Inlining a reference monitor

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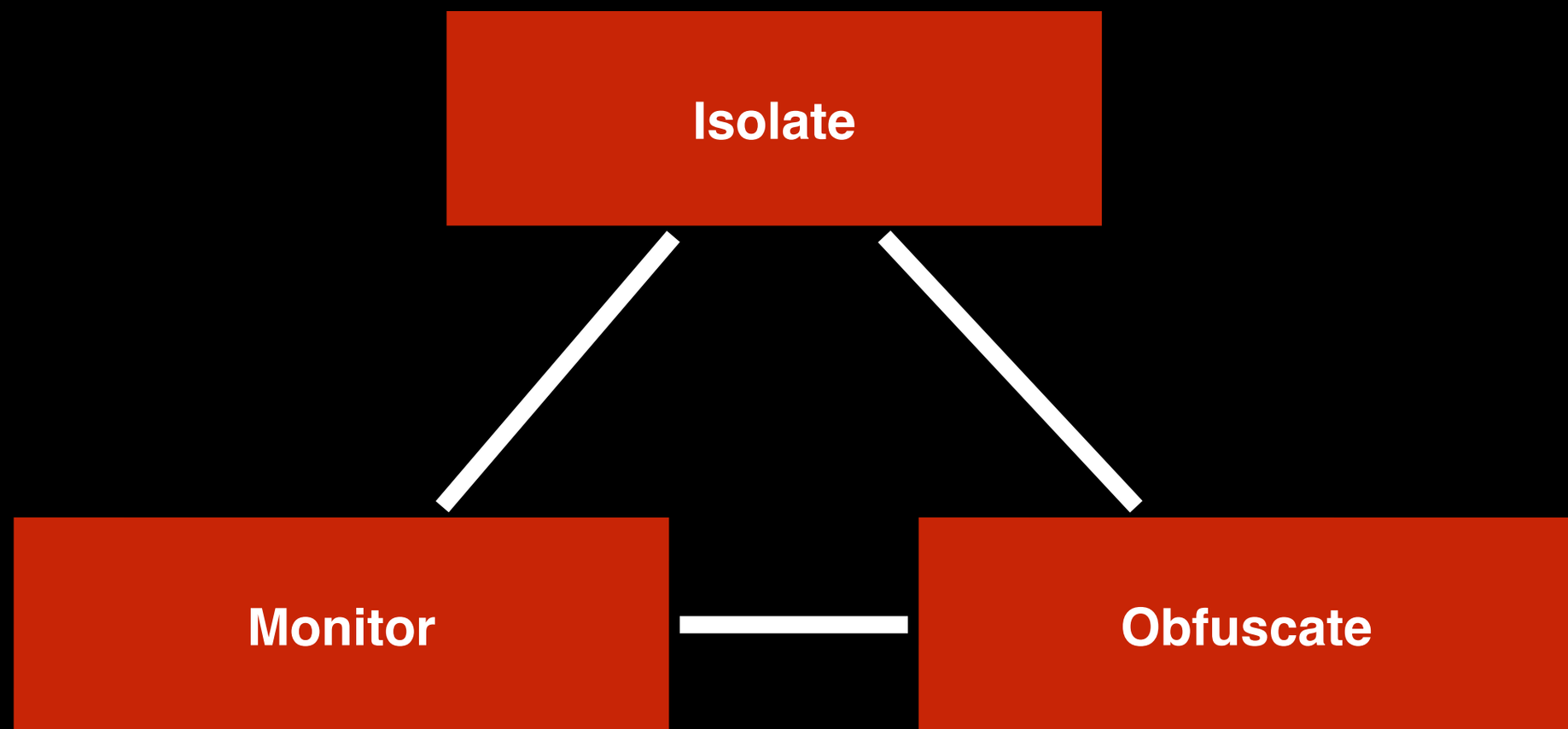
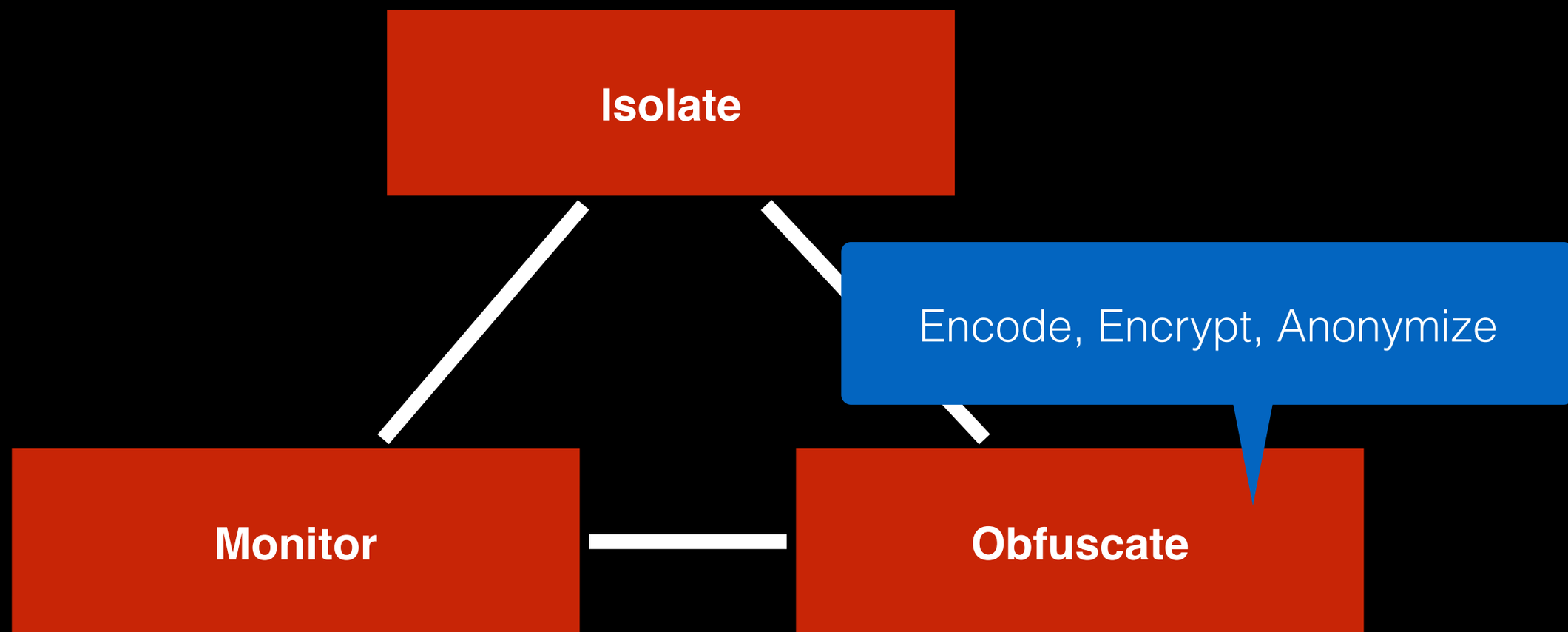
Dimensions of Security



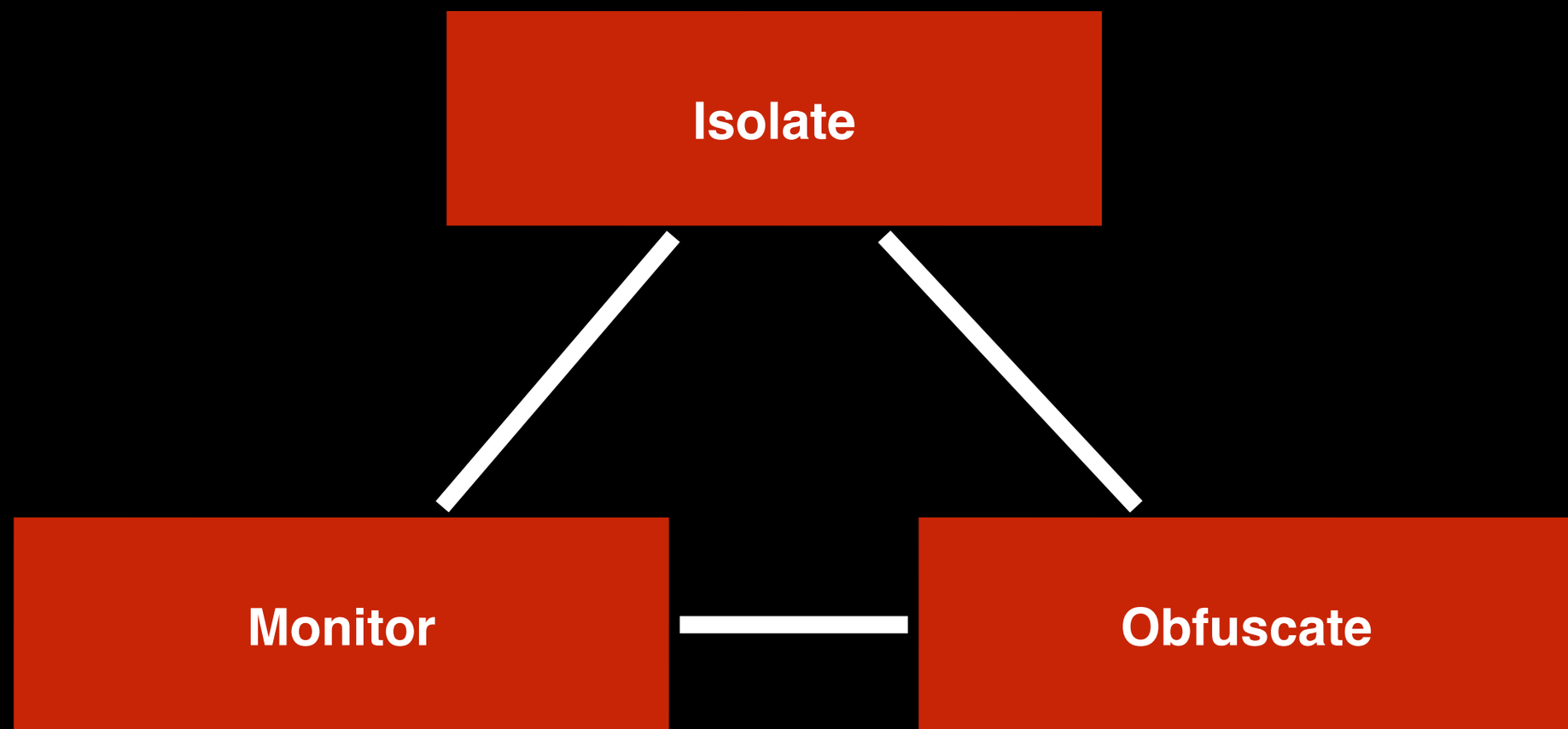
exercise 7.6

Dimensions of Security



exercise 7.6

Dimensions of Security



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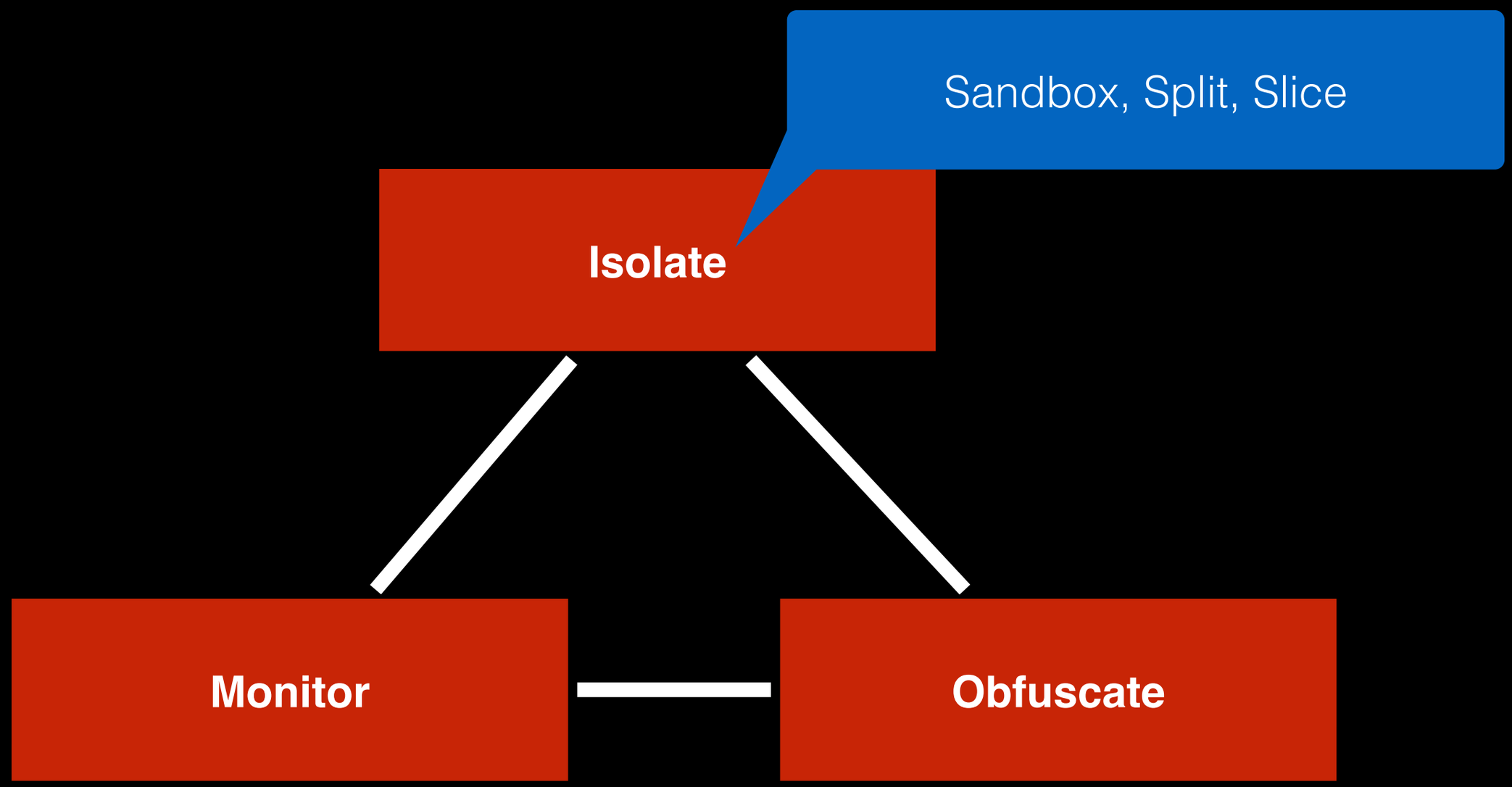

exercise 7.6

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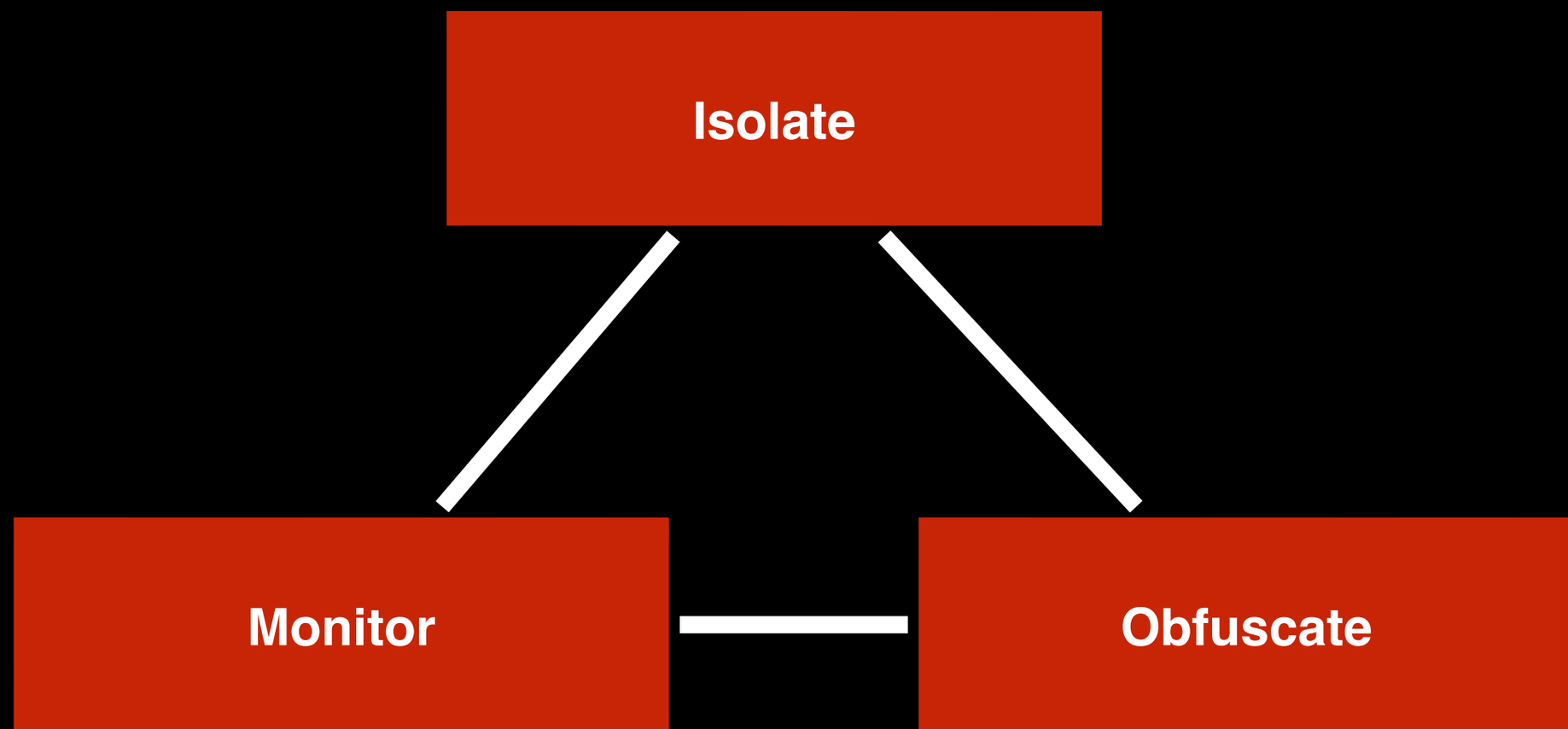

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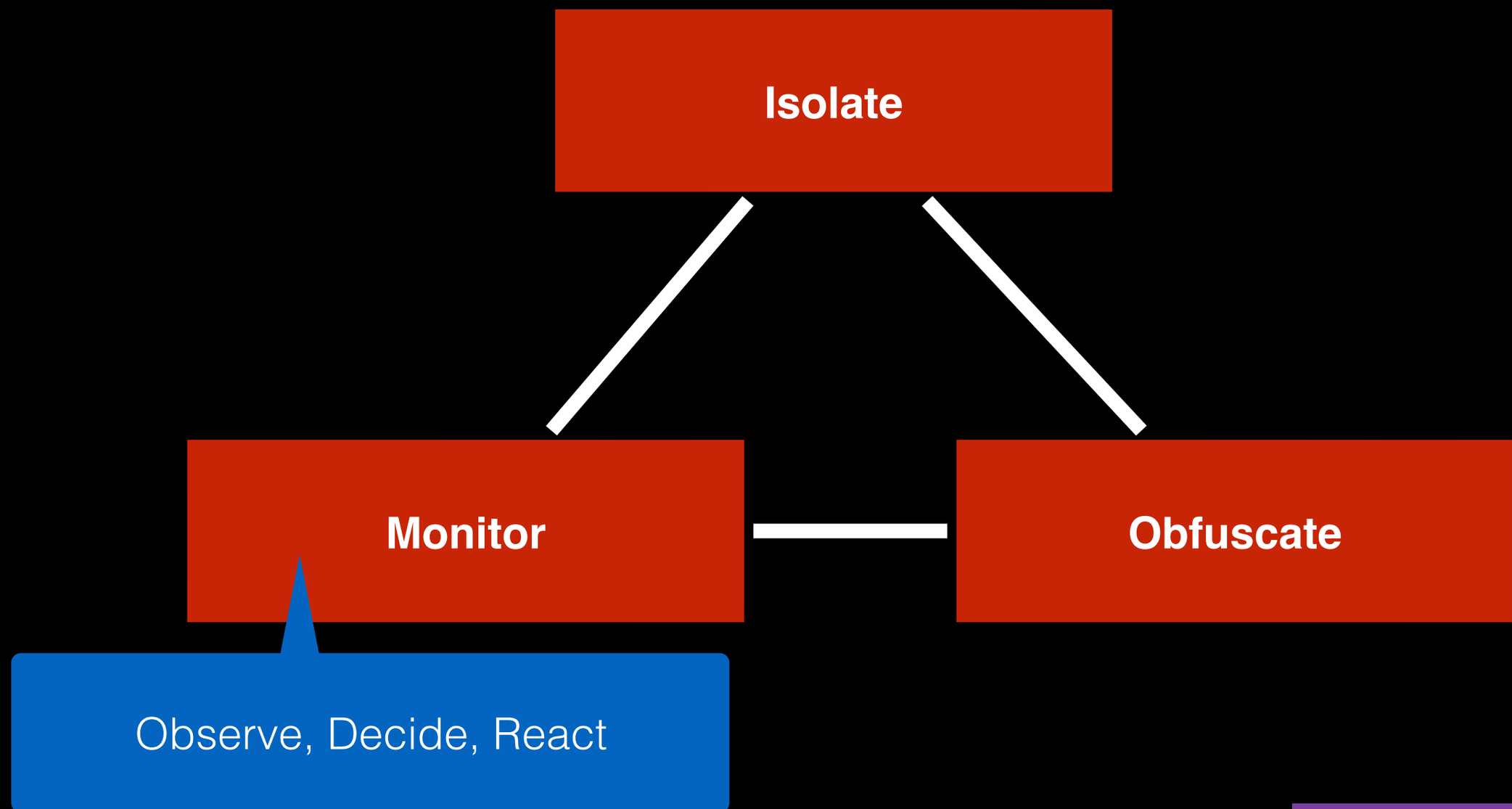

exercise 7.6

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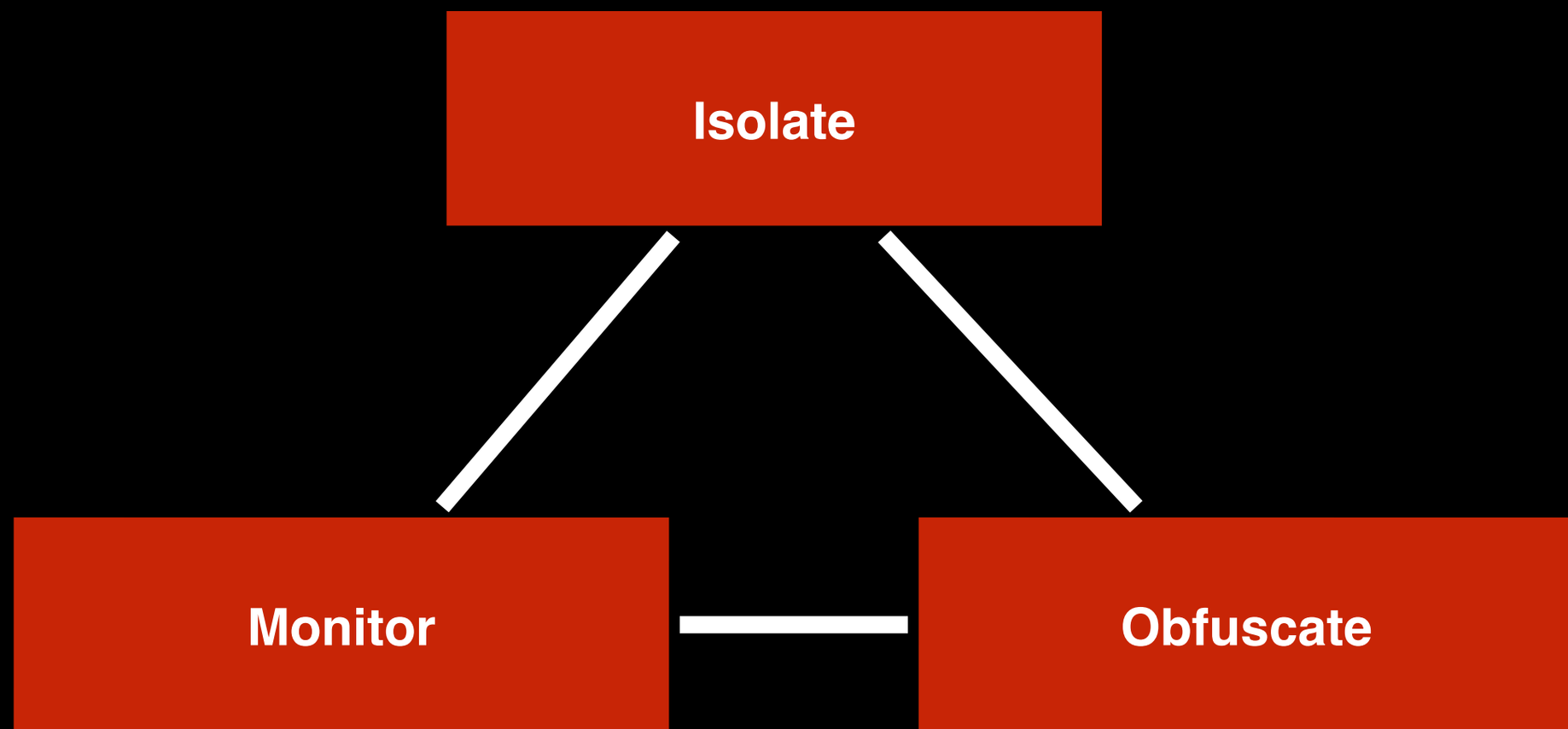


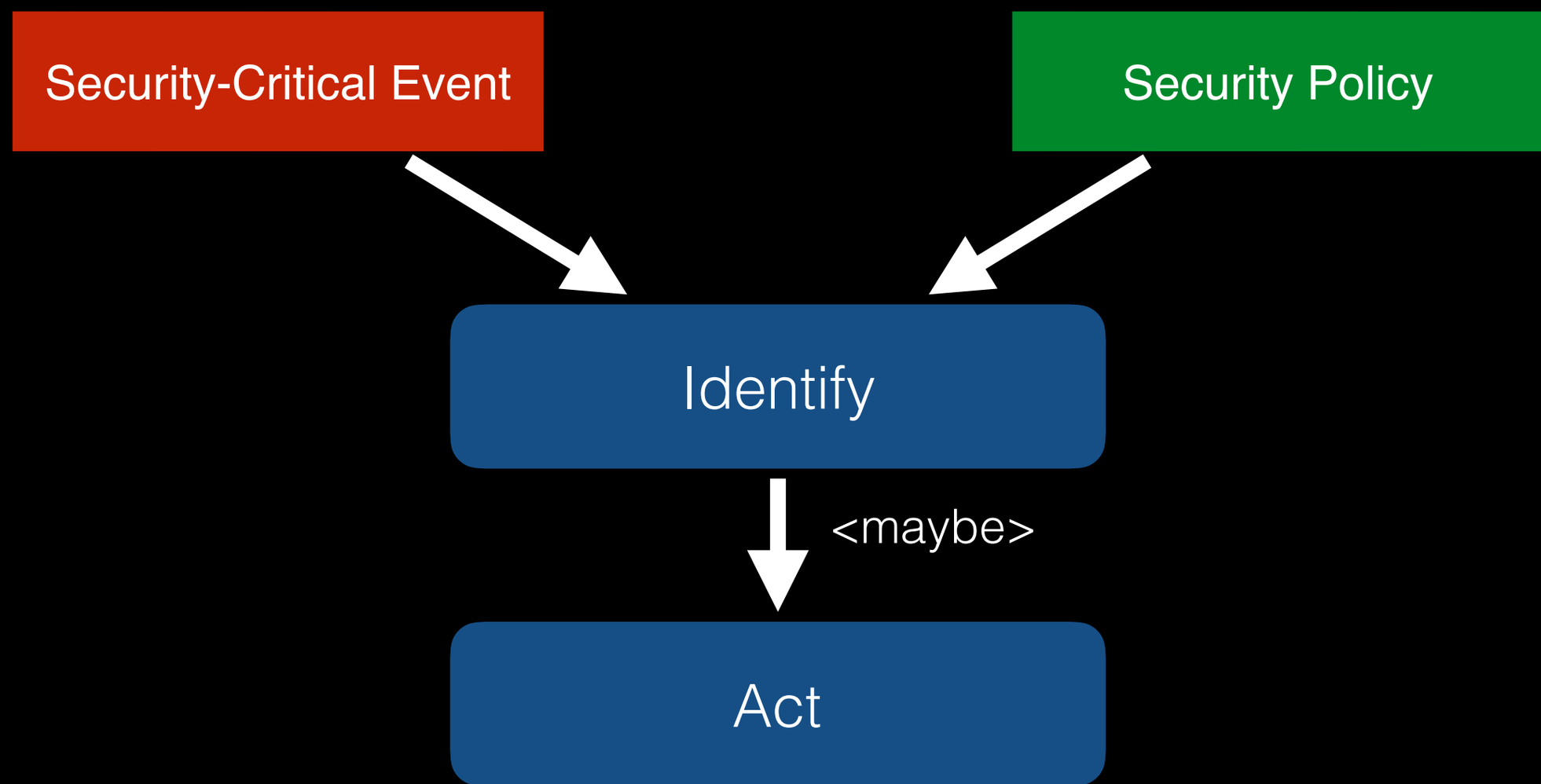
exercise 7.6

Exercise: Inline Reference Monitor

- A reference monitor observes the execution of a program
- It halt or pauses the execution if something “bad” happens
- What “bad” ist defines a security policy
- It makes sense to observe only security critical events

exercise 7.6

Exercise: Inline Reference Monitor



exercise 7.6

Exercise: Inline Reference Monitor

- Goal: Write a transformer that injects a reference monitor according to the following specification.

Security-Critical Event	Any function calls
Security Policy	Prevent function calls when the first argument is a number of value 42

- If you want to make that very elegant you decompose it into different passes and make it configurable

exercise 7.6

Identifying Events

```
bool matchesEvent(Instruction* i) {
  if (i->getFunction()->getName().startswith("irm"))
    return false;

  CallInst* call = dyn_cast<CallInst>(i);
  if (!call) return false;
  if (call->getNumArgOperands() < 1) return false;

  Value* firstOperand = call->getArgOperand(0);

  if (!(firstOperand->getType()->isIntegerTy())) return false;

  return true;
}
```

exercise 7.6

Identifying Events

Protect the IRM itself from injection

```
bool matchesEvent(Instruction* i) {
  if (i->getFunction()->getName().startswith("irm"))
    return false;

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  if (!call) return false;
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exercise 7.6

Identifying Events

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exercise 7.6

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  return true;
}
```

Only process calls

exercise 7.6

Identifying Events

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exercise 7.6

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}
```

At least one operand

exercise 7.6

Identifying Events

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exercise 7.6

Identifying Events

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  if (!(firstOperand->getType()->isIntegerTy())) return false;

  return true;
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First operand is an integer

exercise 7.6

Identifying Events

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  if (!(firstOperand->getType()->isIntegerTy())) return false;

  return true;
}
```

exercise 7.6

Injecting IRM call

```
for (CallInst *i : injectBefore) {
  errs() << "Injecting IRM call\n";
  IRBuilder<> builder(i);
  Function *irmCall = getIRMCallPrototype(i->getContext(),
                                          i->getModule());

  Value *irmCall_params[] = {
     i->getArgOperand(0),
     ConstantInt::get(i->getArgOperand(0)->getType(), 42)
   };

  builder.CreateCall(irmCall, irmCall_params);
}
```

exercise 7.6

Injecting IRM call

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for (CallInst *i : injectBefore) {
  errs() << "Injecting IRM call\n"
  IRBuilder<> builder(i);
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```

Create a function prototype

exercise 7.6

Injecting IRM call

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exercise 7.6

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   };

  builder.CreateCall(irmCall, irmCall_params);
}
```

Reuse call operand

exercise 7.6

Injecting IRM call

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exercise 7.6

Injecting IRM call

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     ConstantInt::get(i->getArgOperand(0)->getType(), 42)
   };

  builder.CreateCall(irmCall, irmCall_params);
}
```

Create constant for policy

exercise 7.6

Injecting IRM call

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  builder.CreateCall(irmCall, irmCall_params);
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exercise 7.6

Injecting IRM call

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  Function *irmCall = getIRMCallPrototype(i->getContext(),
                                          i->getModule());

  Value *irmCall_params[] = {
     i->getArgOperand(0),
     ConstantInt::get(i->getArgOperand(0)->getType(), 42)
   };

  builder.CreateCall(irmCall, irmCall_params);
}
```

Inject call

exercise 7.6

Injecting IRM call

```
for (CallInst *i : injectBefore) {
  errs() << "Injecting IRM call\n";
  IRBuilder<> builder(i);
  Function *irmCall = getIRMCallPrototype(i->getContext(),
                                          i->getModule());

  Value *irmCall_params[] = {
     i->getArgOperand(0),
     ConstantInt::get(i->getArgOperand(0)->getType(), 42)
   };

  builder.CreateCall(irmCall, irmCall_params);
}
```

exercise 7.6

Getting the IRM function

```
Function *getIRMCallPrototype(LLVMContext &ctx, Module *mod) {
  Function *existing = mod->getFunction("irmCall");
  if(existing) return existing;

  return createReferenceMonitor(ctx, mod);
}
```

Creating the IRM function

```
Function *createReferenceMonitor(LLVMContext &ctx, Module *mod) {
  Type *i32 = IntegerType::getInt32Ty(ctx);

  FunctionType *irmcall_type =
     TypeBuilder<void(int, int), false>::get(getGlobalContext());
  Function *func =
     cast<Function>(mod->getOrInsertFunction("irmCall",
                                             irmcall_type));

  IRBuilder<> *builder =
       new IRBuilder<>(BasicBlock::Create(ctx, "initial", func));
  // %1 = alloca i32, align 4
  Value *firstAlloc = builder->CreateAlloca(i32);
  // %2 = alloca i32, align 4
  Value *secondAlloc = builder->CreateAlloca(i32);
  // store i32 %actual, i32* %1, align 4

...
```

Demo Time!

Guard and Sanitizer Detection

```
void callerOne(int n) {
 if (n > 0 && n <= 4096)
   criticalOperation(n);
}
```

```
void callerFour(int n) {
 criticalOperation(n);
}
```

```
void callerOne(int n) {
 if (n > 0 || n <= 4096)
   criticalOperation(n);
}
```

```
void callerOne(int n) {
  n = clear(n);
  criticalOperation(n);
}
```

Guard and Sanitizer Detection

Shameless Advertisement

```
void callerOne(int n) {
 if (n > 0 && n <= 4096)
   criticalOperation(n);
}
```

```
void callerFour(int n) {
 criticalOperation(n);
}
```

```
void callerOne(int n) {
 if (n > 0 || n <= 4096)
   criticalOperation(n);
}
```

```
void callerOne(int n) {
  n = clear(n);
  criticalOperation(n);
}
```

Exercises in this Block

exercise 7.6 Inline Reference Monitor