

A classic locked-room mystery. Eve was in the false branch of a conditional the whole time, how could she do it?

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Craig Disselkoen, Radha Jagadeesan, Alan Jeffrey, James Riely

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 $\mathsf{E} \mathsf{x} \mathsf{p} \mathsf{e} \mathsf{r} \mathsf{i} \mathsf{m} \mathsf{e} \mathsf{n} \mathsf{t} \mathsf{s}$

Why? Spectre!



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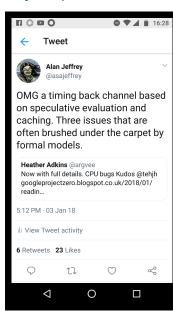
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Experiment:

Why? Spectre!



Attacks bypass dynamic security checks:

```
if (canReadSecret) {
  doStuffWith(SECRET);
}
```

Information flow from SECRET even though canReadSecret is false.

Most formal models ignore code in branches that aren't taken.

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Models that include speculation?

There are some models that include speculation relaxed memory models:

- ► The Java Memory Model Manson, Pugh and Adve, 2005.
- Generative Operational Semantics for Relaxed Memory Models Jagadeesan, Pitcher and Riely, 2010.
- A promising semantics for relaxed-memory concurrency Kang, Hur, Lahav, Vafeiadis and Dreyer, 2017.

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Models that include speculation?

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Question: is there a simple model similar to those of relaxed memory, that can model speculation?

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Information flow attacks on speculation

Speculation happens in many places:

- Speculation in hardware (branch prediction,...)
- Transactions (transactional memory,...)
- ► Relaxed memory (compiler optimizations,...)

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Information flow attacks on speculation

Speculation happens in many places:

- Speculation in hardware (branch prediction,...) Attacked by Spectre (Kocher et al. 2019).
- ► *Transactions* (transactional memory,...) Attacked by Prime+Abort (Disselokoen *et al.* 2017).
- Relaxed memory (compiler optimizations,...)
 No known attacks

Question: are there information flow attacks against compiler optimizations?

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Contributions

- A simple compositional model.
- Examples.
- Attacks (including a new attack on relaxed memory).
- Experiments (testing practicality of new attacks).

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Implementing the new attacks

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