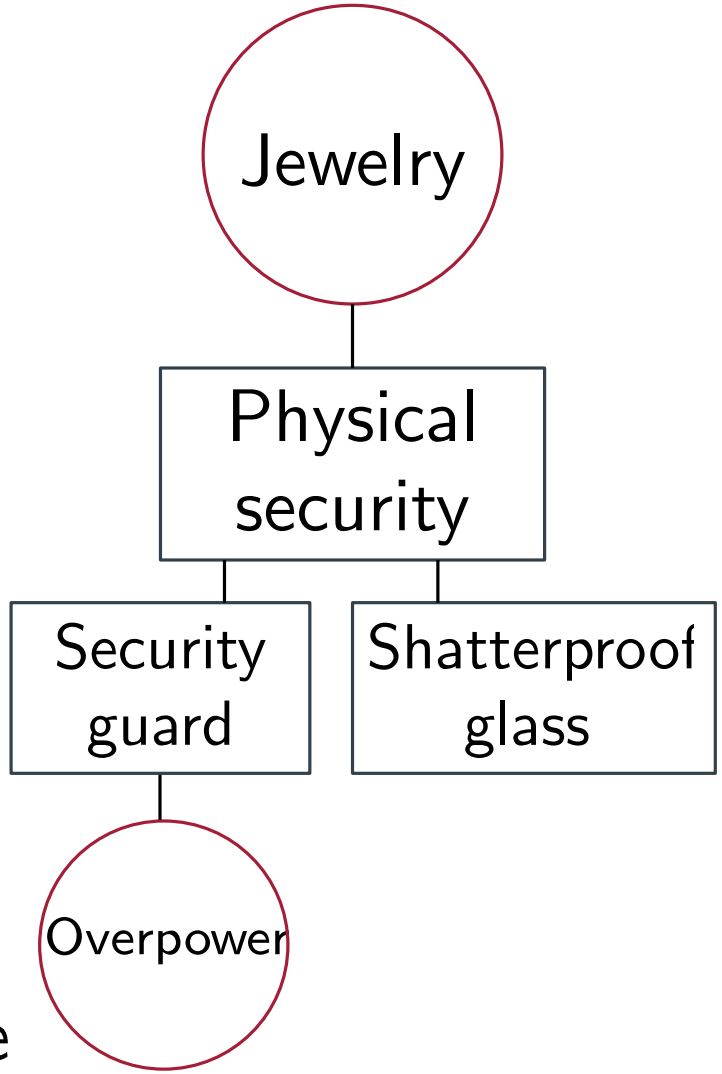

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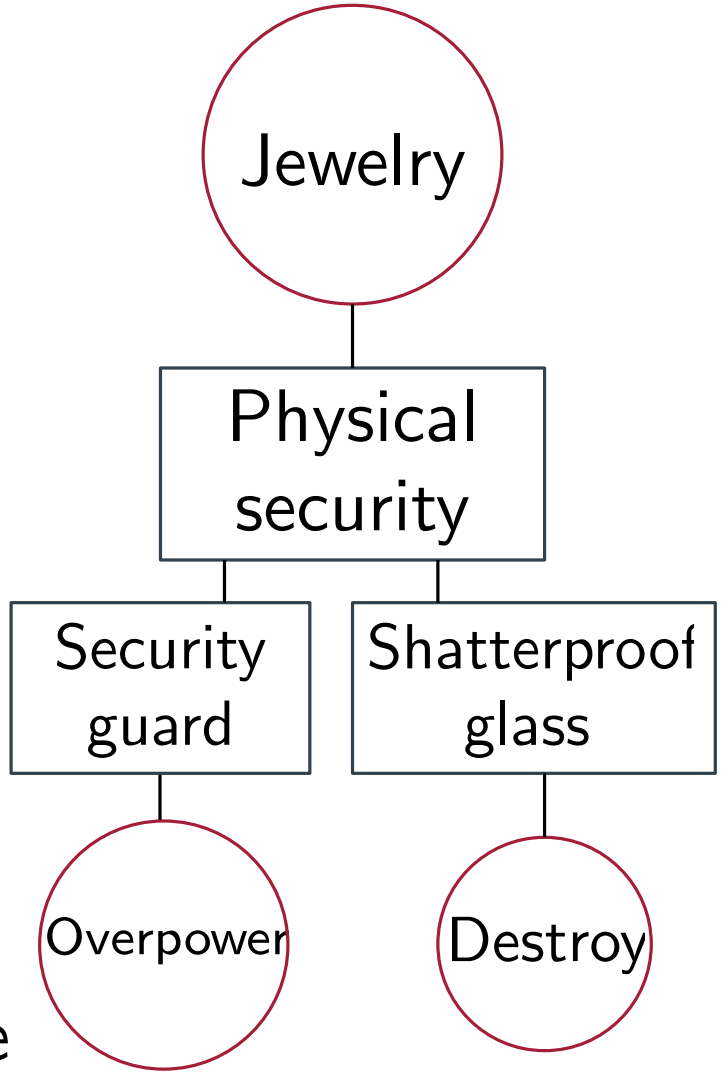

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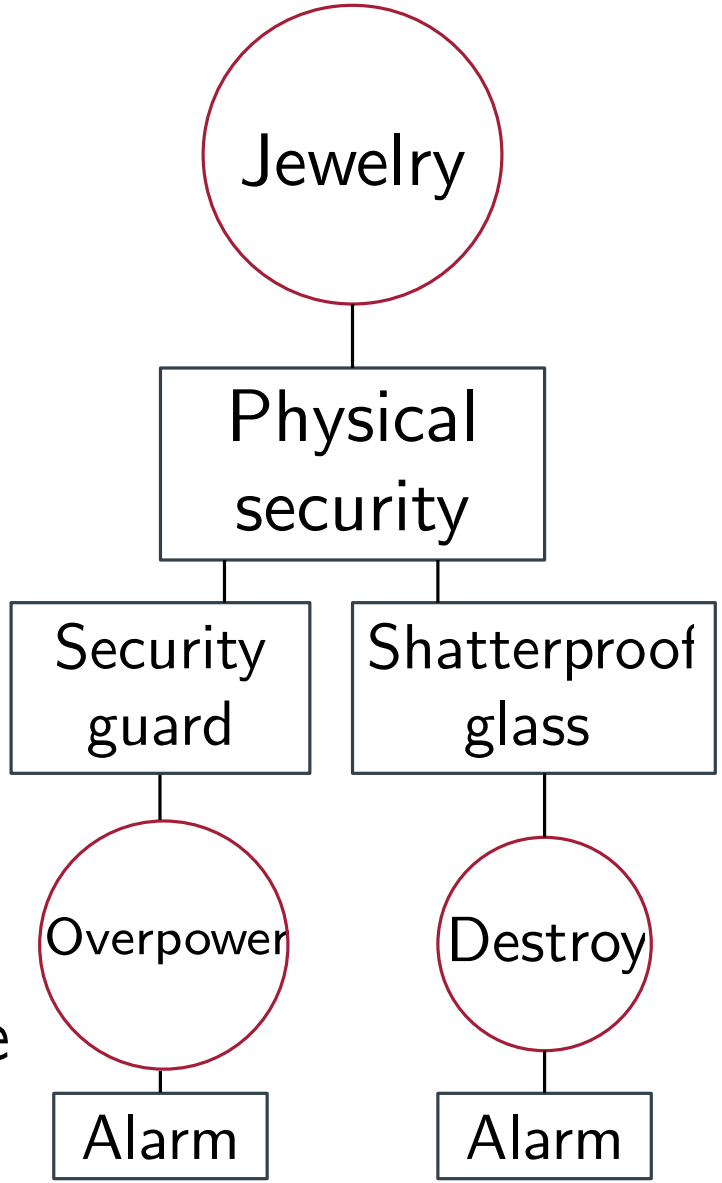

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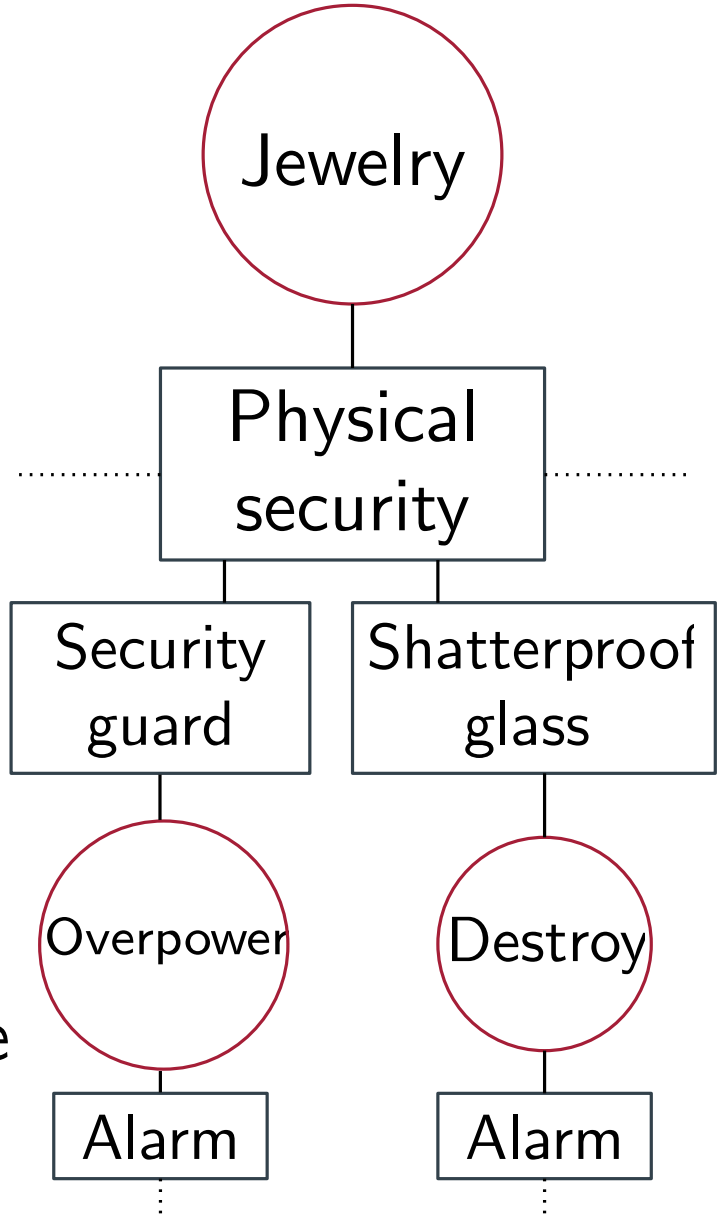

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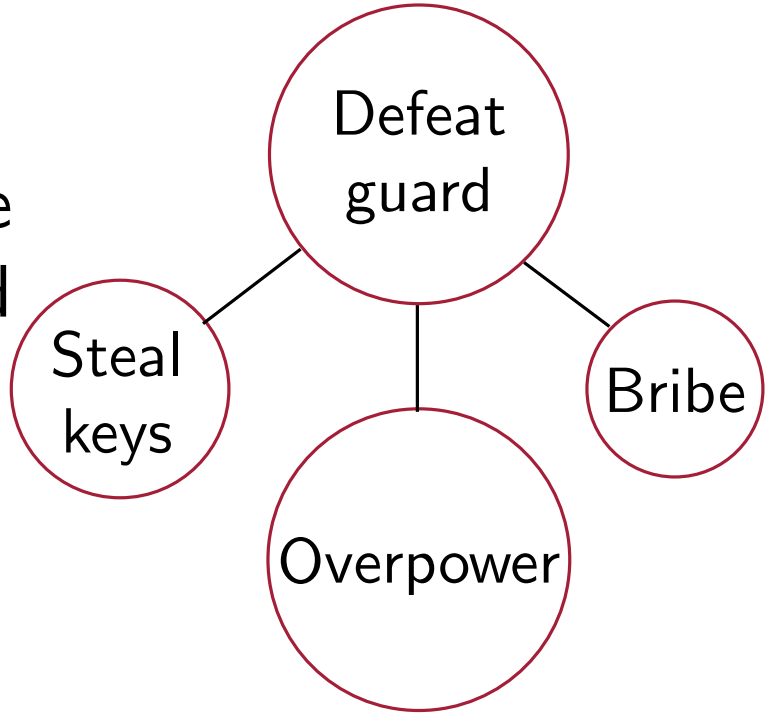

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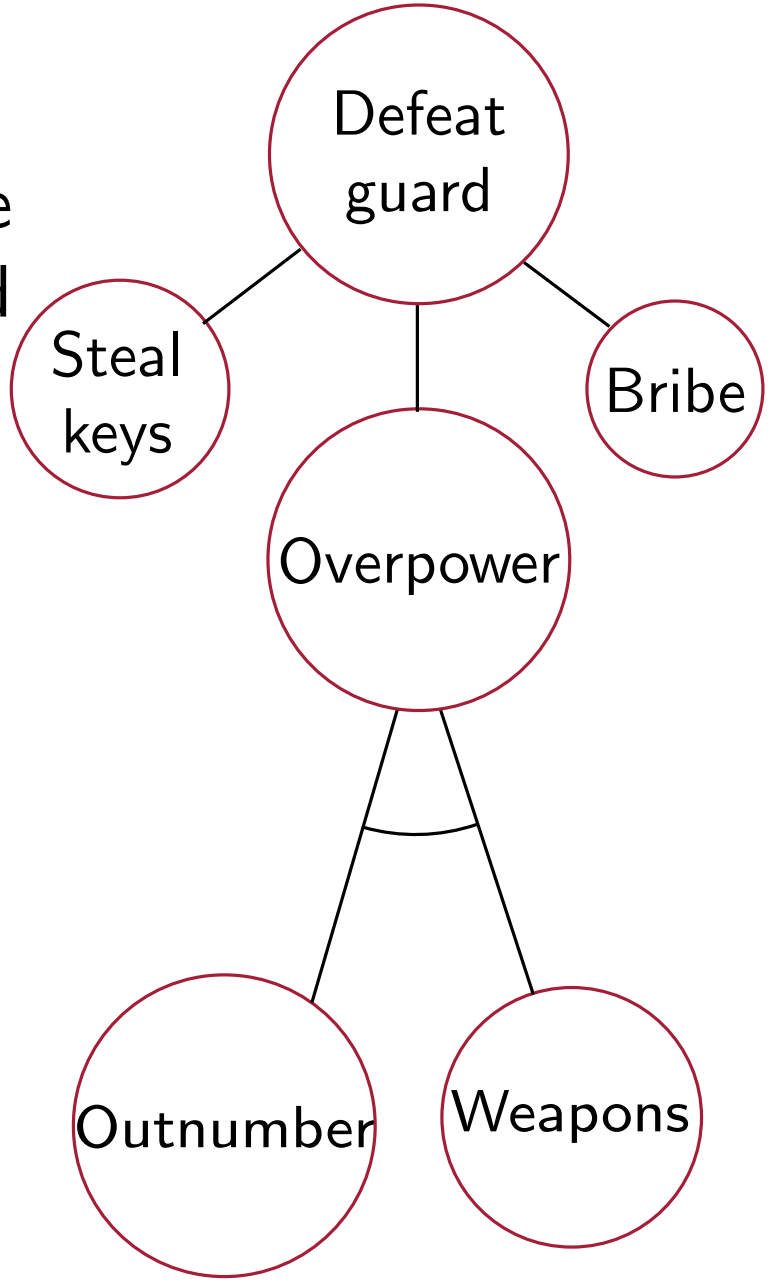

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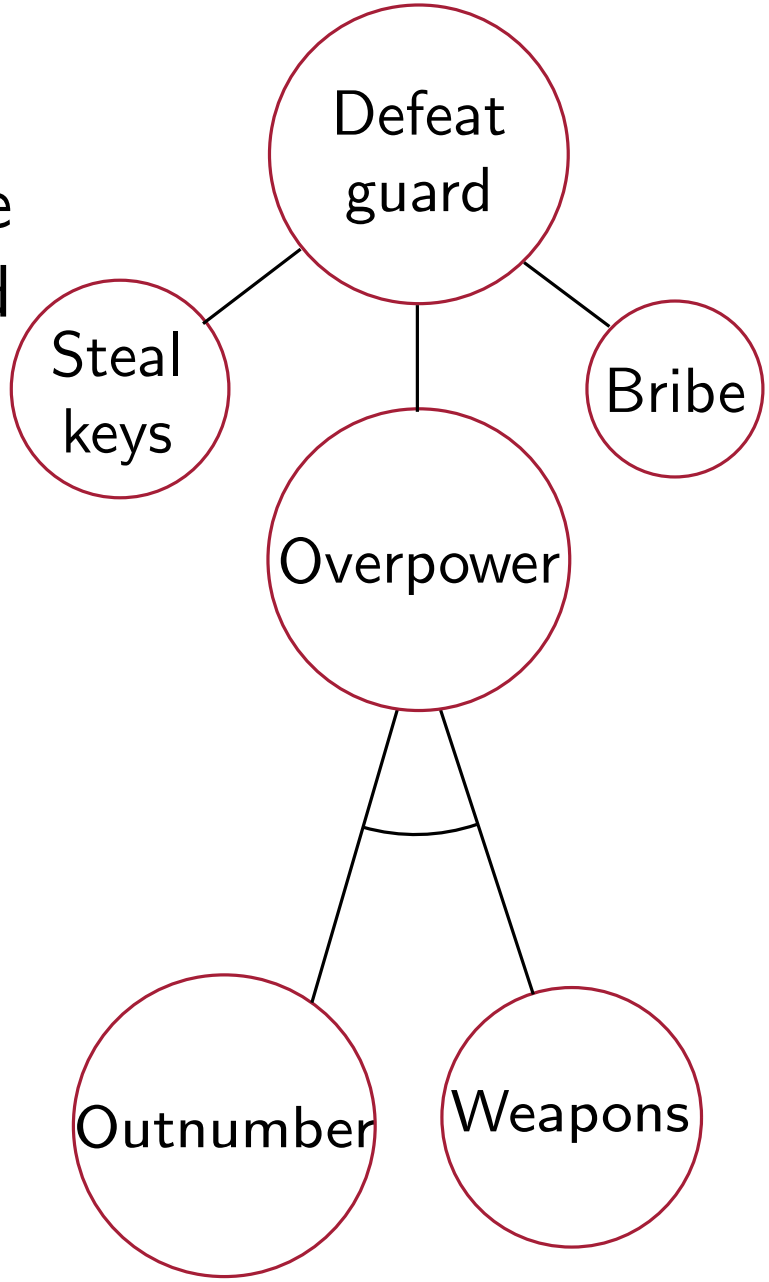
- Nodes without any refinement will represent *basic actions*



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- ... we then need to define semantics of ADTrees (logic)
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- ... then, we finally need an approach to quantitatively analyze attack-defense scenarios (algorithm)
  - Attributes

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- Terms typed over a signature Σ

ADTerms

- Formally, an ADTree is a finite ordered tree T over the set of labels $\mathbb{B}^s \cup \wedge^s \cup \vee^s, s \in S$

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- Any ADTree can be transformed into an ADTerm and vice versa

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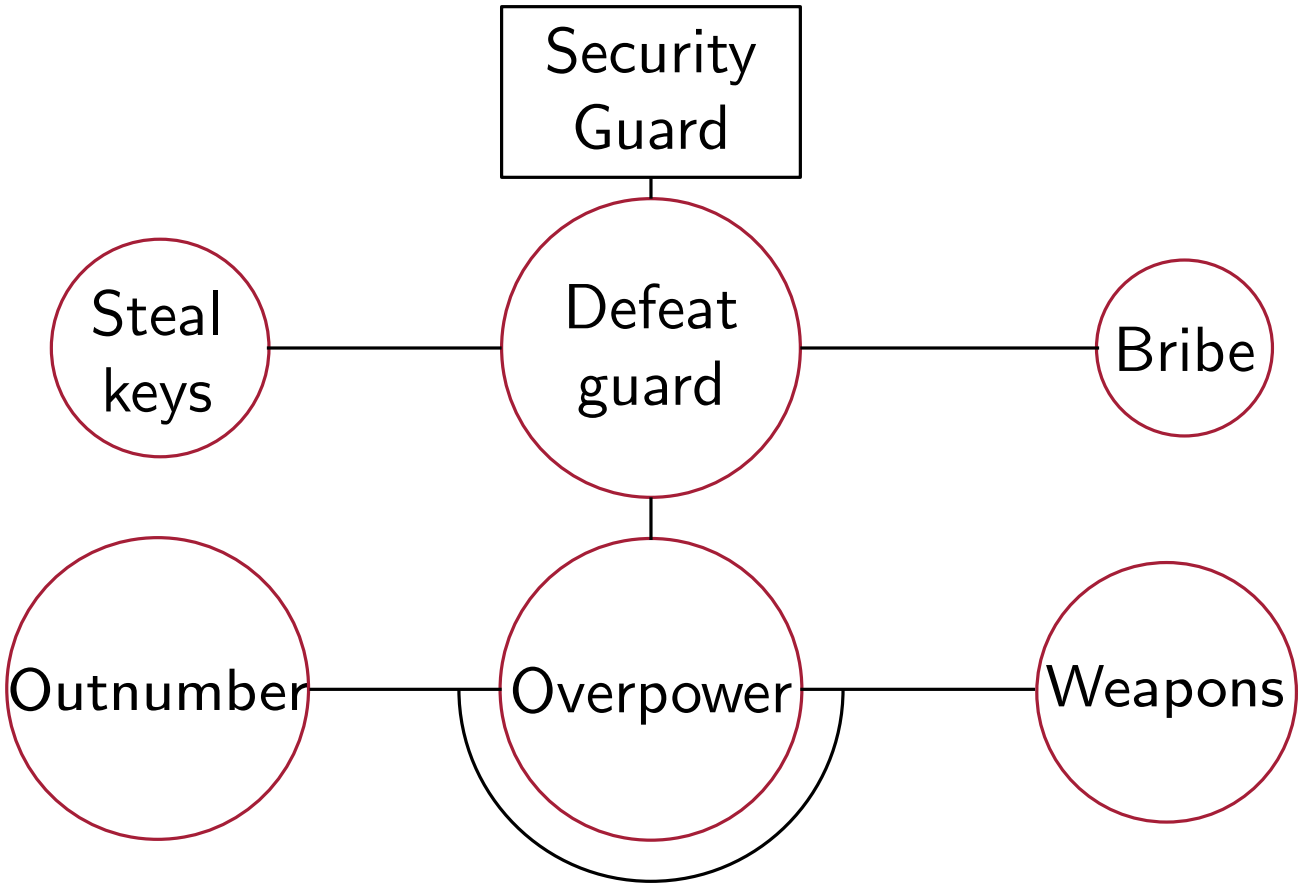
- This sub-tree can be evaluated to following ADTerm:



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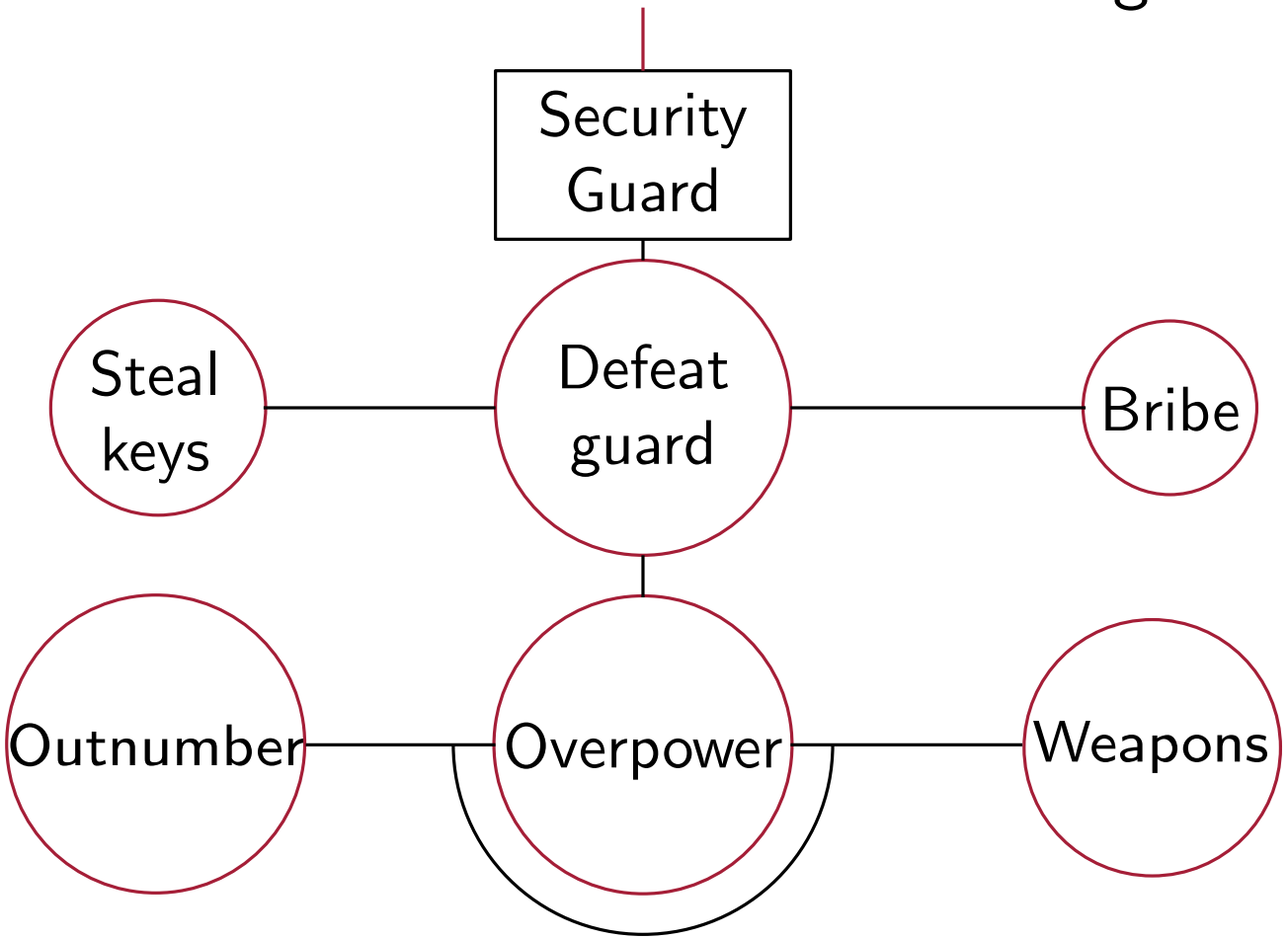

$$c^o\,(\text{SecGuard}, c^p\,(\vee^p\,(\text{StealKeys}, \wedge^p\,(\text{Outnum}, \text{Weapons})\,, \text{Bribe})))$$

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- Finding a feasible attack for a given ADTree is $\mathcal{NP}$-complete

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- Other approaches of semantics available for more conclusive answers

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- This "mapping" defines a *domain* an attribute is defined on

Attribute Domain

- The attribute domain is a tuple

$$A_\alpha = (D_\alpha, \underbrace{\vee_\alpha^p, \wedge_\alpha^p, \vee_\alpha^o, \wedge_\alpha^o, c_\alpha^p, c_\alpha^o}_{\text{functions defined on } D_\alpha})$$

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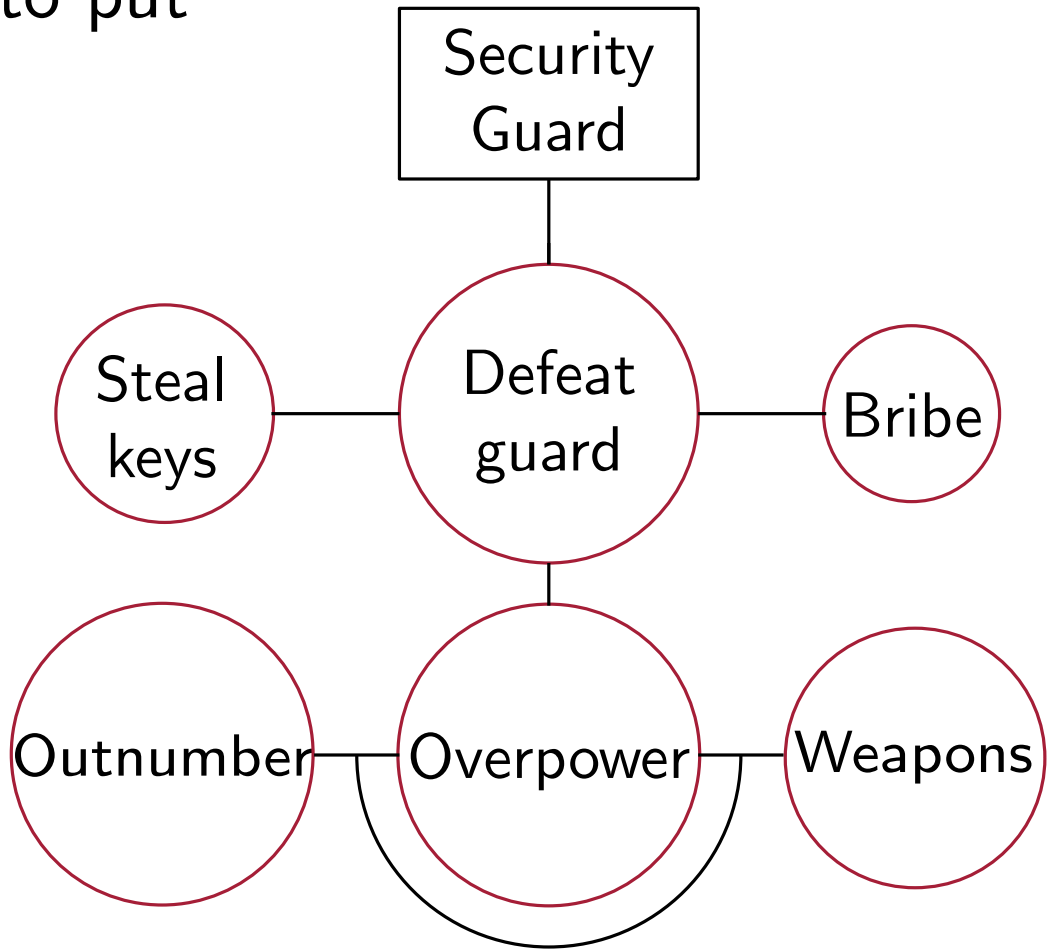
- Every ADTerm is evaluatable for a given attribute domain

Attribute evaluation

- Evaluate the minimal cost to put down the guard



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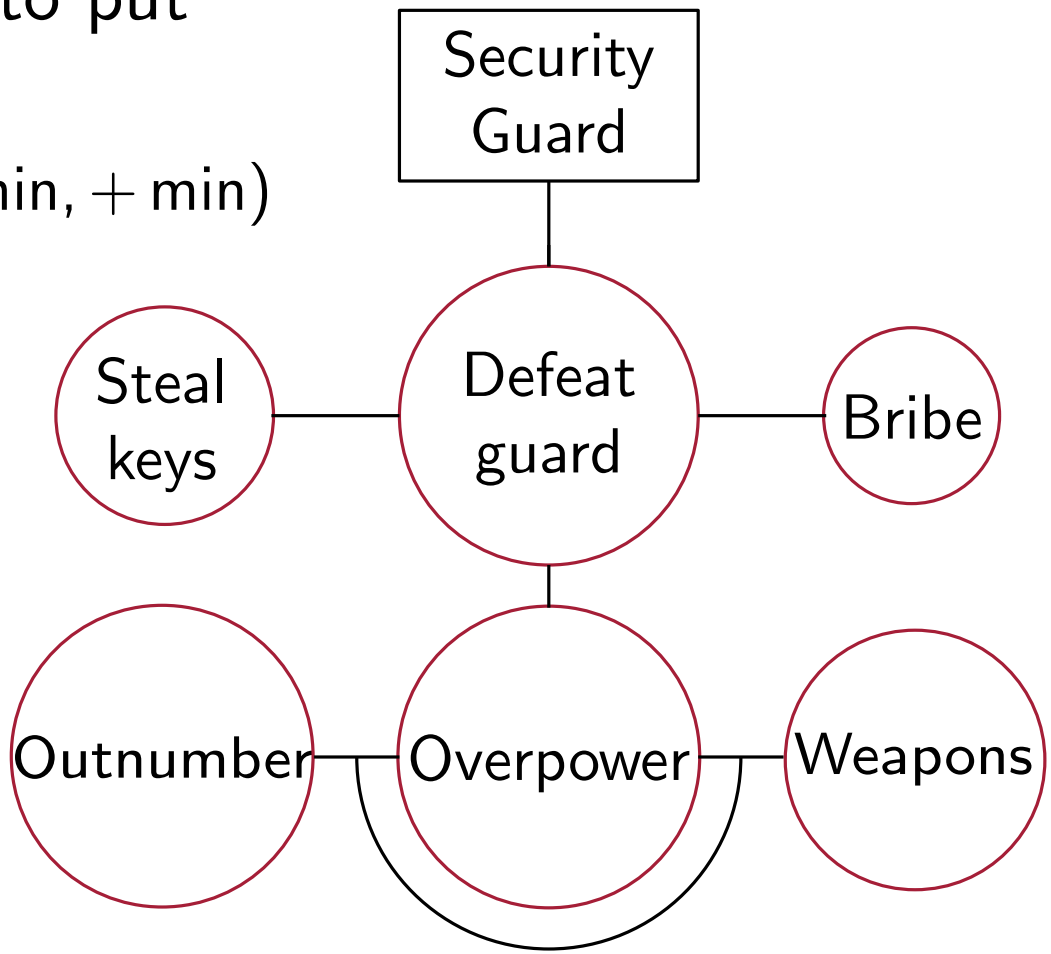

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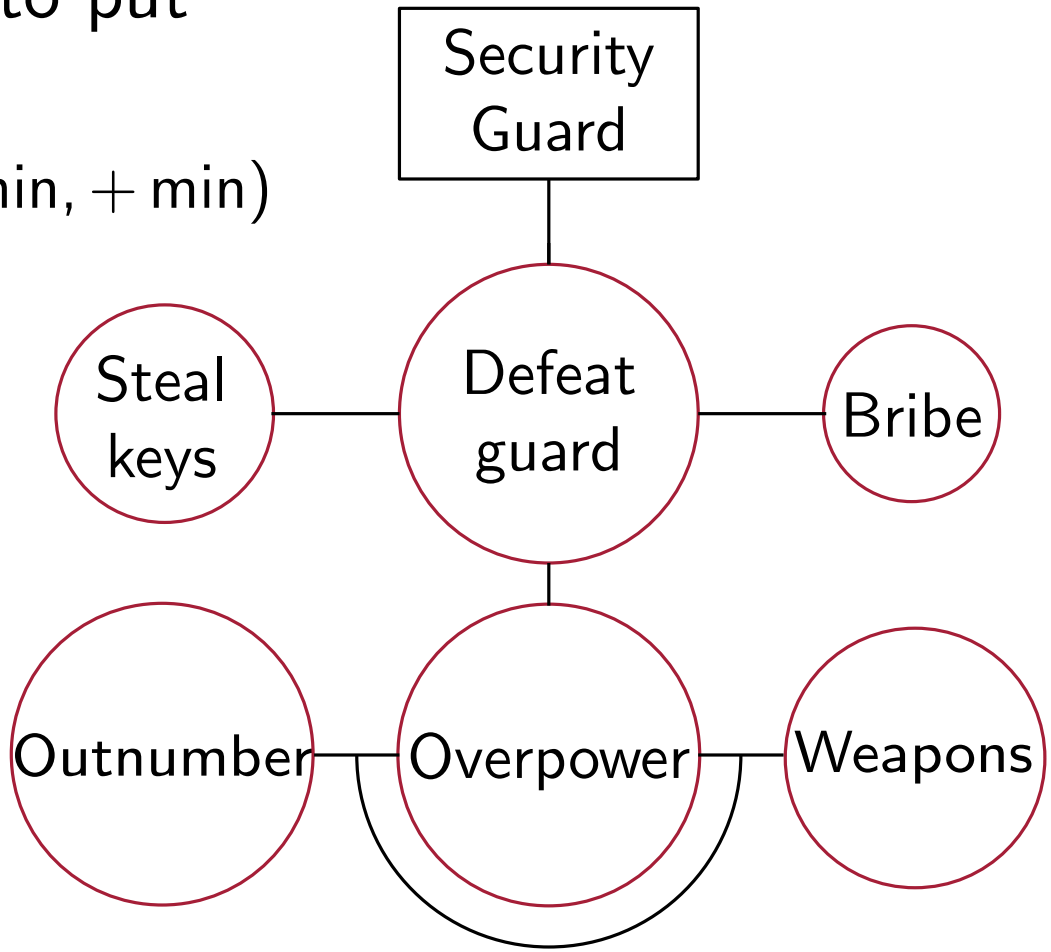

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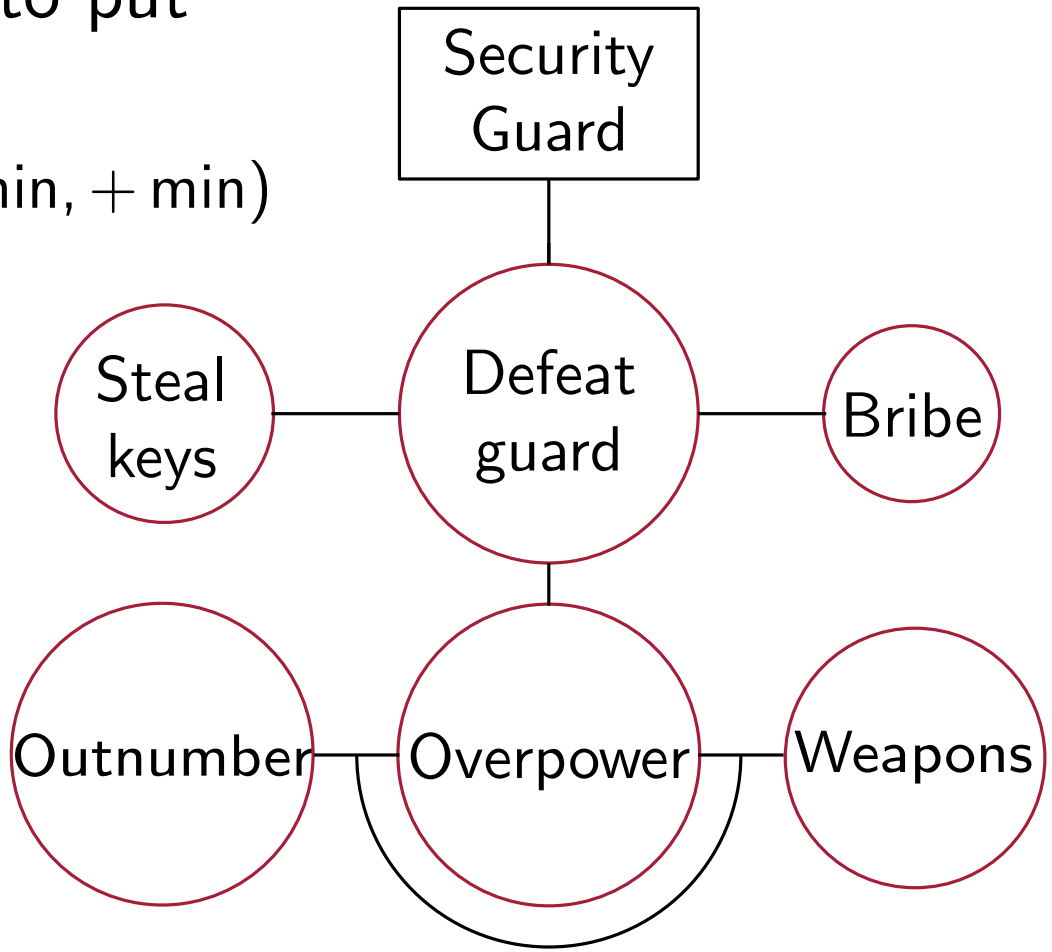

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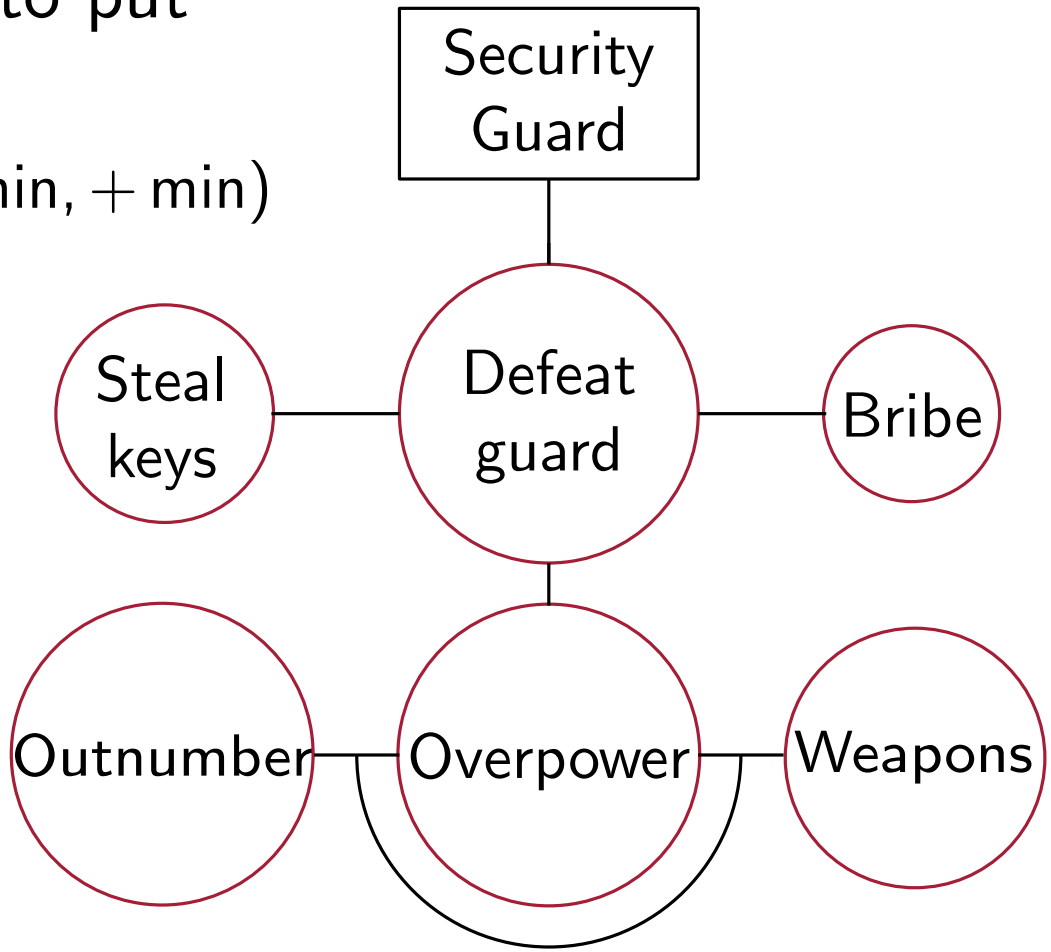

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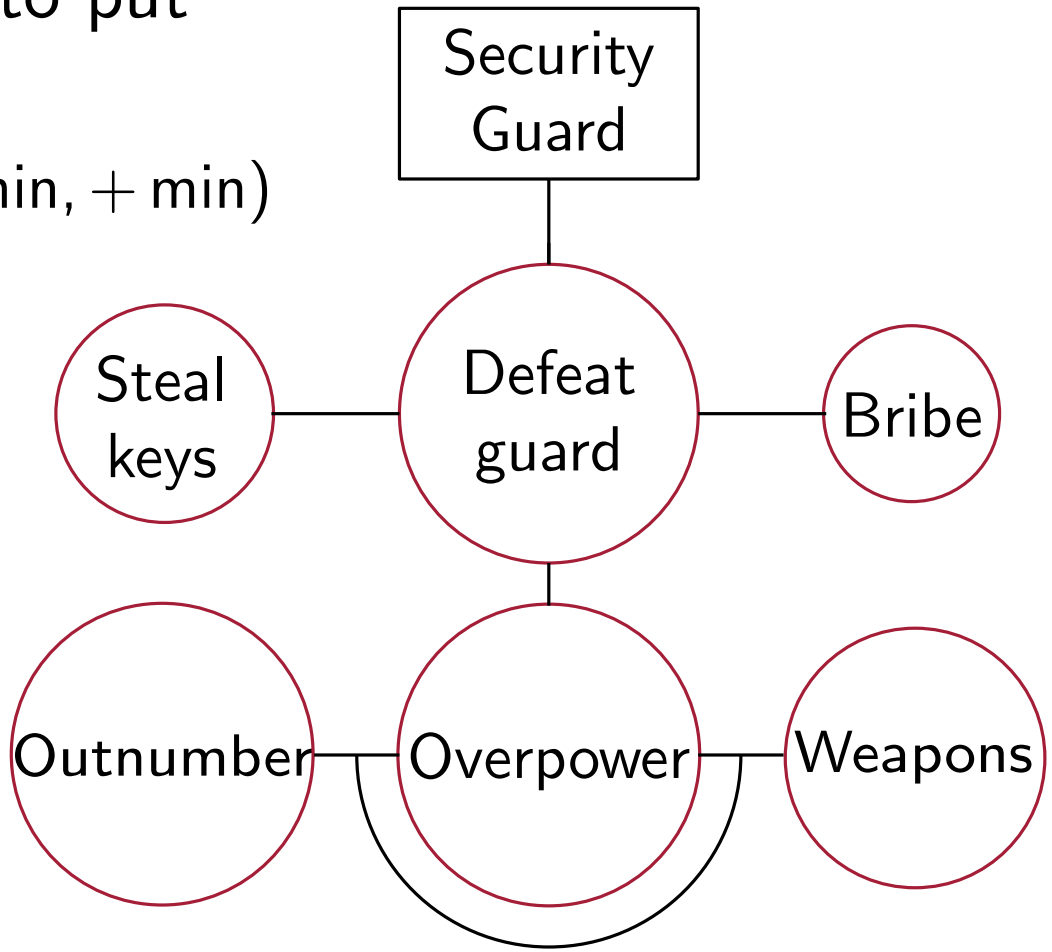

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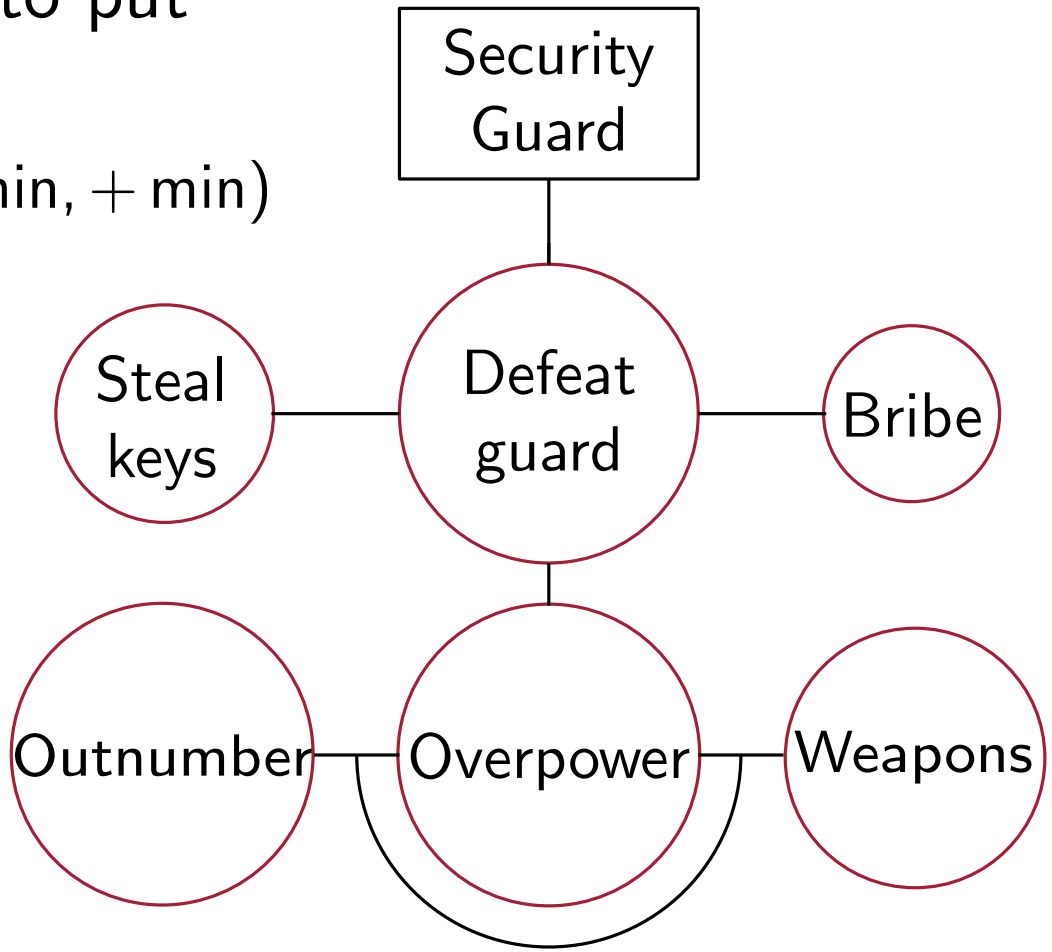
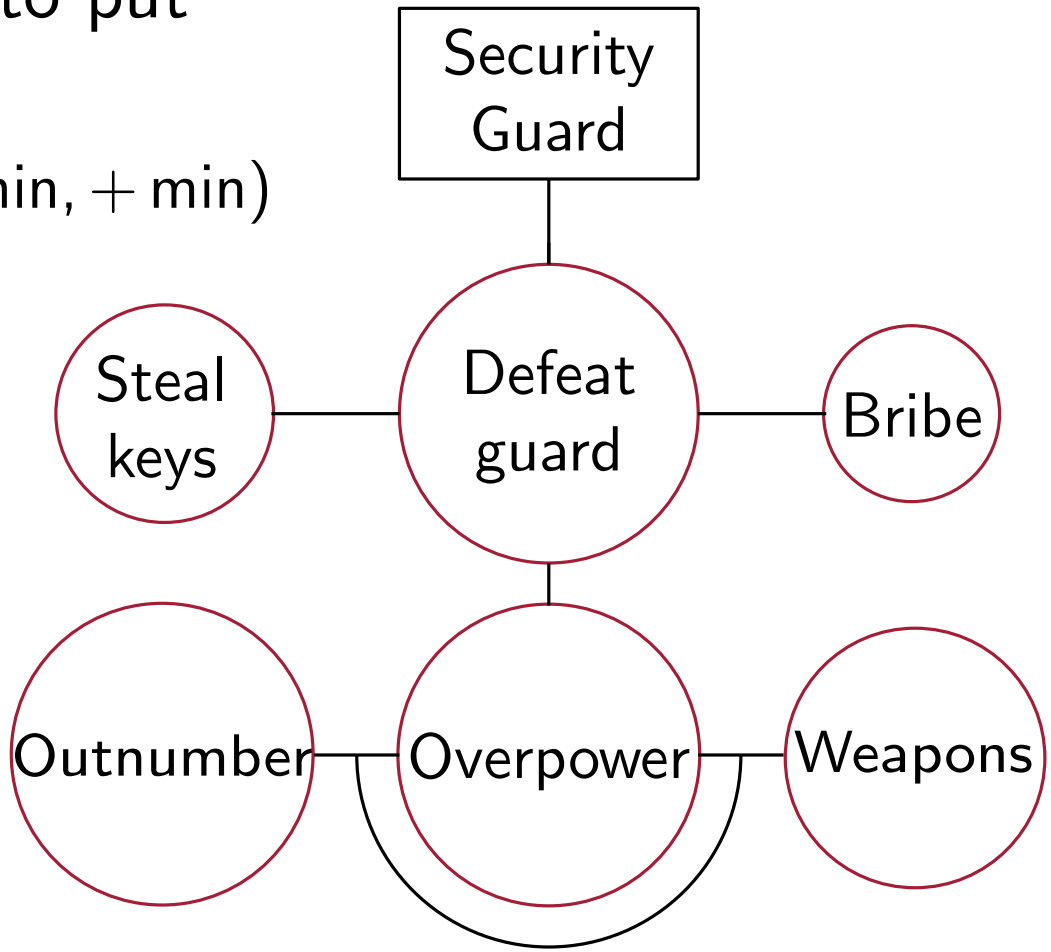


$t = \vee^p (\text{StealKeys}, \wedge^p (\text{Outnum}, \text{Weapons}), \text{Bribe})$

Attribute evaluation

- Evaluate the minimal cost to put down the guard
- $A_{\text{cost}} = (\mathbb{R}^+ \cup \{\infty\}, \min, \cdot, +, \min, + \min)$
- Cost function β
  - $\beta(\text{Weapons}) = 500$
  - $\beta(Outnum) = 4$
  - $\beta(\text{Keys}) = \infty$
  - $\beta(\text{Bribe}) = 10000$



$t = \vee^p (\text{StealKeys}, \wedge^p (\text{Outnum}, \text{Weapons}), \text{Bribe})$

$\Rightarrow \text{cost}(t) = (\min(\infty, \cdot(4, 500), 10000)) = 2000$

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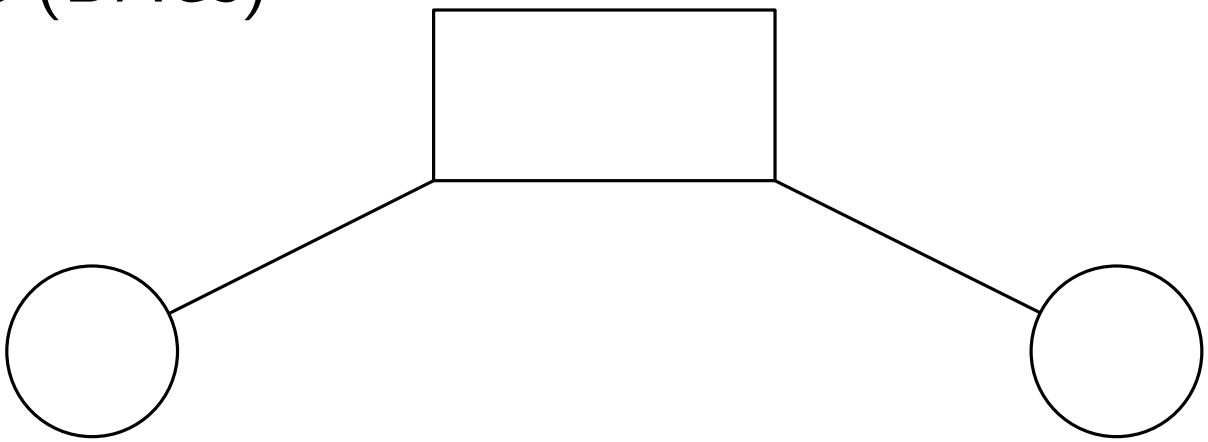
- ADTrees as extension of Attack Trees can represent a security system evolution
- ADTerms deliver an attack-defense language to operate on
- Attributes for ADTerms deliver a base to evaluate a given system, considering a semantics
- Computer tool “ADTool2“ supports large ADTrees with graphical representation and evaluation algorithms

GitHub repository

Homepage of SaToSS Luxembourg

Next (big) step

- Introduction of dependencies in an ADTree
  - Extension of the model to a subclass of Directed Acyclic Graphs (DAGs)



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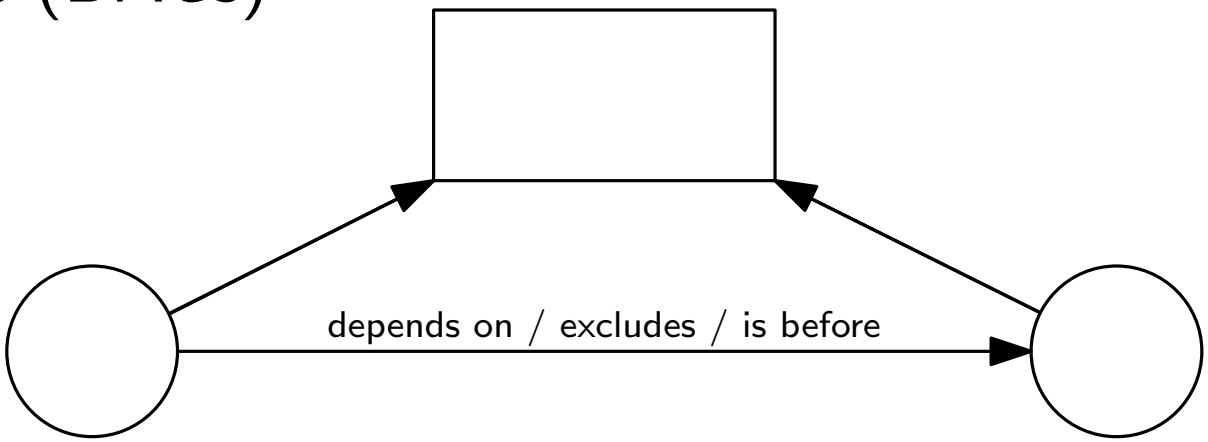

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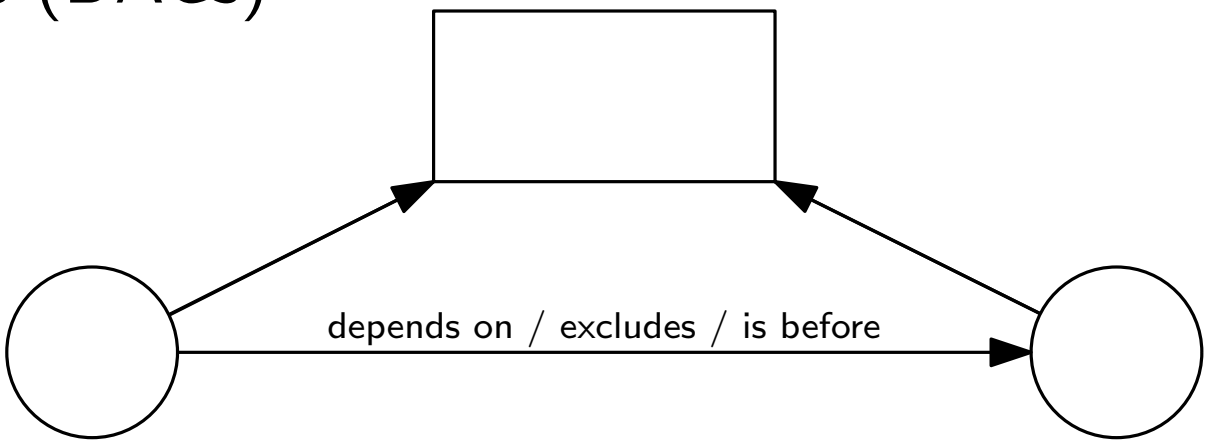

- Then, an execution order can be evaluated
- Also, attack-defense scenario from a propabilistic point of view can be analyzed

Questions?

Thank you!

:)