Attack Modelling

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Attack Trees

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- We need to model threats against computer systems.
- What are the different ways in which a system can be attacked?
- If we can understand this, we can design proper countermeasures.
- Attack trees are a way to methodically describe the security of a system.

Structure of Attack Trees

- The root node is the overall goal the attacker wants to achieve.
- Attack trees have both AND and OR nodes:
  - OR: Alternatives to achieving a goal.
  - AND: Different steps toward achieving a goal.
- Each node is a subgoal.
- Child nodes are ways to achieve a subgoal.

Example I — Open a Safe

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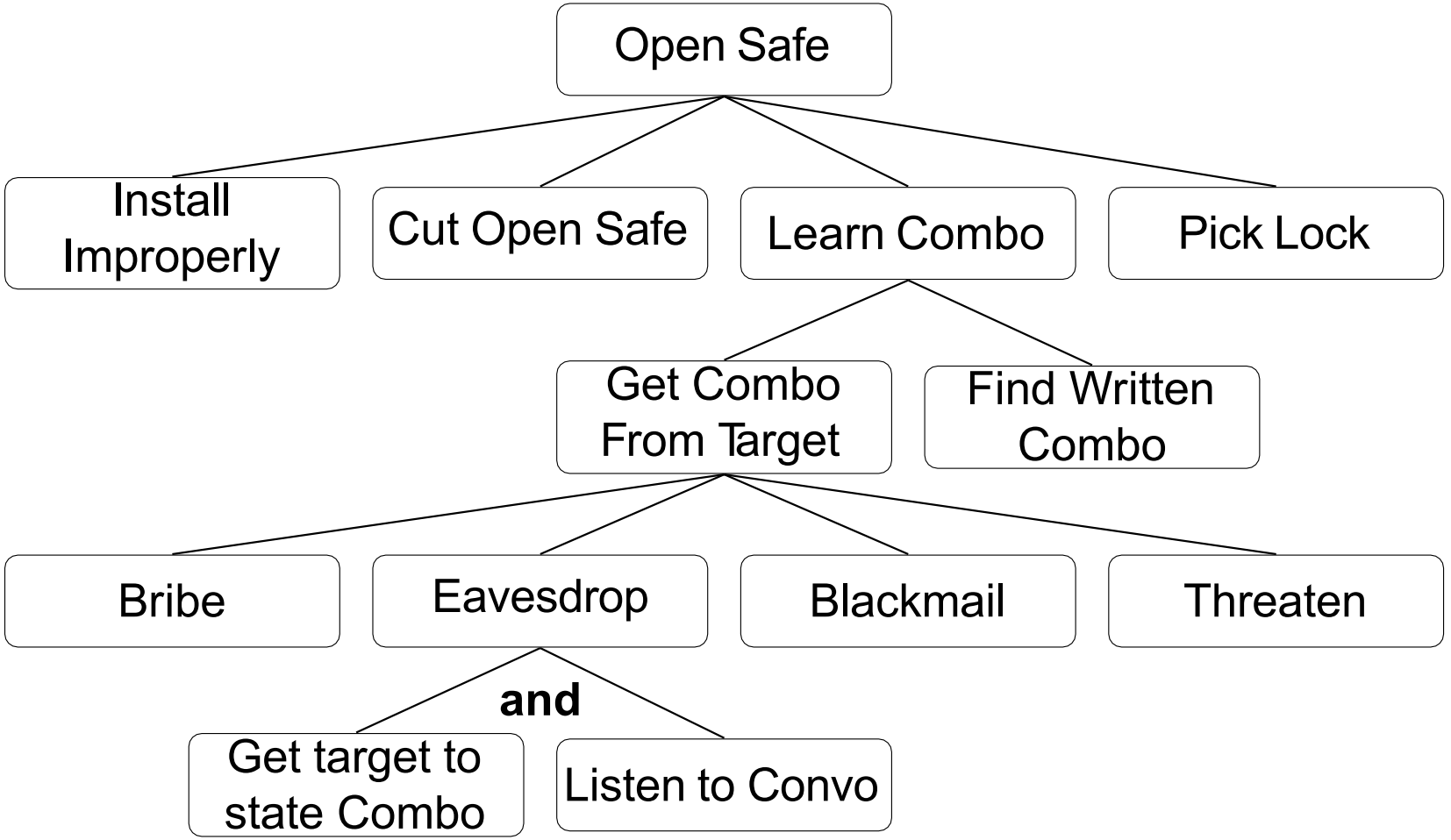

Example I — Open a Safe

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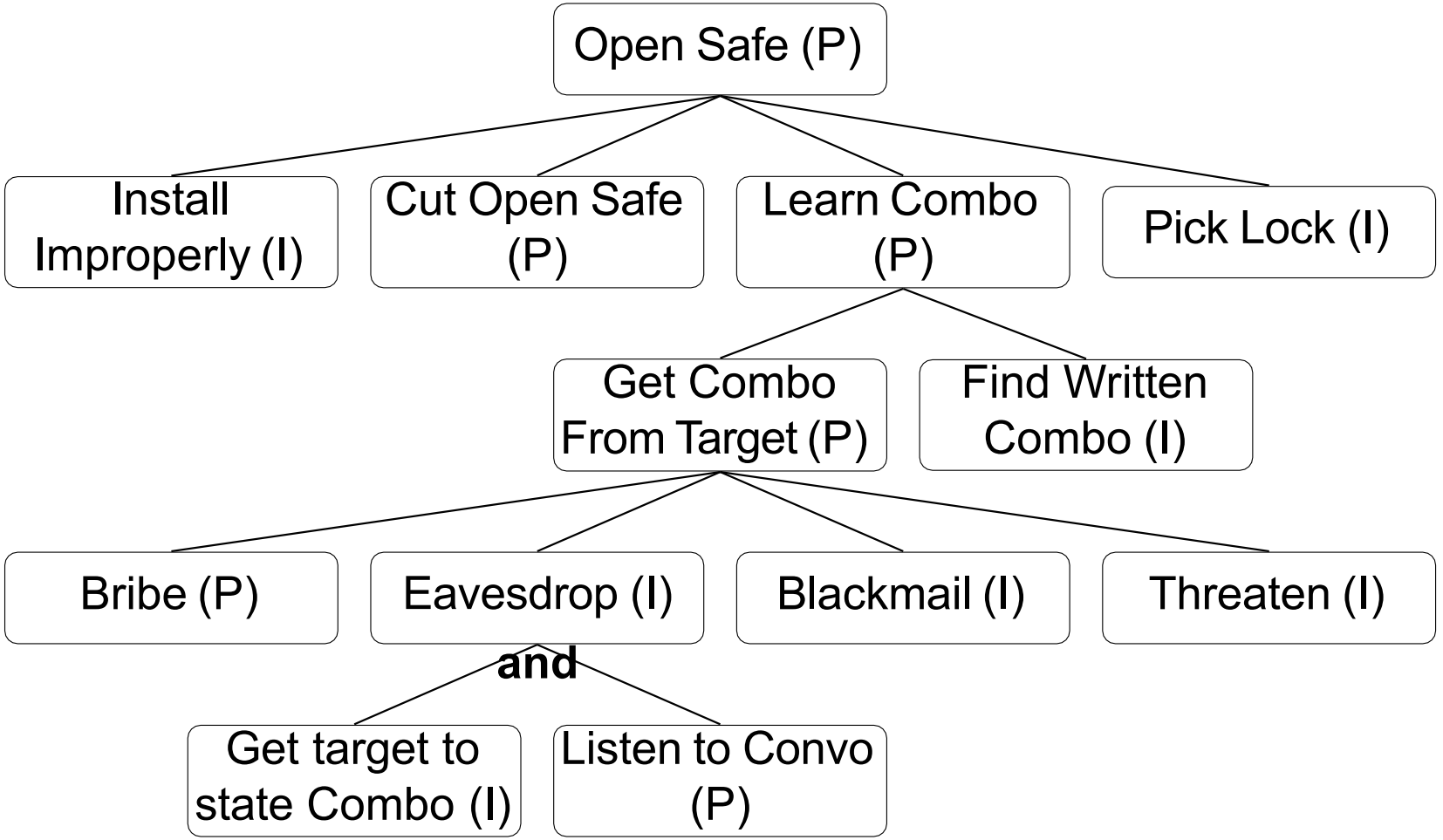
- Examine the safe/safe owner/attacker's abilities/etc. and assign values to the nodes:
  - P = Possible
  - I = Impossible
- The value of an OR node is possible if any of its children are possible.
- The value of an AND node is possible if all children are possible.
- A path of P to s from a leaf to the root is a possible attack!
- Once you know the possible attacks, you can think of ways to defend against them!

Example I — Open a Safe



Example I — Open a Safe

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- We can be more specific and model the cost of an attack.
- Costs propagate up the tree:
  - OR nodes: take the min of the children.
  - AND nodes: take the sum the children.

Example I — Open a Safe

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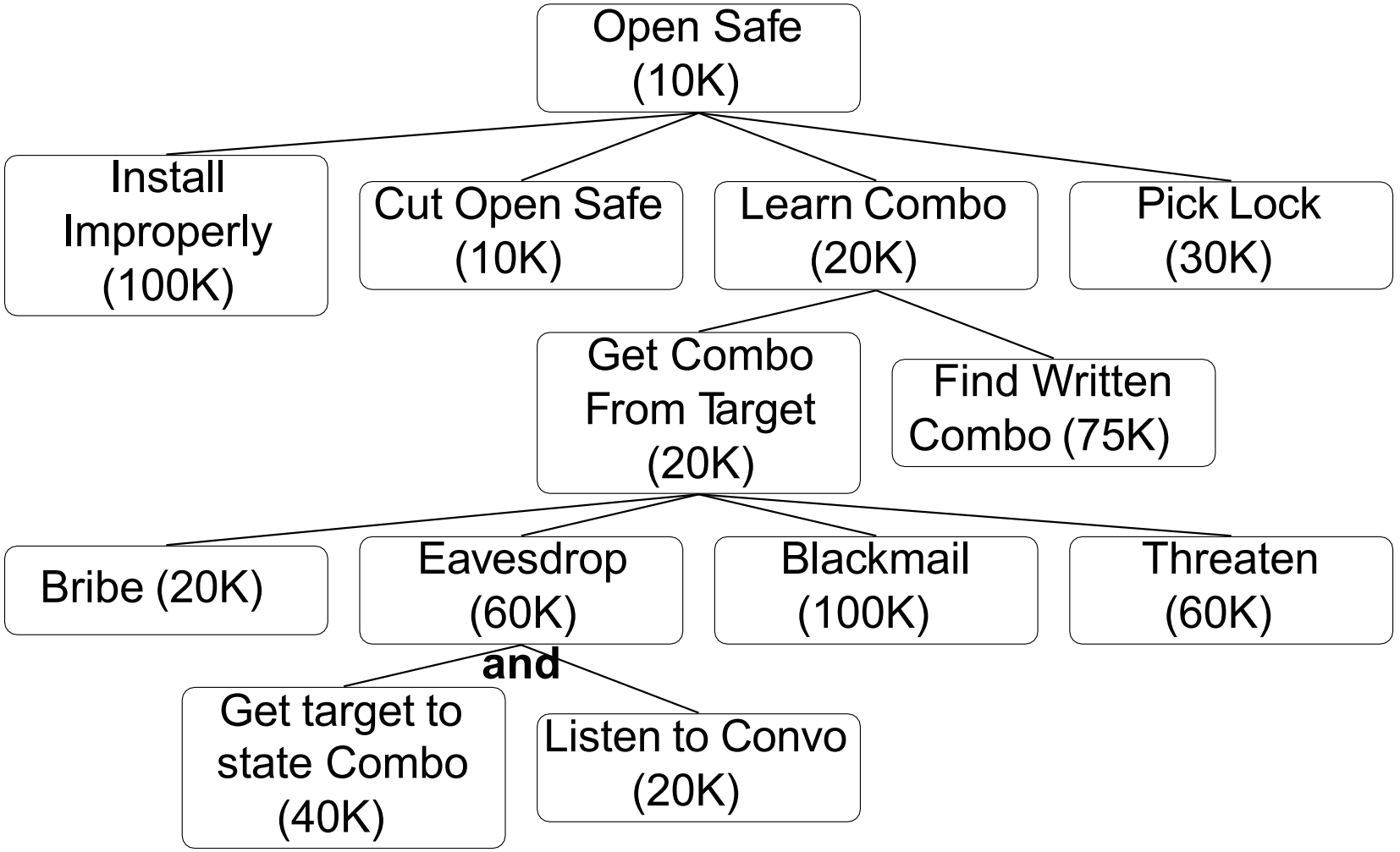

Exercise — Read a Message

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Goal:

Read a message sent from a sender on computer A to a receiver on computer B.

What can you do?

Start sketching an attack tree!

Example II — Read a Message

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Goal: Read a message sent from computer A to B.

1. Convince sender to reveal message

- Bribe user, OR
- Blackmail user, OR
- Threaten user, OR
- Fool user

2. Read message while it is being entered

- Monitor electromagnetic radiation, OR
- Visually monitor computer screen.

Example II — Read a Message

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3. Read message while stored on A's disk.

- Get access to hard drive, AND
- Read encrypted file.

4. Read message while being sent from A to B.

- Intercept message in transit, AND
- Read encrypted message.

Example II — Read a Message

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5. Convince recipient to reveal message

- Bribe user, OR
- Blackmail user, OR
- Threaten user, OR
- Fool user

6. Read message while it is being read

- Monitor electromagnetic radiation, OR
- Visually monitor computer screen

Example II — Read a Message

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7. Read message when being stored on B's disk.

- Get stored message from B's disk after decryption
  - Get access to disk, AND Read encrypted file.
- OR
- Get stored message from backup tapes after decryption.

8. Get paper printout of message

- Get physical access to safe, AND
- Open the safe.

Example Smart Meter

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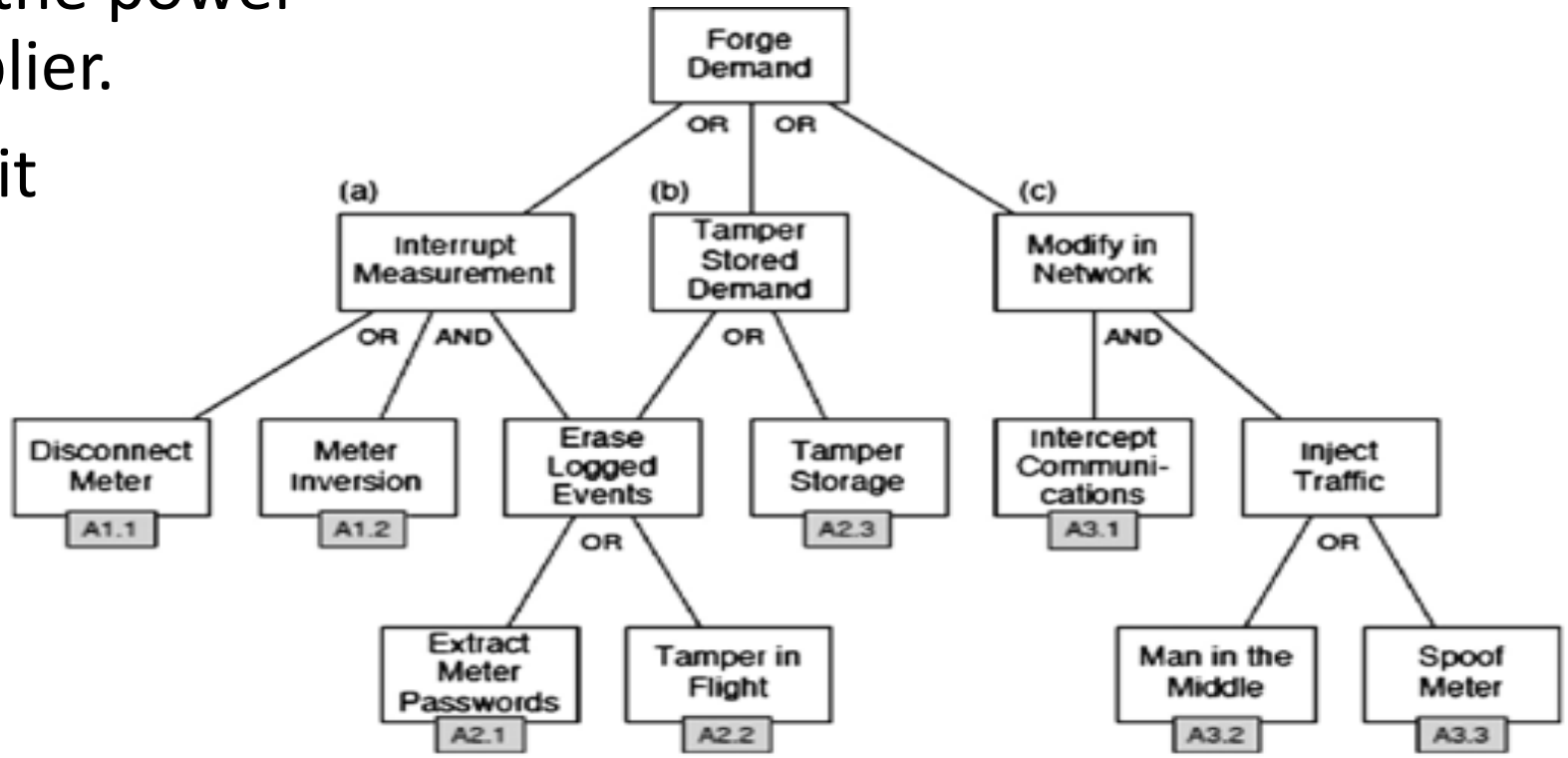
Smart meter is a device that communicate via network the power demand to the Power supplier.

It stores the logs and send it periodically to the server



Quiz

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The main goal of the attacker is to "Forge Demand": which attack path here below is NOT enough to perform a successful attack?

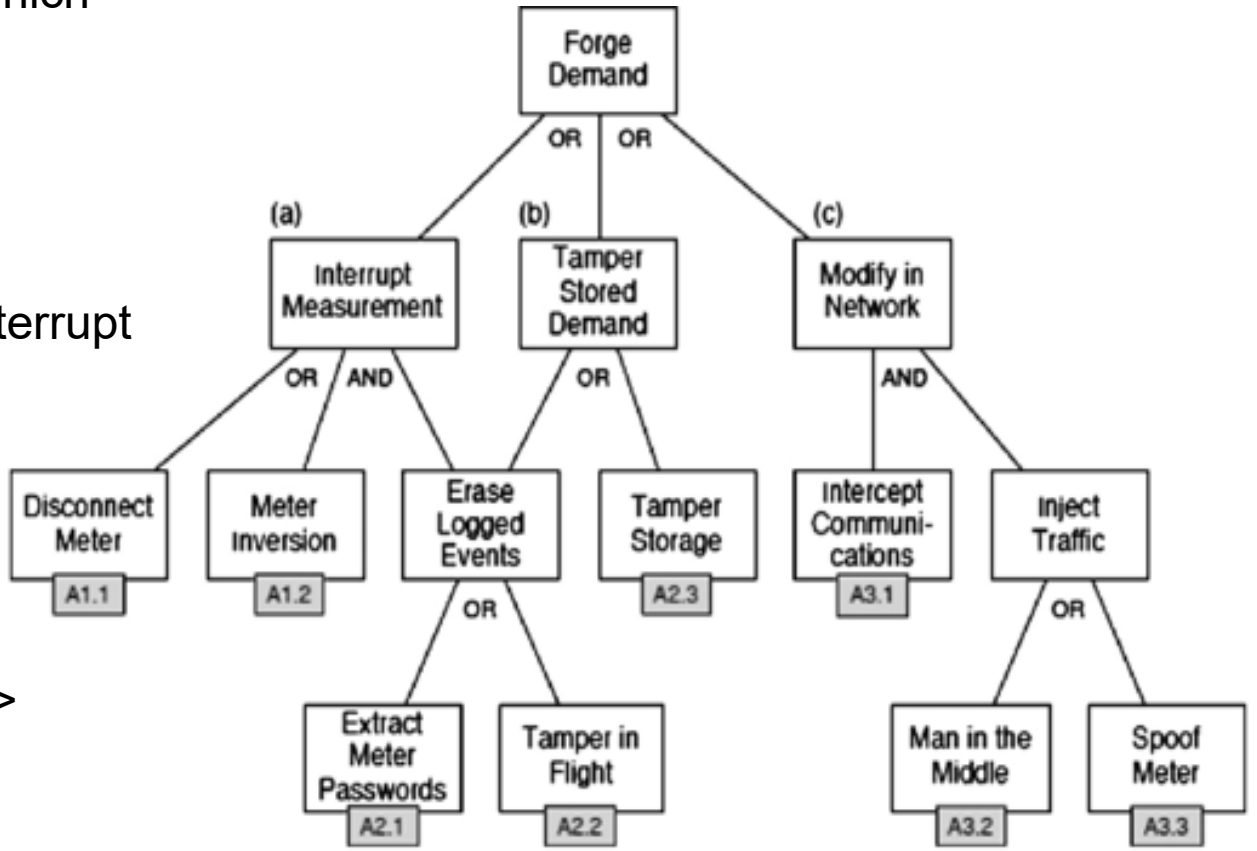
A. Disconnect Meter –> Interrupt Measurement

B. Meter Inversion –> Extract Meter Passwords –> Interrupt Measurement

C. Tamper Storage –> Tamper Stored Demand

D. Spoof Meter –> Inject Traffic –> Modify in network

E. Extract Meter password -> Erase Logged Events -> Tamper Stored Demand



Attack Tree: Breaking Checksum

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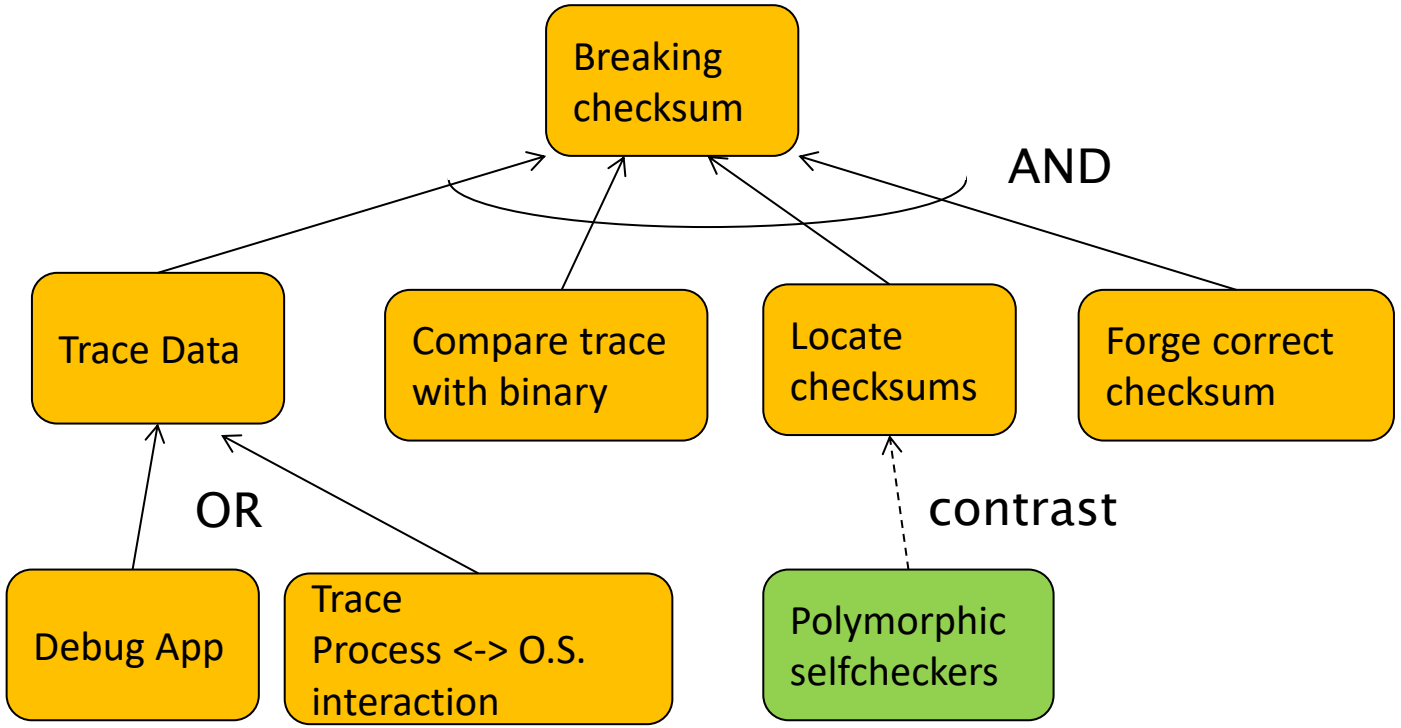
- Relate attack goal, subgoals
- Optionally link protections to the sub-goal they are contrasting



In-class Exercise 2

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- Every night, Alice, 18, sits down with her laptop in front of the TV in the living room and adds a paragraph to her diary, describing her latest dating adventures.
- Bob, her 13-year-old bratty brother, would love to get his hands on her writings.
- Help Bob plan an attack (or Alice to defend herself against an attack!) by constructing a detailed attack tree!

In-class Exercise 2

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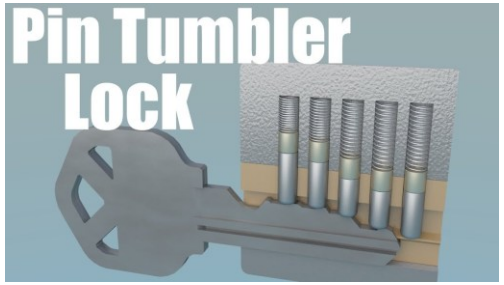
Bob knows this about Alice:

- She writes and stores her diary directly on her laptop.
- The hard drive is encrypted with 512-bit AES.
- She's written down her pass-phrase on a post-it note.
- She stores the post-it note in a safe in her bedroom.
- The safe is locked with a 5-pin pin-and-tumbler lock.



- She carries the key to the safe on a chain around her neck wherever she goes.
- She leaves the laptop next to her bed at night.
- The laptop is always connected to the Internet over wifi.

In-class Exercise 2

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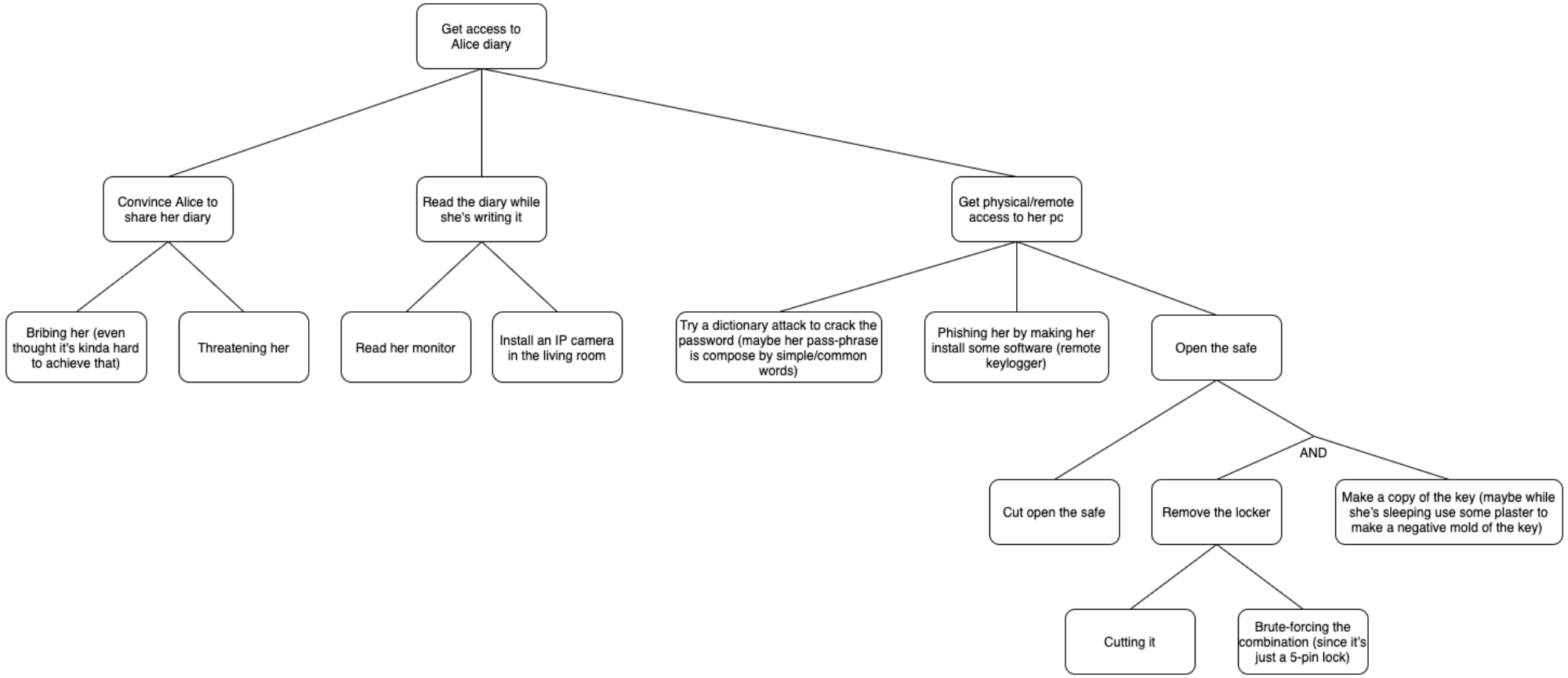
We know the following about Bob:

- He can roam freely around the house.
- His gaming skills has given him the financial means to purchase various attack tools off the Internet.
- Your solution should consider both physical attacks and cyber attacks.
- You don't have to assign costs to the nodes of the tree.
- Make sure to mark AND and OR nodes unambiguously.
- You can draw the actual tree or, if you prefer, represent the tree with indented, nested, numbered lists.

Possible Solution



Attack Trees
Software Protection Example

Who's our adversary?

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- What does a typical program look like?
- What assets does the program contain?
- What is the adversary's motivation for attacking your program?
- What information does he start out with as he attacks your program?
- What is their overall strategy for reaching their goals?
- What tools do they have to their disposal?
- What specific techniques do they use to attack the program?

Example Program

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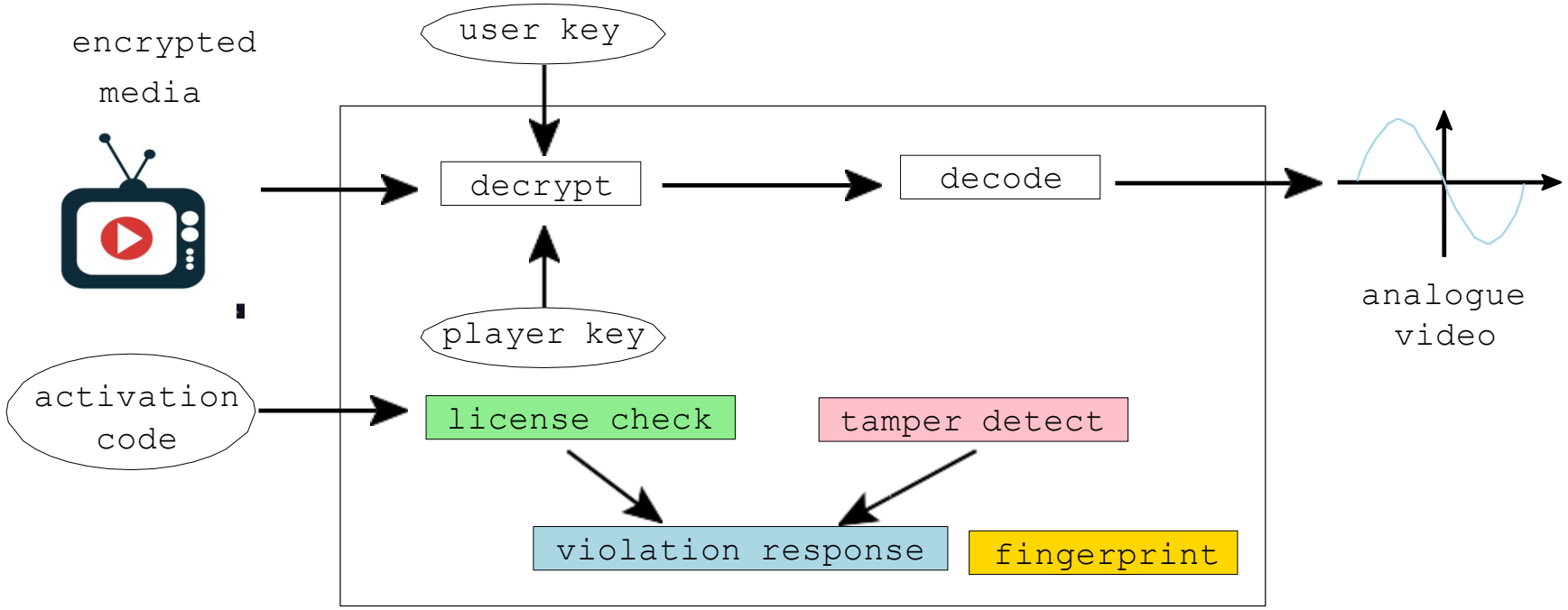

What's the Adversary's Motivation?

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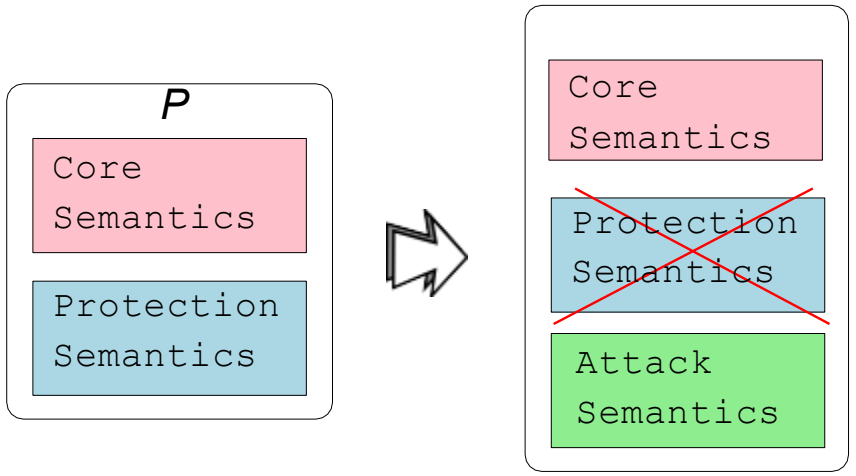
The adversary wants to

- remove the protection semantics.
- add his own attack semantics (ability to save game-state, print)
- ensure that the core semantics remains unchanged.



What does he want to do to the Player program?

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- get decrypted digital media extract the player key
- use the program after the expiration date
- remove use-before check remove activation code
- distribute the program to other users
- remove fingerprint
- reverse engineer the algorithms in the player

What are the methods of attack?

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1. The Black Box phase
   - feed the program inputs,
   - record its outputs
   - draw conclusions about its behavior.
2. The Dynamic Analysis phase
   - execute the program
   - record which parts get executed for different inputs
3. The Static Analysis phase
   - examining the executable code directly
   - use disassembler, decompiler, . . .

What are the methods of attack?

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4. The editing phase

- use understanding of the internals of the program
- modify the executable disable license checks

5. The automation phase

- encapsulates his knowledge of the attack in an automated script
- use in future attacks.

Example Program

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```
1  typedef unsigned int uint;
2  typedef uint* waddr_t;
3  uint player_key = 0xbabeca75;
4  uint the_key;
5  uint* key = &the_key;
6  FILE* audio;
7  int activation_code = 42;
```

Example Program

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```
 7  void FIRST_FUN(){}
 8  uint hash (waddr_t addr, waddr_t last) {
 9      uint h = *addr;
10      for (;addr<=last;addr++) h^=*addr;
11  return h;
12  }
13  void die(char* msg) {
14      fprintf(stderr,"%s!\n",msg);
15      key = NULL;
16  }
```

Example Program

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```
19  uint play(uint user_key,
20            uint encrypted_media[],
21            int media_len) {
22      int code;
23      printf("Please enter activation code: ");
24      scanf("%i",&code);
25      if (code!=activation_code) die("wrong code");
26
27      *key = user_key ^ player_key;
```

Example Program

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```
27      int i;
28      for(i=0;i<media_len;i++) {
29          uint decrypted = *key ^ encrypted_media[i];
30
31
32          if (time(0) > 1221011472) die("expired");
33
34
35          float decoded = (float)decrypted;
36          fprintf(audio,"%f\n",decoded); fflush(audio);
37
38
39      }
40  }
```

Example Program


```
41 void LAST_FUN(){}
42 uint player_main (uint argc, char *argv[]) {
43     uint user_key = ···
44     uint encrypted_media[100] = ···
45     uint media_len = ···
46     uint hashVal = hash((waddr_t)FIRST_FUN,
47                         (waddr_t)LAST_FUN);
48     if (hashVal != HASH) die("tampered");
49     play(user_key, encrypted_media, media_len);
50 }
```