EXERCISE 14

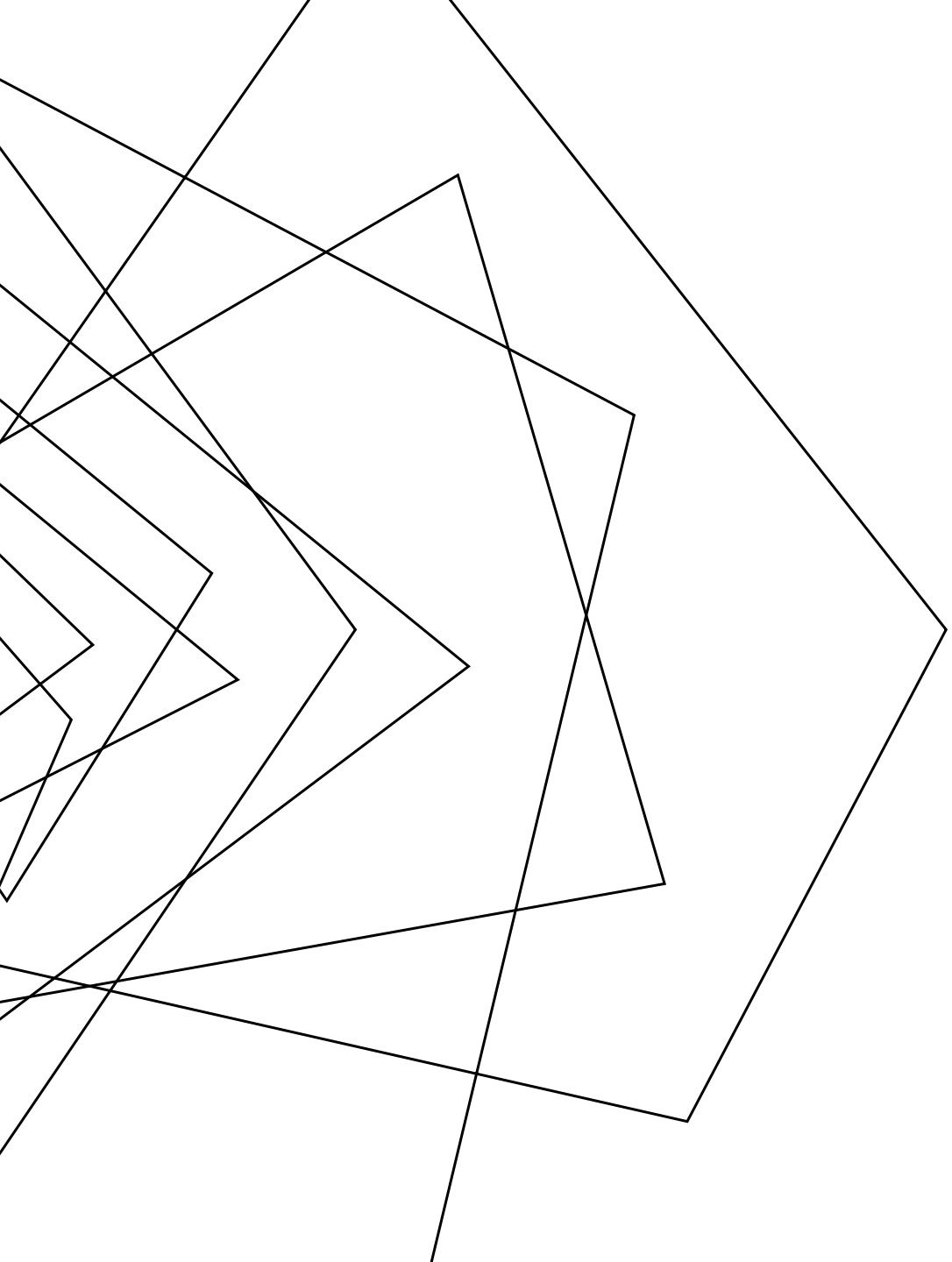
REVIEW: INFORMATION FLOW

Write your name and answer the following on a piece of paper

Give an example of a (pseudocode) program with an information flow that may be considered to violate integrity. Explain why the program violates integrity.

ADMINISTRIVIA AND ANNOUNCEMENTS

Thanks for the HOPE Award nomination!



CLASS PROGRESS

SHOWING SOME APPLICATIONS OF STATIC DATAFLOW

LAST TIME: DATAFLOW DEPLOYMENT

PREVIOUSLY: INFORMATION FLOW

USING DATAFLOW IN PRACTICAL CONTEXTS

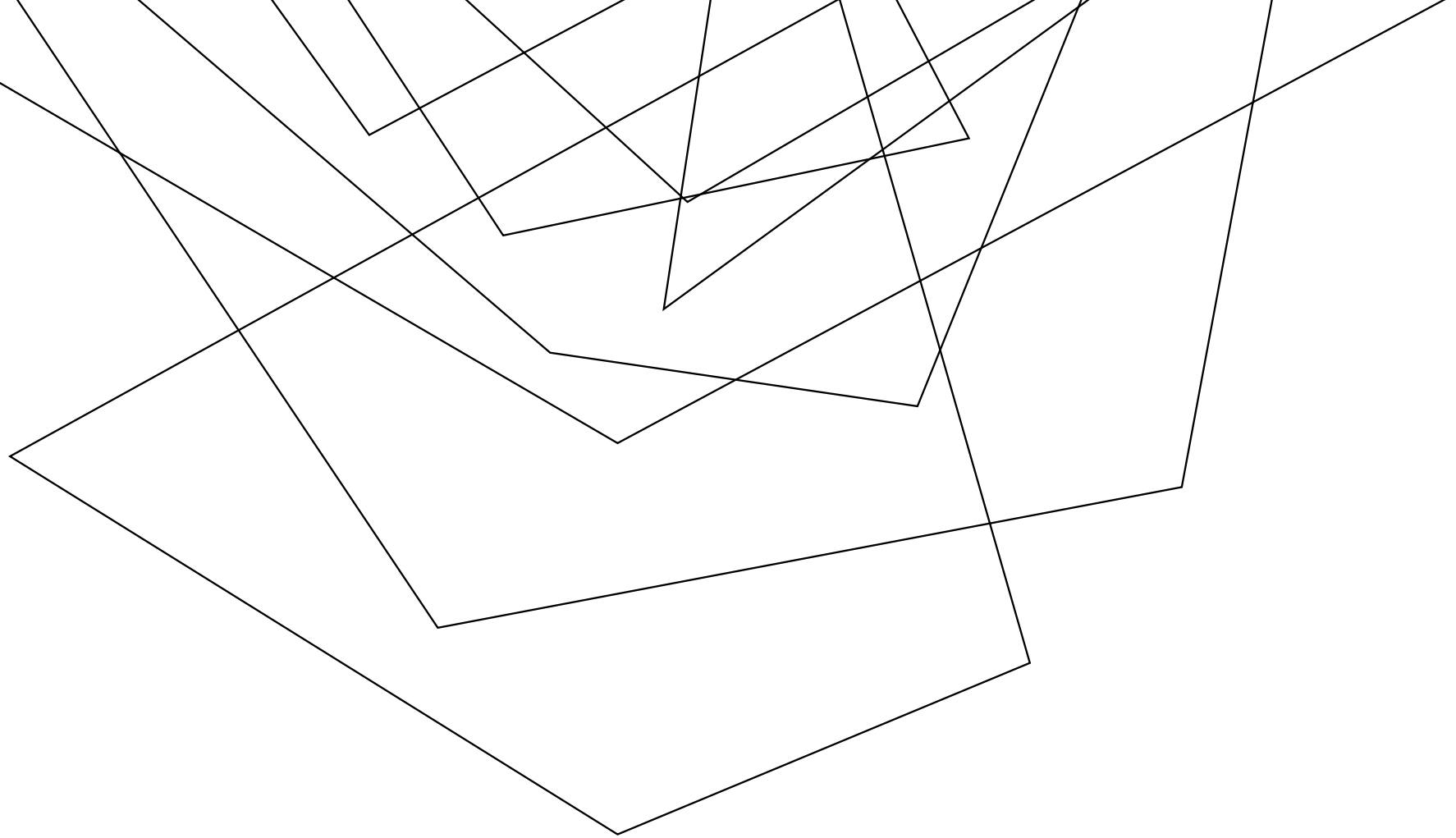
- Ex. - Looking for secret-holding variables

IMPLICIT FLOW

PREVIOUSLY: INFORMATION FLOW

```
X = source();
Y = 0;
if (X == 1){
  Y = 1;
  SINK(1);
}
if (X == 2){
  Y = 2;
}
…
```

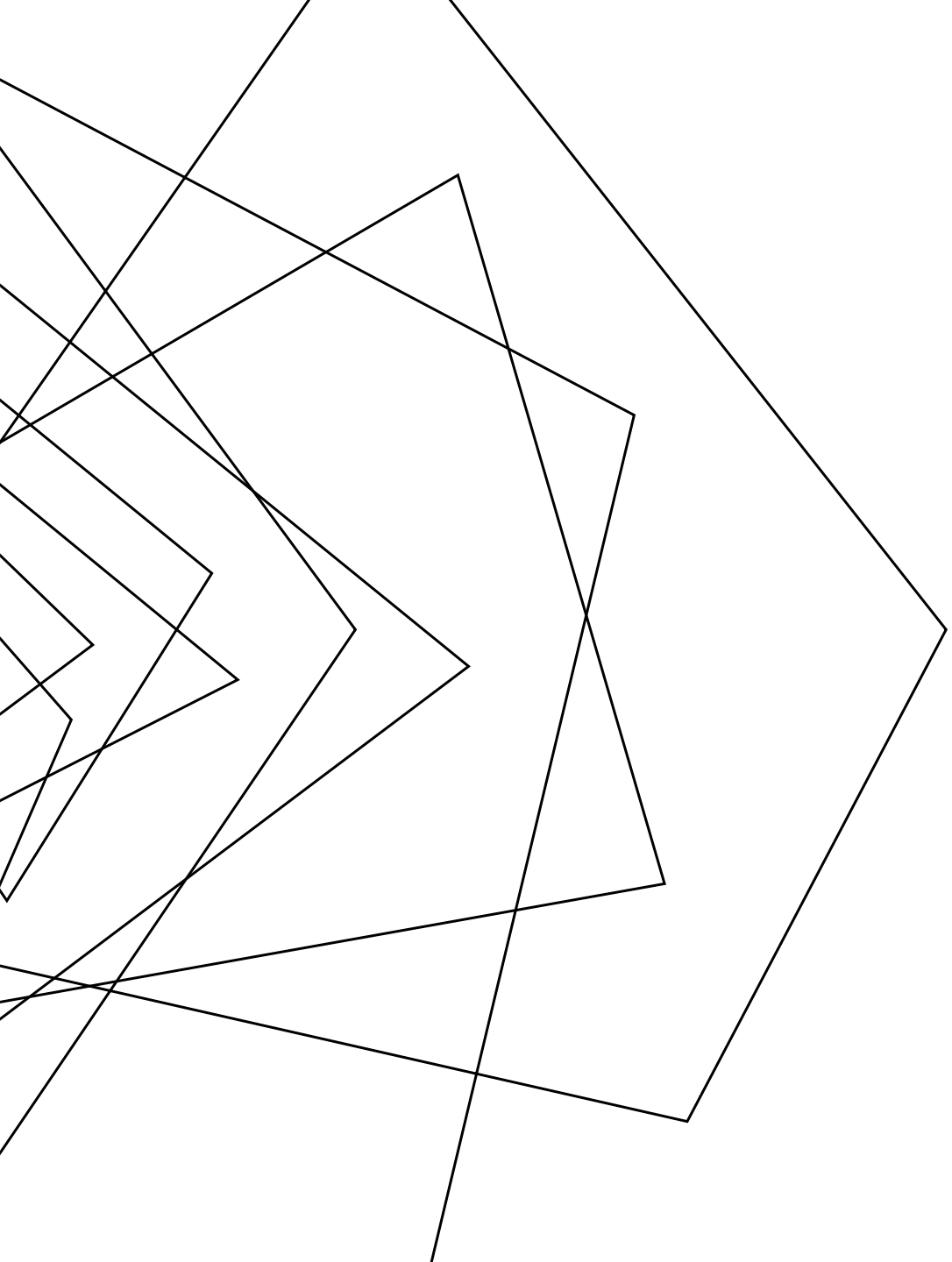
Leak!



SIDE CHANNELS

EECS 677: Software Security Evaluation

Drew Davidson

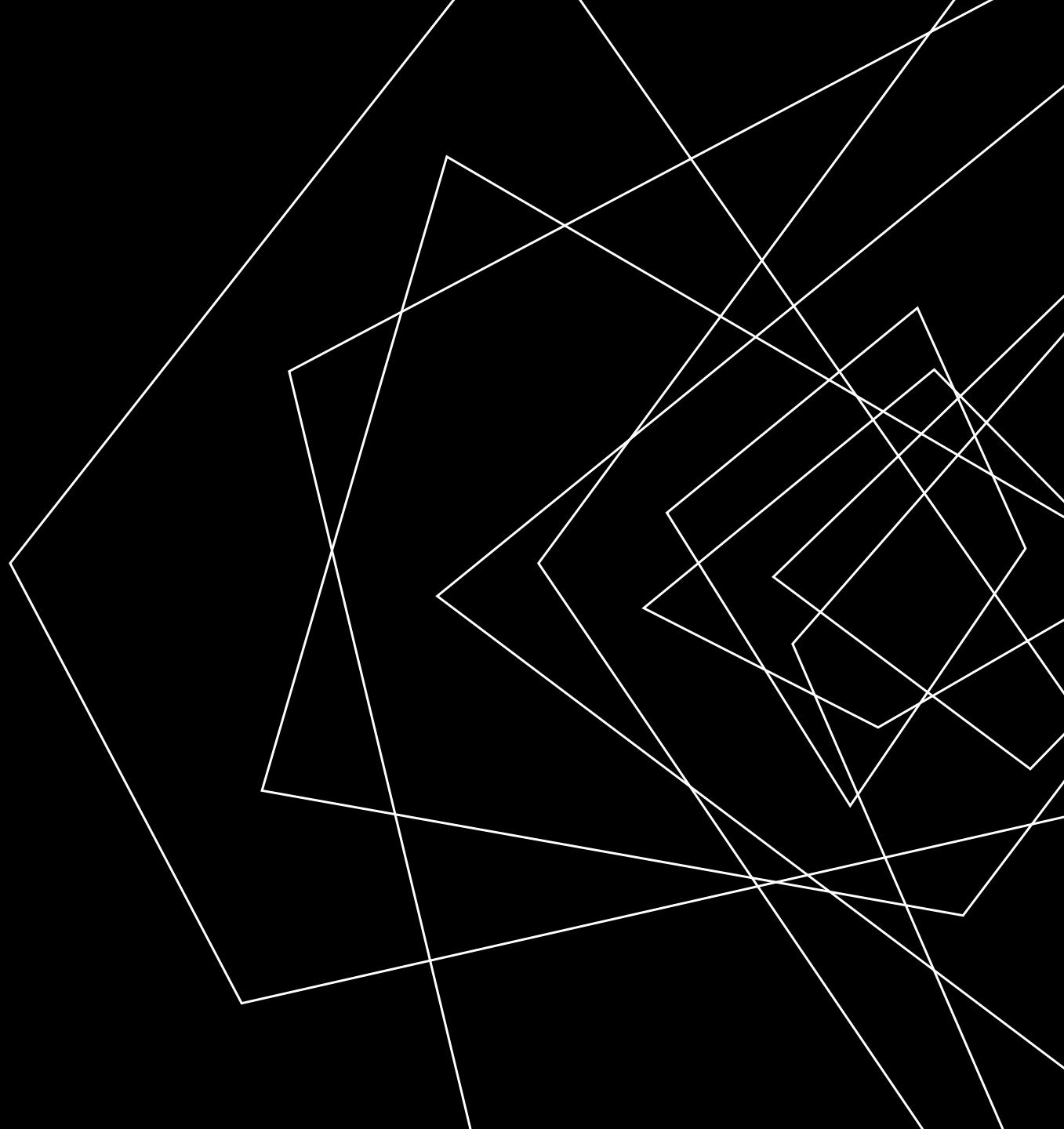


OVERVIEW

CONTEMPLATE OTHER WAYS THAT SNEAKY DATA FLOWS CAN OCCUR

LECTURE OUTLINE

- Threat Models
- Side Channels - Overview
- Timing
- A dataflow approach



THINKING ABOUT ATTACKS

RECALL: THREAT MODELS

THERE'S NO SUCH THING AS "ABSOLUTE SECURITY"

- It's always possible to come up with SOME (potentially wacky) scenario where the adversary can subvert a system

CONSIDER THE VARIOUS ATTACK CLASSES

- **Denial of Service:** Availability is compromised
- **Exfiltration:** Confidentiality policy is compromised
- **Compromise:** Integrity policy is compromised

THINKING ABOUT ATTACKS

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CONSIDER THE VARIOUS ATTACK CLASSES

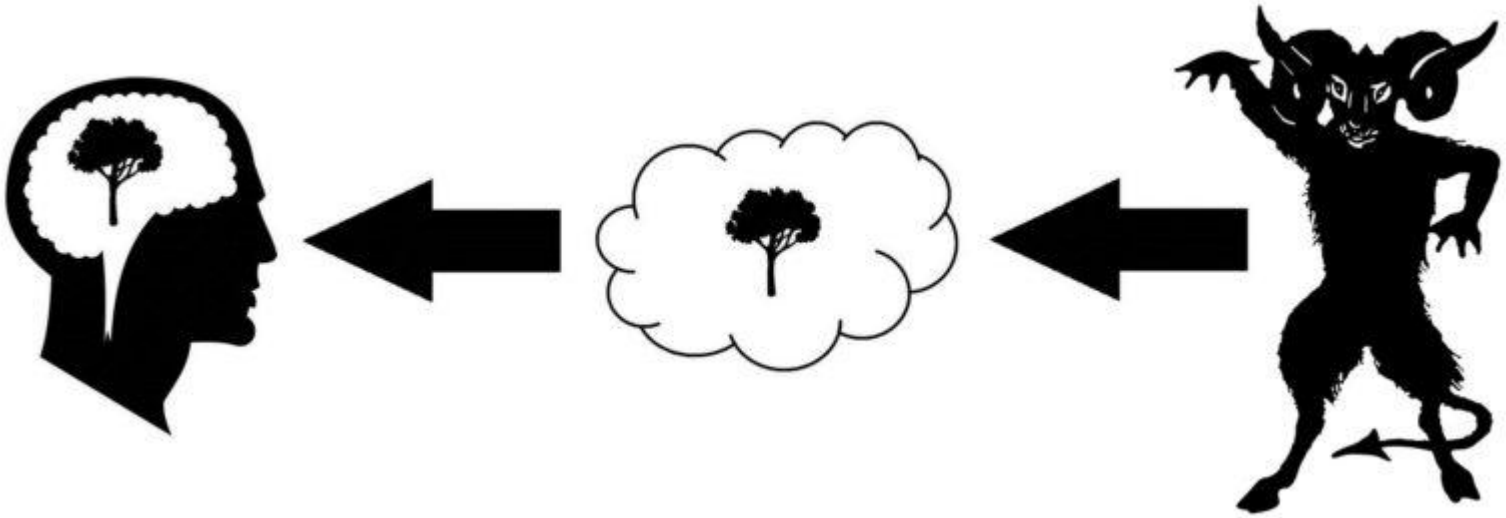
- **Denial of Service:** Availability is compromised
- **Exfiltration:** Confidentiality policy is compromised
- **Compromise:** Integrity policy is compromised

These assumptions are captured by a threat model

UNCONVENTIONAL ADVERSARIES

RECALL: THREAT MODELS

OUR NOTIONS OF COMPLETENESS ARE ULTIMATELY TIED TO OUR ASSUMPTIONS



Deus Deceptor (Game over)

UNCONVENTIONAL ADVERSARIES

RECALL: THREAT MODELS

OUR NOTIONS OF COMPLETENESS ARE ULTIMATELY TIED TO OUR ASSUMPTIONS

- An adversary may have the ability to influence (or observe) phenomena that are outside of the threat model
- Anecdote: sensor input spoofing attacks

Side-channels: Extra-semantic observation

SISA: Extra-semantic influence

LECTURE OUTLINE

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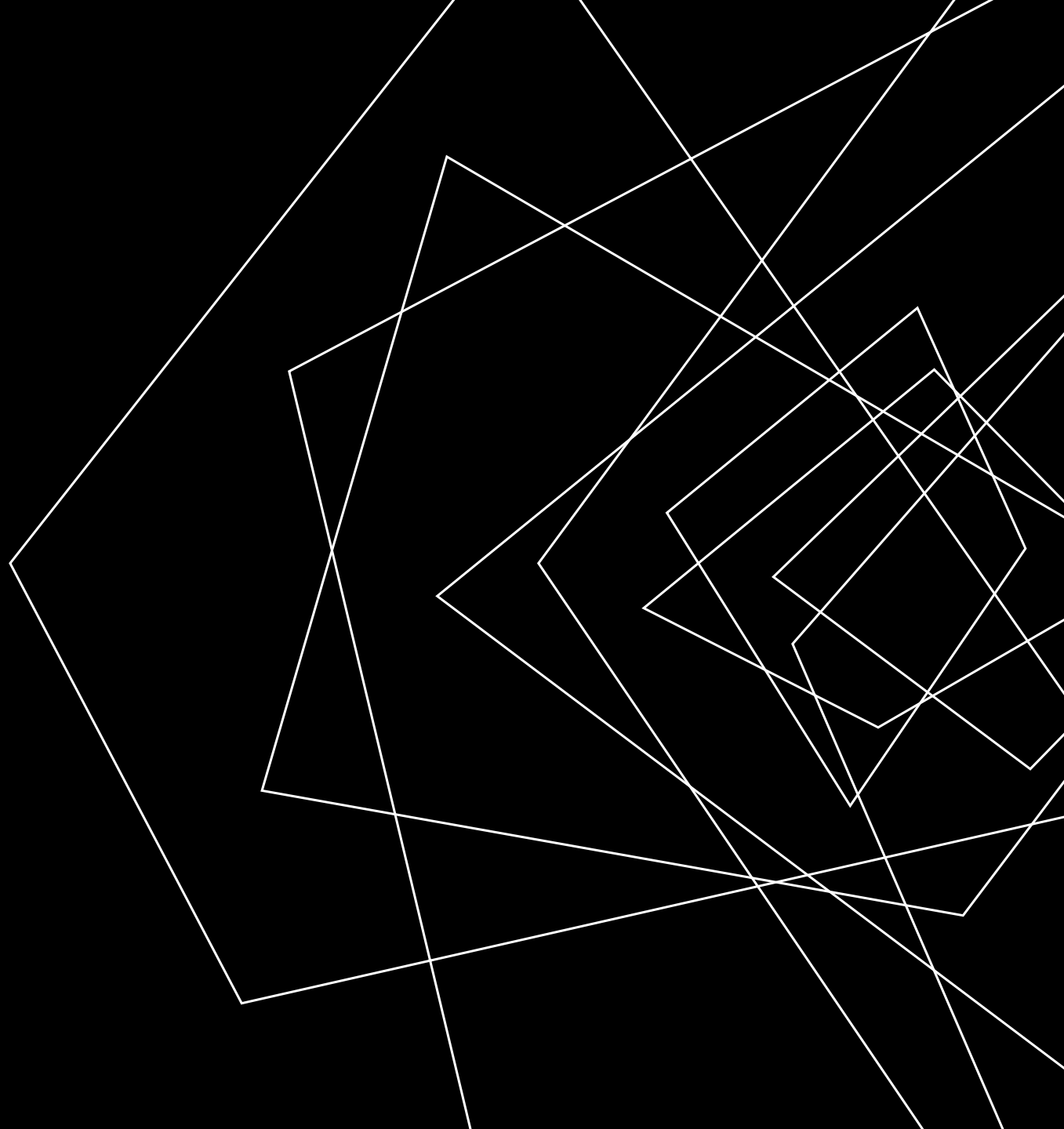

THE BASIC IDEA OF SIDE CHANNELS

SIDE CHANNELS

Abstraction is a key principle of Computer Science!

As a programmer, you shouldn't need to know underlying details

As a security expert, these details might end up being important!

The way a program accomplishes its tasks are important, especially from a security aspect

- How long does it take for the program to do X ?
- How hot does it make the processor when X happens?
- How much power does it draw when X happens?

UNCONVENTIONAL ADVERSARIES

RECALL: THREAT MODELS

(SADLY) OUR SOFTWARE NEEDS TO BE MANIFESTED IN HARDWARE

SIDE CHANNELS – THE BIG IDEA

SIDE CHANNELS - INSTANCES

COMPUTATION MAY HAVE EFFECTS OUTSIDE OF PROGRAM SEMANTICS

Some operations (internally) take longer based on aspects of the data

TEMPEST

SIDE CHANNELS – HISTORY

Electromagnetic Leakage of keys

- **WWII:** Bell Telephone discovers electromagnetic leakage in one-time pad teleprinters, detectable at 100-ft radius
- **1951:** CIA rediscovers leakage, detectable at 200-ft radius
- **1964:** TEMPEST shielding protocol established

TEMPEST

SIDE CHANNELS – HISTORY

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VAN ECK PHREAKING

SIDE CHANNELS – HISTORY

Electromagnetic Leakage of Monitors

- Pick up the monitor's electromagnetic emanations that differ depending on how the screen lights up
- Originally determined for CRT (1985), also discovered for LCD monitors (2004)

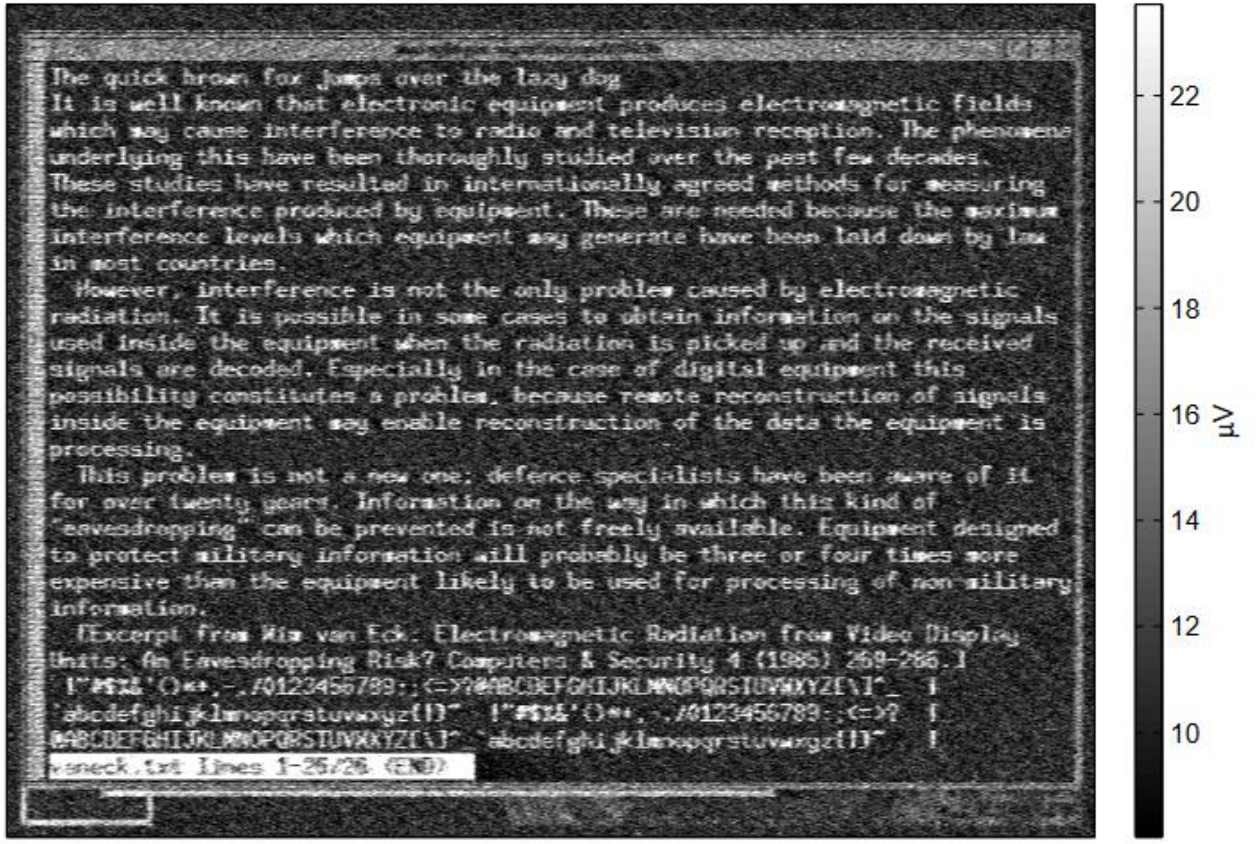


Fig. 3. Text signal received from a 440CDX laptop at 10 m distance through two intermediate offices (3 plasterboard walls).

SIDE CHANNELS – PARTIAL CREDIT

EVEN "HINTS" ABOUT SECRET DATA CAN BE PROBLEMATIC

Assume you're trying to guess a password

– knowing even 1 character massively reduces the search space

– knowing the length of the password reduces the search space

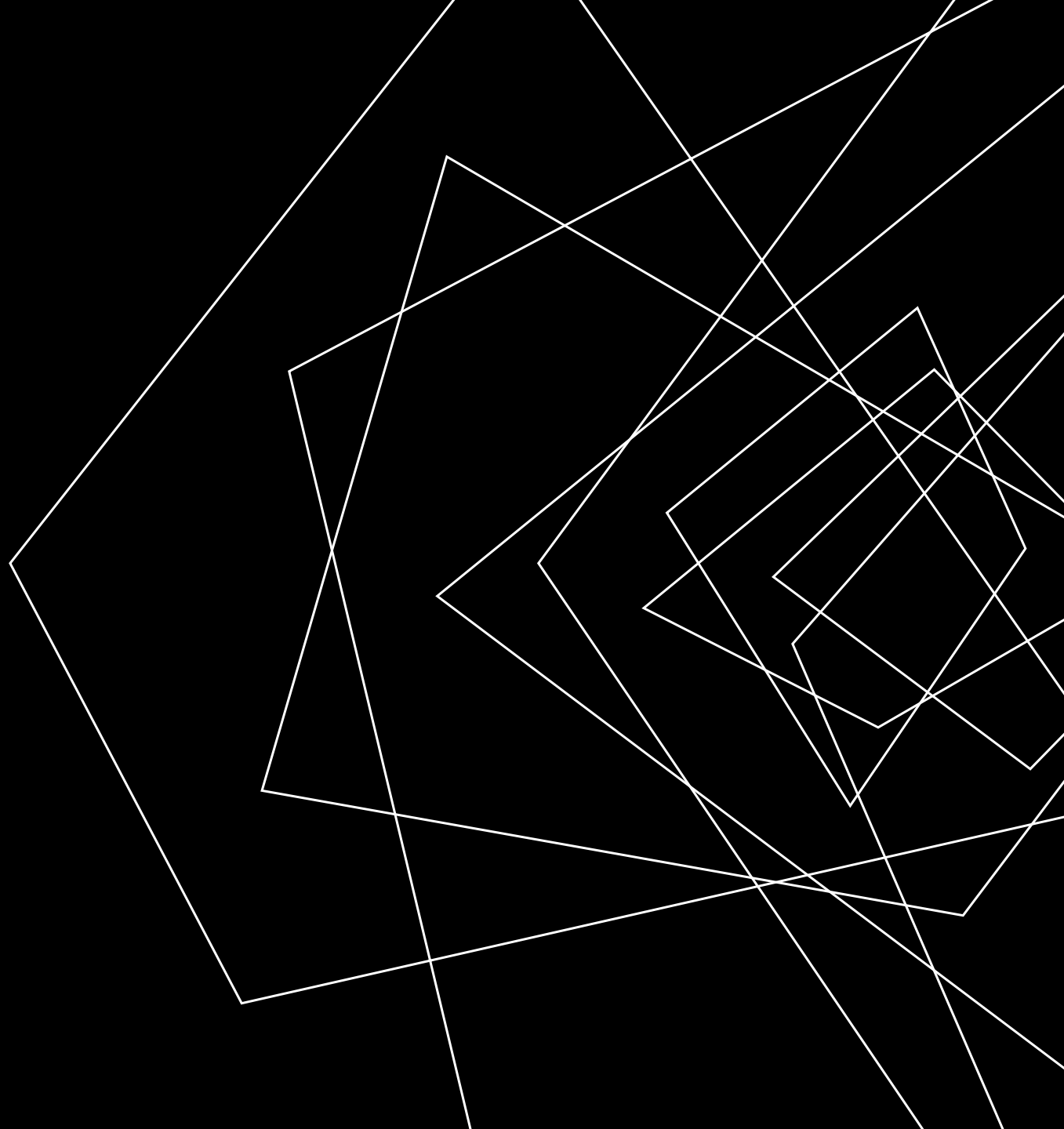
COVERT CHANNELS
SIDE CHANNELS

Sometimes a Program Wants to Leak data

Exfiltration !

LECTURE OUTLINE

- Threat Models
- Side Channels - Overview
- Timing
- A dataflow approach



TIMING SIDE CHANNELS

SIDE CHANNELS - INSTANCES

SOME COMPUTATIONS TAKE LONGER THAN OTHERS

Some operations (internally) take longer based on aspects of the data

```
bool checkPW(const char * given){
  const char * expected = “12345”;
  int gLen = strlen(given);
  int eLen = strlen(expected);
  if (gLen != eLen){ return false; }
  for (int i = 0; i < eLen; i++){
    if (given[i] != expected[i]){
      return false;
    }
  }
  return true;
}
```

TIMING SIDE CHANNELS

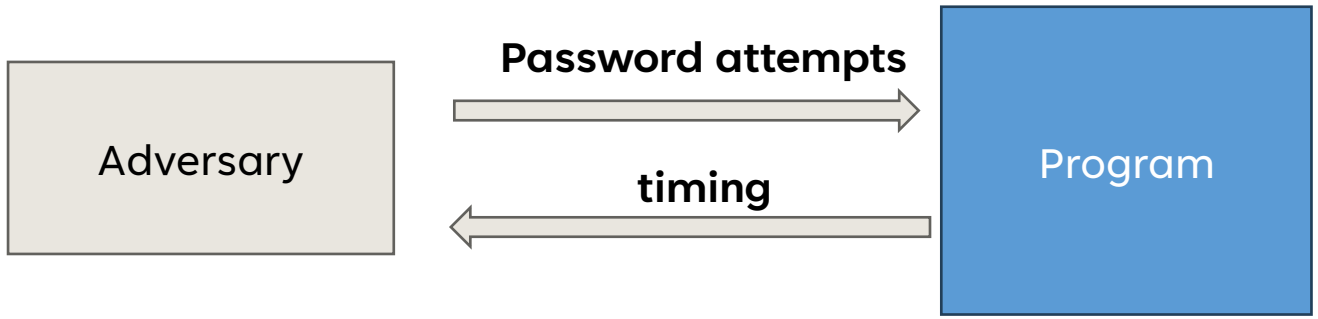
SIDE CHANNELS - INSTANCES

SOME COMPUTATIONS TAKE LONGER THAN OTHERS

Some operations (internally) take longer based on aspects of the data

THREAT MODEL

Interactive, low-latency*, black-box access to the program, precise timer



*: May be overcome with more samples

TIMING SIDE CHANNELS - FIX

SIDE CHANNELS - INSTANCES

```
bool checkPW(const char * given){
  const char * expected = "12345";
  int gLen = strlen(given);
  int eLen = strlen(expected);
  if (gLen != eLen){ return false; }
  for (int i = 0; i < eLen; i++){
    if (given[i] != expected[i]){
      return false;
    }
  }
  return true;
}
```

```
bool checkPW(const char * given){
  const char * expected = "12345";
  int gLen = strlen(given);
  int eLen = strlen(expected);
  bool ok = true;
  if (gLen != eLen){ ok = false; }
  for (int i = 0; i < eLen; i++){
    int gIdx = math.min(gLen - 1, i);
    if (given[gIdx] != expected[i]){
      ok = false;
    }
  }
  return ok;
}
```

TIMING SIDE CHANNELS - FIX

SIDE CHANNELS - INSTANCES

Limitations of Uniform Execution

- Necessarily slow down your computation to the worst case
- May require some pretty precise understanding of timing
- May not always be obvious what the worst-case even is

LECTURE OUTLINE

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- Instances
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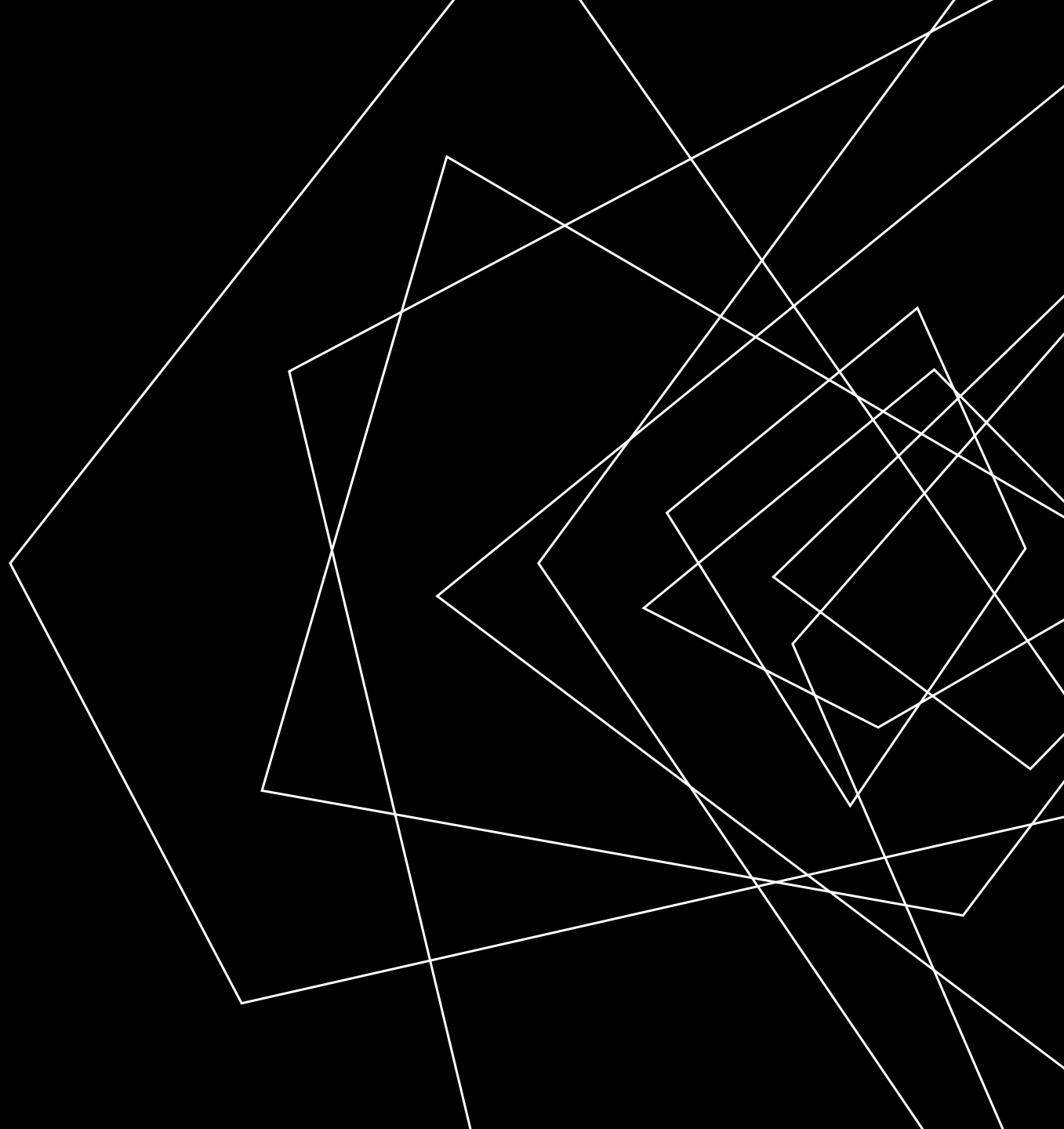

TIMING SIDE CHANNELS – FIX

SIDE CHANNELS – INSTANCES

CAN WE FIX THIS ISSUE WITH OUR DATAFLOW APPROACH?

- Instruction transformers: how much time that instruction takes
- Block composition: the sum total of instruction times
- Merge operation: some sort of check that all paths are of comparable time?

WRAP-UP