Seeing the bigger picture

Or, “Can you see the bug?”

Part 2

Andrzej Krzemieński

Setting the stage

- W&B calculator: “Is thus loaded aircraft safe to fly?”
- Life-critical system
  - Wrong results can cause injuries or deaths
- Not a real-time system
  - If the program goes down, we can calculate manually

Agenda

- Example – magic value
  - Find the bug
  - Find the root cause
  - Take precautions
- Exercise on perceptiveness
- Example – exceptions
- Advice

Dealing with contingency

- Bugs usually reveal in contingent cases
- These execution paths are toughest to get right
- They are given least thought
- They are least tested
- Bug can hide there undetected for long time

Find the bug

```
double Flight_plan::weight() {
  if (Impl* impl = get_impl()) { // lazy init?
    return impl->compute_weight();
  }
  else {
    // TODO: need to handle it
  }
}
```

Can you see the bug?

Find the bug

```
const double BOGUS_WEIGHT = -666.66;

double Flight_plan::weight() {
  if (Impl* impl = get_impl())
    return impl->compute_weight();
  else
    return BOGUS_WEIGHT;
}
```

Can you see the bug?

Find the bug

```
bool too_heavy(Flight_plan const& p)
{
  return p.weight() > p.aircraft().max_weight();
}
```

Inadvertent consequence:

- lazy load problem?
  - → aircraft never too heavy

```
const double BOGUS_WEIGHT = -666.66;

double Flight_plan::weight() {
  if (Impl* impl = get_impl())
    return impl->compute_weight();
  else
    return BOGUS_WEIGHT;
}
```

Find the root cause

"Bogus weight":

- A documented interface
- Useful optimization
- Following the design of `atoi()`

The caller:

- Didn't read the instructions
- Is not cautious enough

```
const double BOGUS_WEIGHT = -666.66;

double Flight_plan::weight() {
  if (Impl* impl = get_impl())
    return impl->compute_weight();
  else
    return BOGUS_WEIGHT;
}
```

```
bool too_heavy(Flight_plan const& p)
{
  return p.weight() >
         p.aircraft().max_weight();
}
```

Find the root cause

"Bogus weight":

- A documented interface
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const double BOGUS_WEIGHT = -666.66;

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```

The caller:

- Didn't read the instructions
- Is not cautious enough

```
bool too_heavy(Flight_plan const& p)
{
  return p.weight() >
         p.aircraft().max_weight();
}
```

WRONG!

Find the root cause

"bogus weight":

- Returns two different things: *either* weight *or* error code

Declaration:

```
double Flight_plan::weight();
```

- How am I supposed to see it?
- "weight", "double" --> I should be able to compare with <
- The design is *counterintuitive, deceptive*

Taking precautions

What if we returned NaN?

Same problem:

```
(NaN > max_weight()) == false
```

- Comparisons with NaN always return false
- NaN has better be never used (never divide 0/0)

What if we returned Infinity?

- Comparison would return “too heavy”, but don’t do that…
- We will cover it later

Taking precautions

- Irregularity of the results should be reflected in the interface.
- Can’t afford changing the interface? Use exceptions.

Taking precautions

Boost.Optional:

```
optional<double> Flight_plan::weight();
```

- Clear message: why is it not just `double`?

But:

- `sizeof(optional<double>) > sizeof(double)`
- No information about the cause of failure
- Accidental comparison still works:

```
(optional<double>() > max_weight()) == false
```

Taking precautions

`Expected<T>`:

```
expected<double> Flight_plan::weight();
```

- Clear message.
- Contains info about the cause of failure

But:

- Bigger than `double`
- Accidental comparison may still work

Taking precautions

Improve the trick:

```
class OptionalQuantity {
  double val;
public:
  explicit OptionalQuantity(double v) : val(v) {}
    // precondition: v >= 0.0
  OptionalQuantity() : val(NaN) {};
  bool has_value() const { return !isnan(val); }
  double quantity() const { return val; }
    // precondition: has_value()
};
```

Taking precautions

Improve the trick:

- Still a `double`, but with different interface
- Using type system!
- `sizeof(OptionalQuantity) == sizeof(double)`
- No possibility of accidental comparison

```cpp
class OptionalQuantity {
  double val;
public:
  explicit OptionalQuantity(double v) : val(v) {}
    // precondition: v >= 0.0
  OptionalQuantity() : val(NaN) {};
  bool has_value() const { return !isnan(val); }
  double quantity() const { return val; }
    // precondition: has_value()
};
```

Taking precautions

Clever ideas:

- Is it intuitive (to anyone else but you)?
- Are your colleagues convinced?

Exercise – perceptiveness

```cpp
double Flight_plan::weight() {
  if (Impl* impl = get_impl())
    return impl->compute_weight();
  else
    throw Internal_error();
}
```

Can you see other potential bugs?

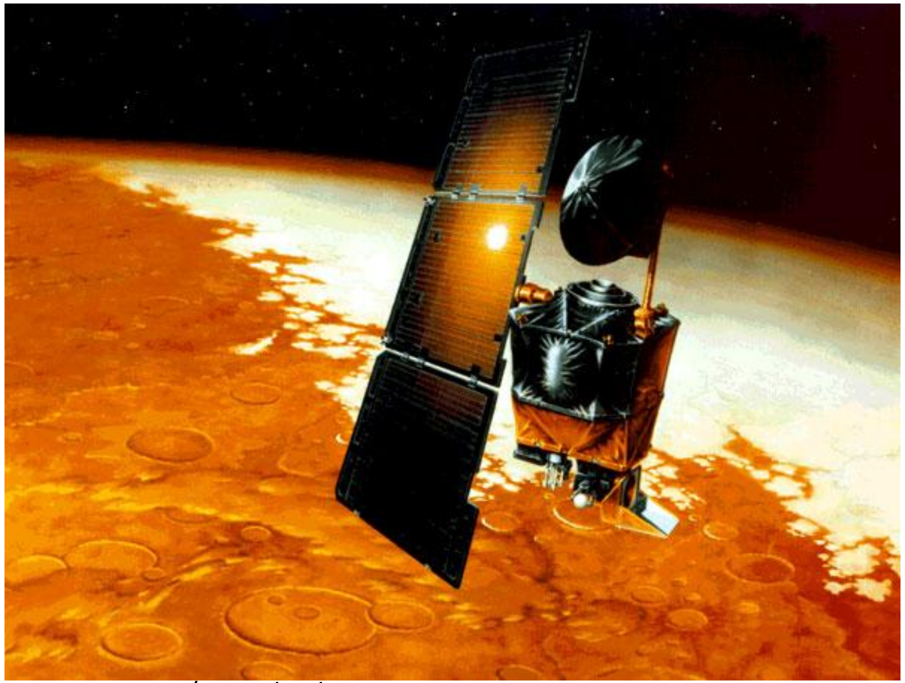
Exercise – perceptiveness

Physical quantity but no units!

- Newtons? Pound-force?

```
const double BOGUS_WEIGHT = -666.66;

double Flight_plan::weight() {
  if (Impl* impl = get_impl())
    return impl->compute_weight();
  else
    return BOGUS_WEIGHT;
}
```


Courtesy NASA/JPL-Caltech.

Exercise – perceptiveness

Using floating point numbers.

- It is not same as “quantity”
- Limited precision
- Are rounding errors acceptable?

```
const double BOGUS_WEIGHT = -666.66;

double Flight_plan::weight() {
  if (Impl* impl = get_impl())
    return impl->compute_weight();
  else
    return BOGUS_WEIGHT;
}
```

Exercise – perceptiveness

Defensive if’s!

- You cannot tell the logic flow from contingency handling
- Difficult to understand
- They may become offensive
- Asks for trouble (like ours)

```
const double BOGUS_WEIGHT = -666.66;

double Flight_plan::weight() {
  if (Impl* impl = get_impl())
    return impl->compute_weight();
  else
    return BOGUS_WEIGHT;
}
```

Exercise – perceptiveness

Improved solution:

```
Newtons Flight_plan::weight() {
  Impl& impl = get_impl(); // may throw
  return impl.compute_weight();
}
```

- A dedicated type, no unit confusion, no fp problems
- A dedicated path for contingency: exceptions

Example – exceptions

Example – exceptions

Improved version:

```
Newtons Flight_plan::weight() {
  if (Impl* impl = get_impl())
    return impl->compute_weight();
  else
    throw Internal_error(); // poor...
}
```

- If I have a contingency, I have to throw.
- But, doesn’t someone need to catch it now?

Example – exceptions

```
bool too_heavy(Flight_plan const& p) {
  try {
    return p.weight() > p.aircraft().max_weight();
  }
  catch (Internal_error const& exc) {
    // TODO: need to handle it
  }
}
```

- Almost a defensive if
- Inadvertently concealing an exception
- We have an undefined (random) behavior

Example – exceptions

But I followed a ‘good advice’: “Catch exceptions, or else `std::terminate()`.”

- Don’t just follow any good advice.
- Think.
- See the bigger picture.
- Understand the consequences.

Example – exceptions

```
bool too_heavy(Flight_plan const& p) {
  try {
    return p.weight() > p.aircraft().max_weight();
  }
  catch (Internal_error const& exc) {
    logger.log(exc);
    return true; // safest bet
  }
}
```

- Now, I can never give the ‘unsafe’ response
- Same effect as if returning `+Infinity`

Example – exceptions

End user perspective:

```
> load 7200kg in compartment 1
aircraft maximum weight exceeded
> load 7198kg in compartment 1
aircraft maximum weight exceeded
> load 7190kg in compartment 1
aircraft maximum weight exceeded
> load 7000kg in compartment 1
aircraft maximum weight exceeded
```

Example – exceptions

End user perspective:

- We deceived the user. We let her think that by reducing the weight she will make the error disappear.
- We wasted her time (how much?),
- Caused delays on the airport,
- Incurred cost.

And it is likely, that you did that for nothing…

Example – exceptions

The top level code:

```
void process_user_input(string input) {
  try {
    variant<Command, Bad_input> command =
      validate(input);
    process(command);
  }
  catch (Internal_error const& exc) {
    output(build_message(exc));
  }
}
```

Example – exceptions

End user perspective:

```
> load 7200kg in compartment 1
! request ignored; internal error; try again?
```

“Something is wrong, I need to restart, or do work by hand.”

- We had the code that reports a malfunction correctly.
- We interfered with the mechanism.
- Why?

Example – exceptions

The fear for `terminate()`

- `terminate()` is not the worst thing that can happen.
- `terminate()` is a viable option (even if not best).
- “Not crashing” is never the primary goal.
- You can’t afford to crash? Can you afford to lie?
- You cannot fix global problems locally.

Advice

```
bool too_heavy(Flight_plan const& p);
```

- Returns `true` or `false`. Neither answer is right on error.
- Having detected contingency is a vital info. Don’t conceal it.

Advice

How not to forget:

```
double Flight_plan::weight() {
  if (Impl* impl = get_impl()) {
    return impl->compute_weight();
  }
  else {
    std::terminate();
    // TODO: improve in spare time
  }
}
```

Advice

Don’t catch exceptions

Advice

Don’t catch exceptions unless:

Advice

Don’t catch exceptions unless:

- You only want to translate it
  - Change type
  - Add information
  - Turn into an error code
- You only do some local clean-up and re-throw
- You close the operation of a sealed module
  - Which does not affect other parts of the program
  - `main()`

Conclusion

- Even when working on small piece, consider the bigger picture
- We have responsibility
  - Sometimes we have to try hard to find it
- More life-critical software out there than you can imagine