Attack Trees
Attack-Defense Trees

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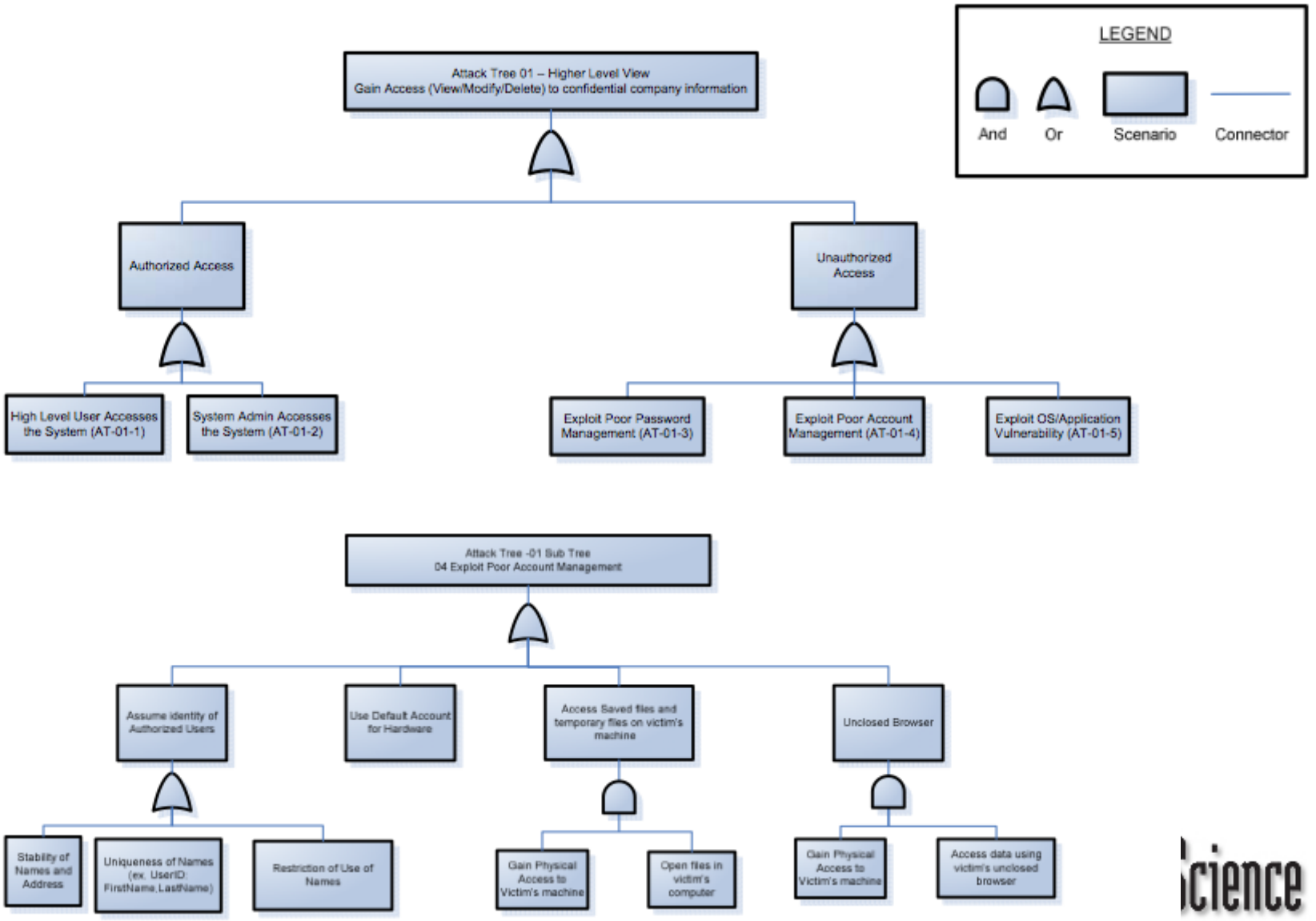
http://www.owasp.org/index.php/Application_Threat_Modeling

Attack Trees

- Provide a formal, hierarchical way of describing the security threats to a system based upon the types of attacks that could happen and how they could be realized.
- Attacker's goal listed as the root node and leaves represent different ways to achieve that goal.

Attack trees



http://www.sei.cmu.edu/reports/05tr009.pdf

Another example

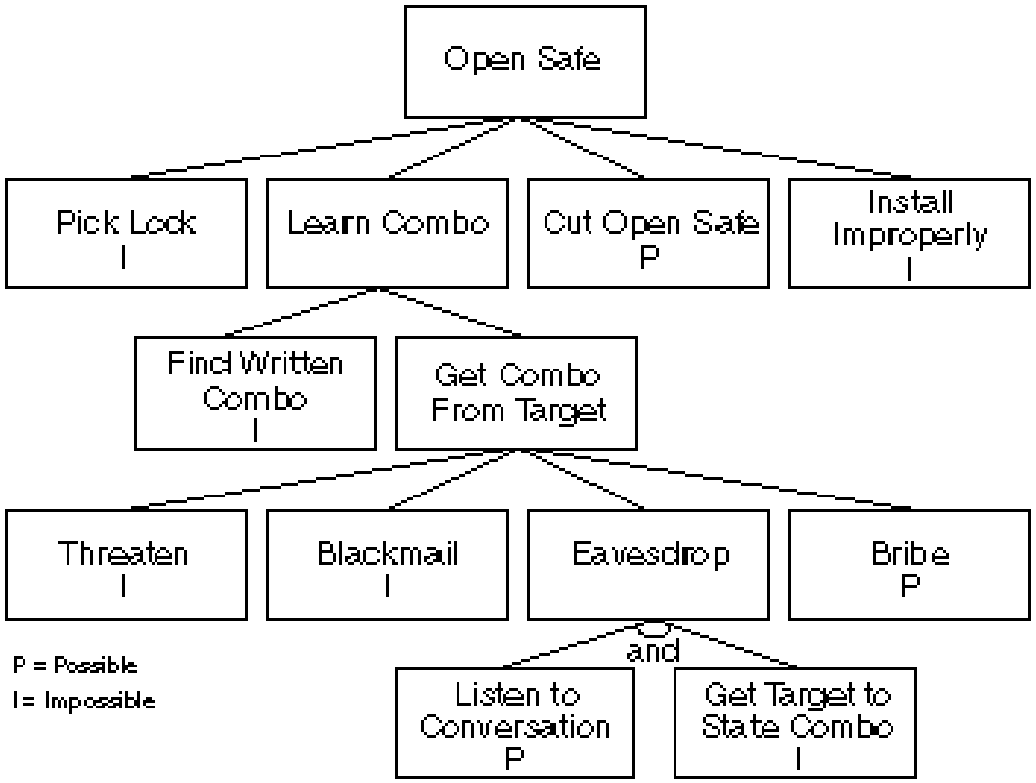


Figure 1: Attack Nodes

https://www.schneier.com/academic/archives/1999/12/attack_trees.html

Prioritizing …

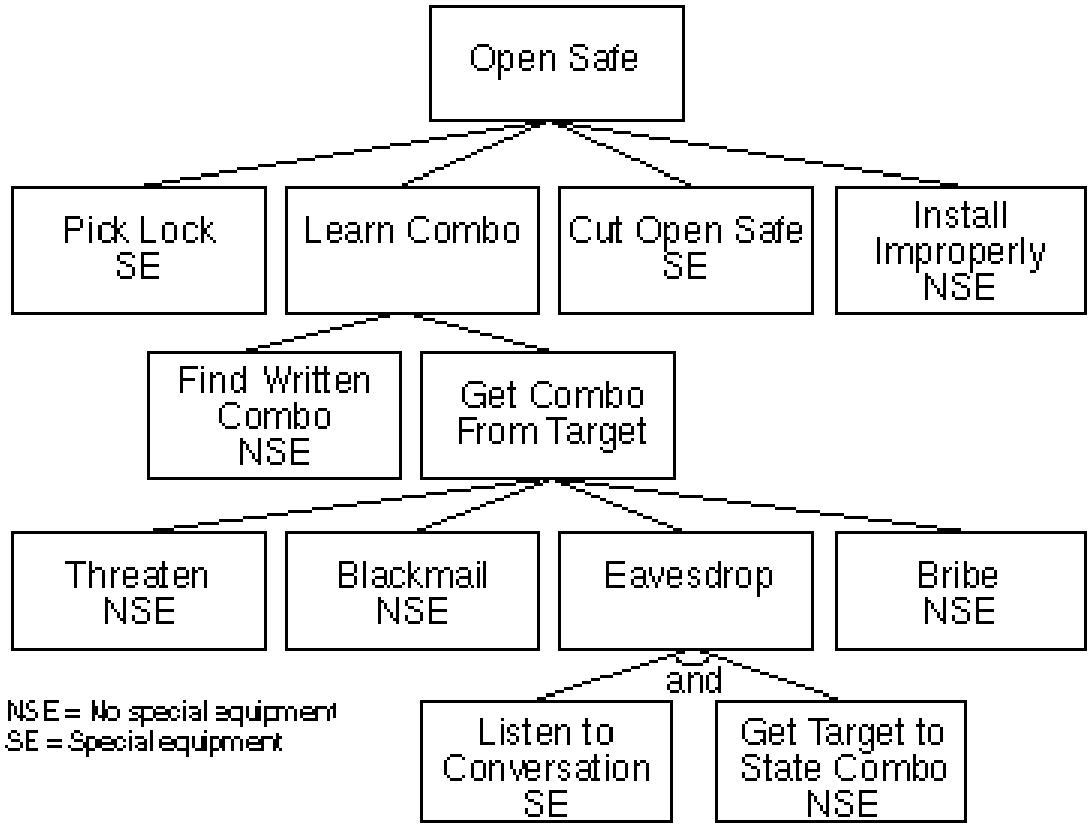


Figure 3: Special Equipment Required

https://www.schneier.com/academic/archives/1999/12/attack_trees.html

Prioritizing …

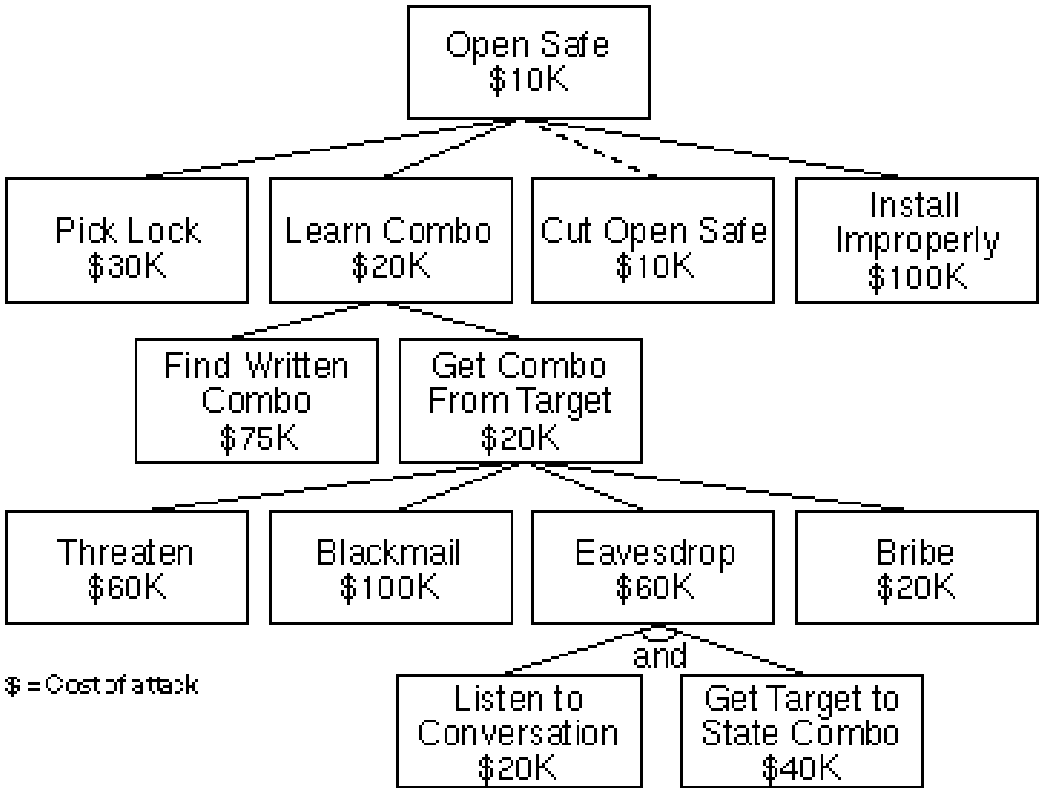


Figure 4: Cost of Attack

https://www.schneier.com/academic/archives/1999/12/attack_trees.html

Prioritizing …

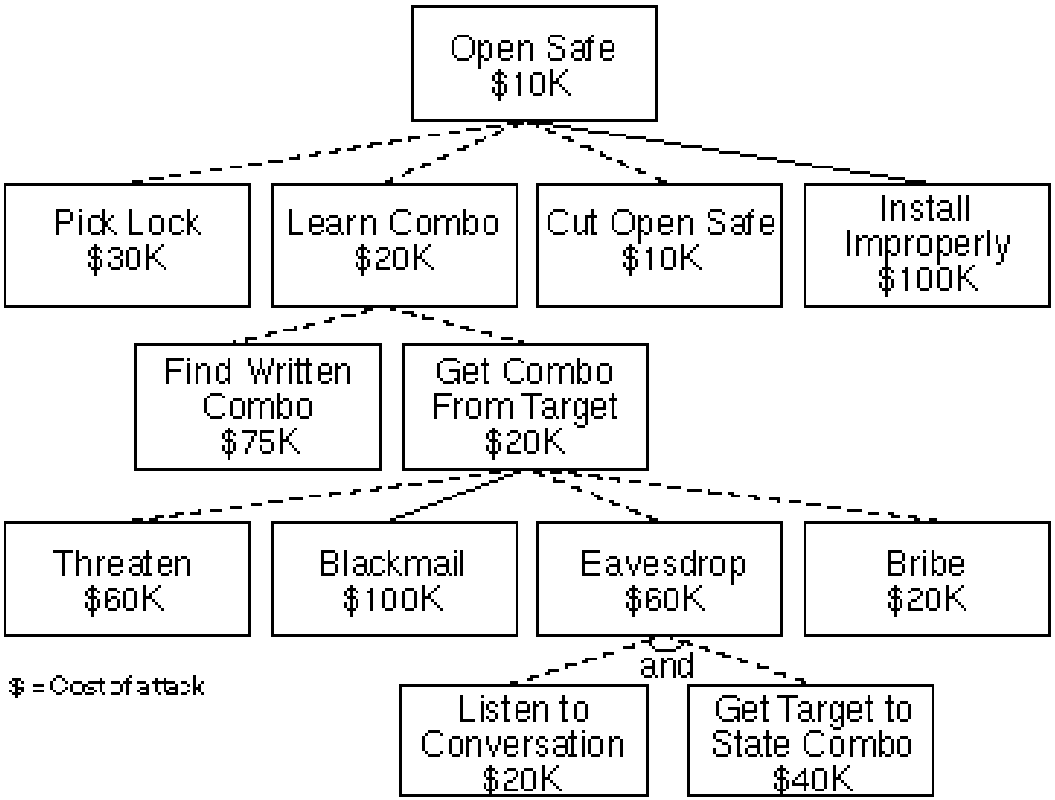


Figure 5: All Attacks Less than $100,000

https://www.schneier.com/academic/archives/1999/12/attack_trees.html

Prioritizing …

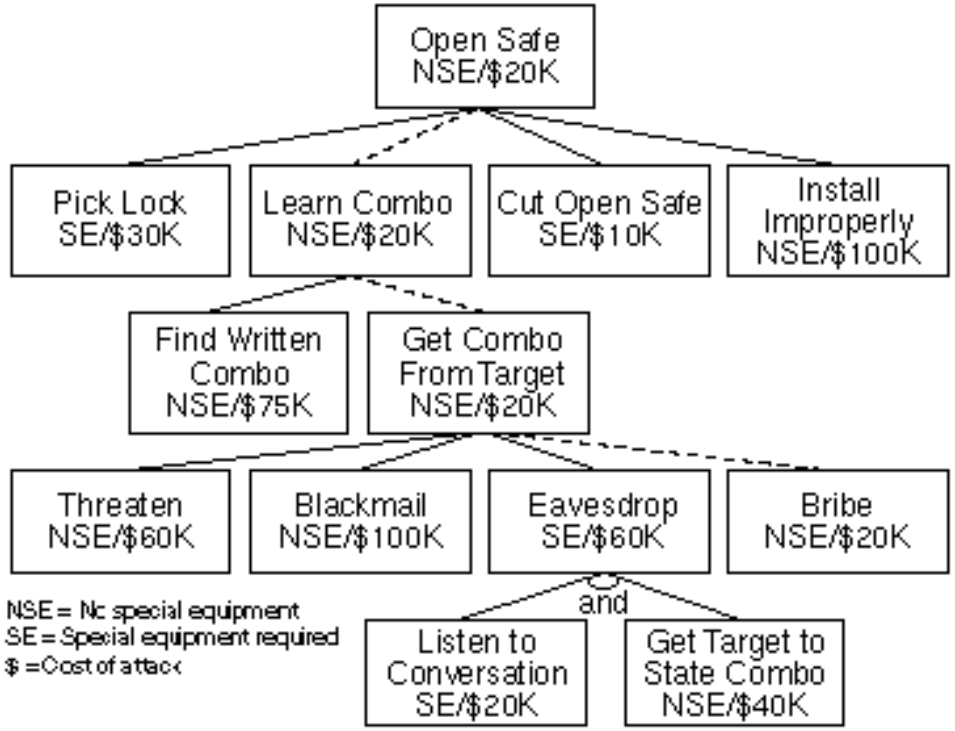


Figure 6: Cheapest Attack Requiring No Special Equipment

Different attackers have different levels of skill, access, risk aversion, money, and so on.

https://www.schneier.com/academic/archives/1999/12/attack_trees.html

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Classic risk

- Classic Risk = probability of success * impact

Table 1 - System Impact Definitions and Numerical Ranges

Numerical Range	Impact Definition
1-3	Minor impact to system. May be a nuisance but is easily detected and/or repaired
4-6	Moderate impact to system. Confidentiality, integrity, and/or availability of system affected. Requires non-trivial effort to detect and/or repair.
7-9	Severe impact to system. Significant damage results to system. Considerable effort required to detect and/or repair damage.
10	System completely compromised, inoperable, or destroyed

Edge, K., et al, USING ATTACK AND PROTECTION TREES TO ANALYZE THREATS AND DEFENSES TO HOMELAND SECURITY, 2006

Attack tree risk

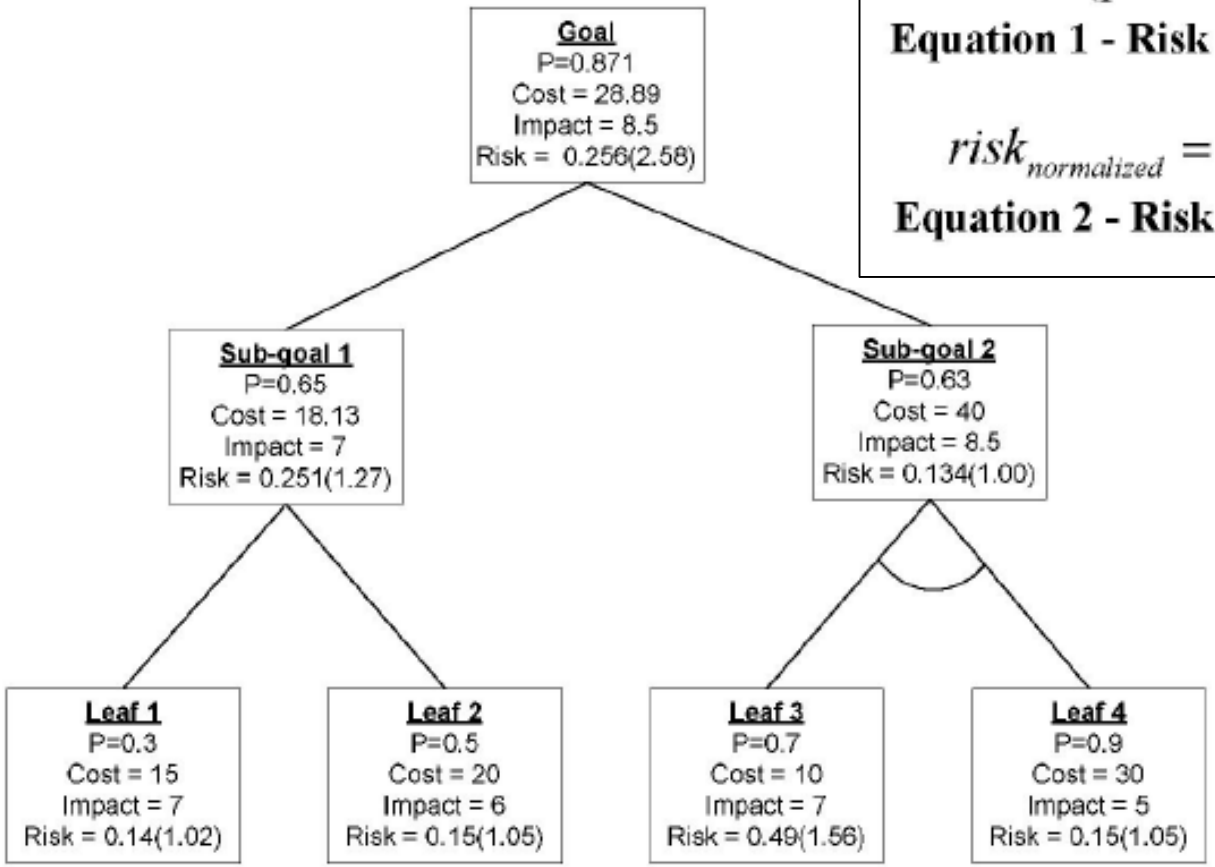
- Classic Risk = probability * impact

$$risk = (probability / cost) \times impact$$

Equation 1 - Risk Calculation for Leaf Nodes

$$risk_{normalized} = \log(risk / risk_{\min} \times 10)$$

Equation 2 - Risk Normalization Calculation



Edge, K., et al, USING ATTACK AND PROTECTION TREES TO ANALYZE THREATS AND DEFENSES TO HOMELAND SECURITY, 2006

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Propogate Metrics Up Tree

Table 2 – Rule Set to Propagate Metrics Up Tree

	AND	OR
Probability	$\prod_{i=1}^{n} prob_i$	$1-\prod_{i=1}^{n}(1-prob_i)$
Cost	$\sum_{i=1}^{n} cost_i$	$\frac{\sum_{i-1}^{n} prob_i \times cost_i}{\sum_{i=1}^{n} prob_i}$
Impact	$\frac{10^n - \prod_{i=1}^{n}(10-impact_i)}{10^{(n-1)}}$	$Max_{i=1}^{n} impact_i$

$prob \in (0,1], cost \in (0,\infty), impact \in [1,10], n = \#$ of child nodes

Edge, K., et al, USING ATTACK AND PROTECTION TREES TO ANALYZE THREATS AND DEFENSES TO HOMELAND SECURITY, 2006

Attack Tree Process - 1

- Identify the possible attack goals. Each goal forms a separate tree, although they might share subtrees and nodes.
- Think of all attacks against each goal. Add them to the tree. Repeat this process down the tree until you are done.
- Give the tree to someone else, and have him think about the process and add any nodes he thinks of.
- Repeat as necessary.

Attack Tree Process - 2

- Assign the node values.
- Recalculate the nodes based on the new information and see how the goal node is affected.
- Compare and rank attacks -- which is cheaper, which is more likely to succeed, and the like.

Uses of attack trees

- See if the system goal is vulnerable to an attack based upon the "how"s.
- Guides you to consider the security assumptions of the system.
- Can be used to determine the impact of a system modification.
- Can be used to compare and rank attacks.

What else?

- Attack trees can show:
  - Intrusive versus non-intrusive attacks
  - Legal versus illegal attacks
  - Budget, skills, and/or access required of the attacker.
  - Probabilities of success for various attacks.
  - Likelihood of different attacks.
  - Value of different attacks.
  - Compare
    - Effects of countermeasures
    - Security of different products

From: http://tnlandforms.us/cs494-cns01/attacktrees.pdf

Protection (or Defense) Trees

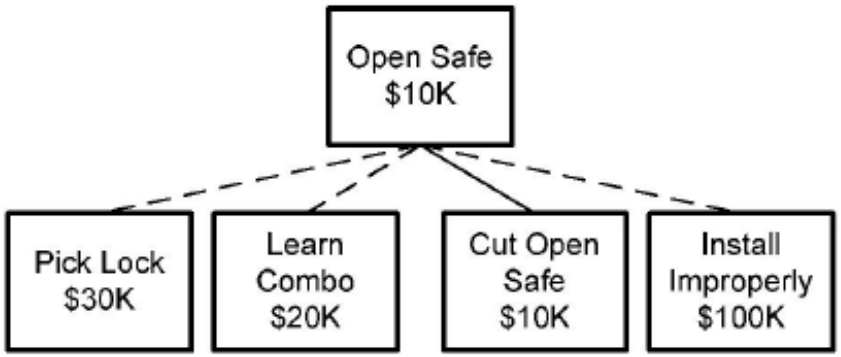

Figure 3 - Partial Attack Tree To Open a Physical Safe **[3]**.

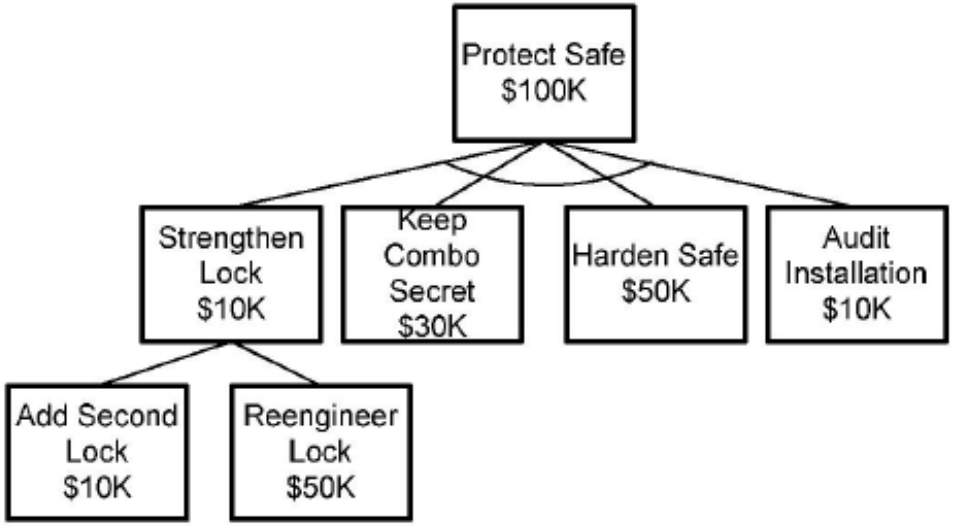

Figure 4 - A Partial Protection Tree for the Safe Attack

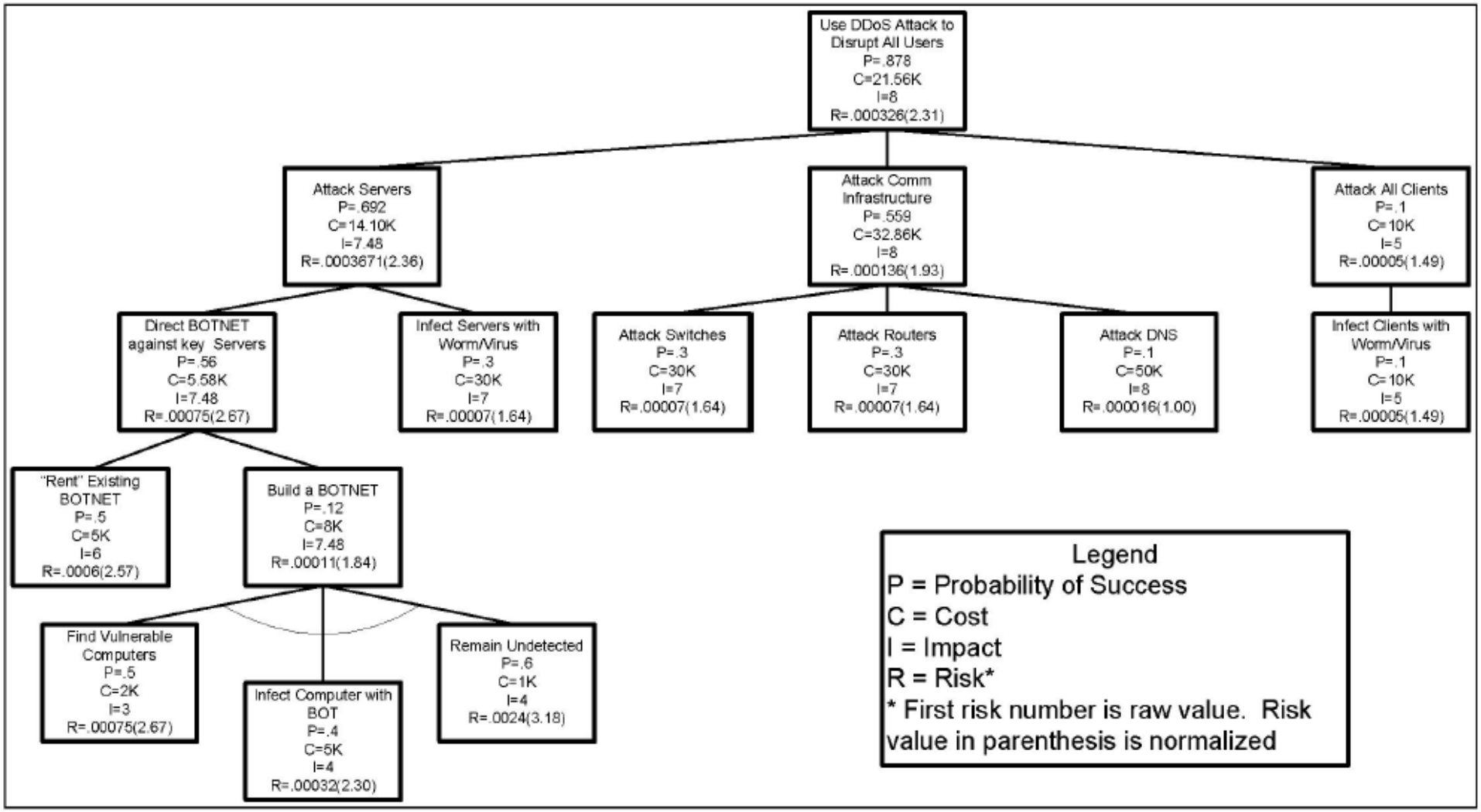

Figure 7 - DDoS Attack Tree

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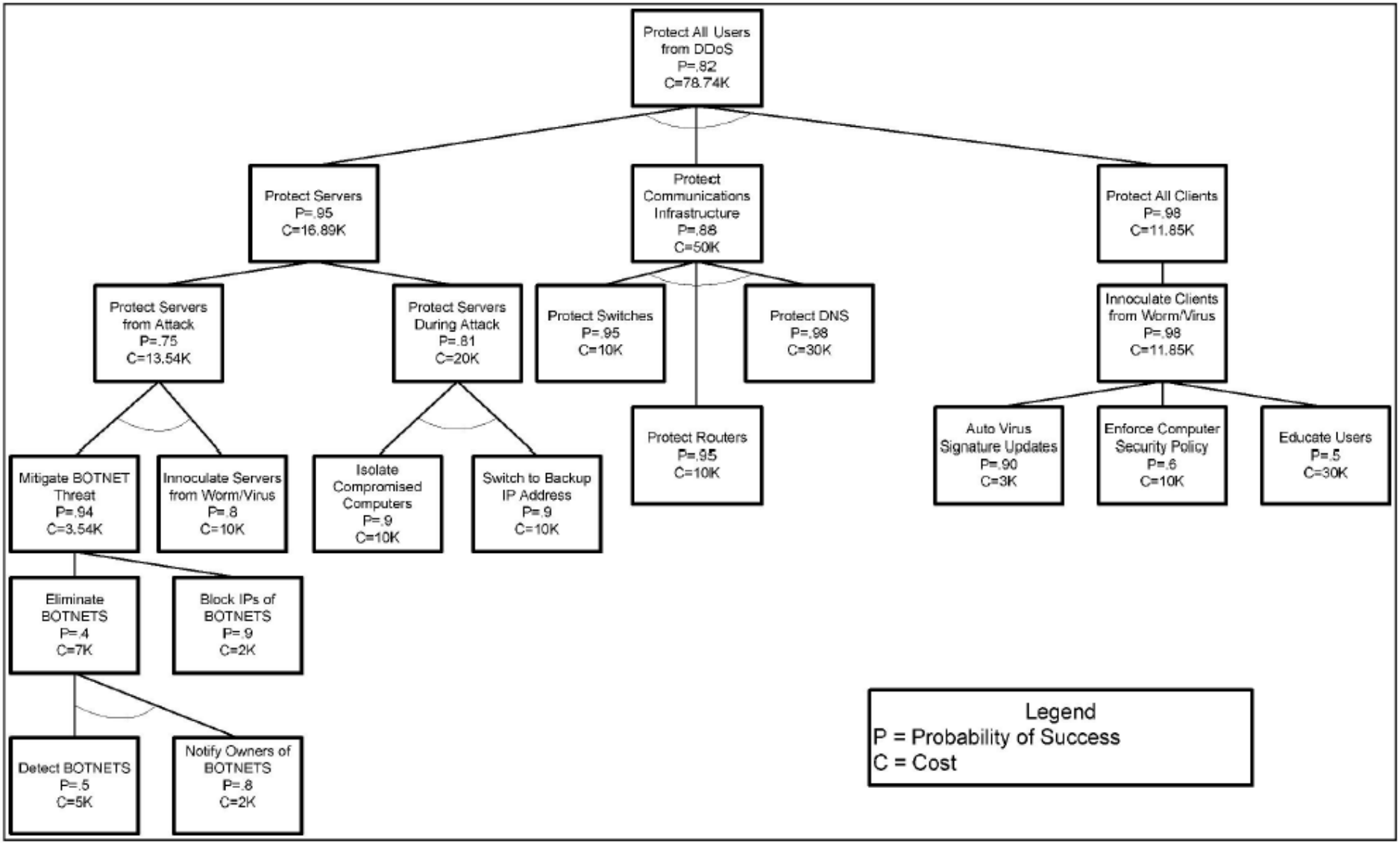

Figure 8 - DDoS Protection Tree

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