COMP1531

9.1 - SDLC Design - Software Complexity

How complicated is software?

No Silver Bullet

- A famous paper from 1986:
  - *No Silver Bullet – Essence and Accident in Software Engineering* by Fred Brooks
- Described software complexity by dividing it into two categories *essential* and *accidental*.
- Further conclusions of the paper are much debated

Essential

Complexity that is inherent to the problem.

For example, if the user or client requires the program to do 30 different things, then those 30 things are essential

Accidental

Complexity that is **not** inherent to the problem.

For example, generating or parsing data in specific formats.

Essential

Fundamentally can't be removed, but can be managed with good *software design.*

Accidental

Can be somewhat mitigated by engineering decisions; e.g. smart use of libraries, standards, etc.

Hard to remove entirely.

Open questions

- Is there a concrete process for distinguishing accidental and essential complexity?
- How much of the complexity of modern software is accidental?
- To what degree has or will accidental complexity be removed in future?

Further reading

- The original No Silver Bullet paper:
  - http://faculty.salisbury.edu/~xswang/Research/Papers/SERelated/no-silver-bullet.pdf
- A more modern description:
  - https://stevemcconnell.com/articles/software-engineering-principles/
- A recent rebuttal:
  - https://blog.ploeh.dk/2019/07/01/yes-silver-bullet/

Can we measure complexity?

Coupling

- A measure of how closely connected different software components are
- Usually expressed as a simple ordinal measure of "loose" or "tight"
- For example, web applications tend to have a frontend that is loosely coupled from the backend

Cohesion

- The degree to which elements of a module belong together
- Elements belong together if they're somehow related
- Usually expressed as a simple ordinal measure of "low" or "high"

Cyclomatic complexity

- A measure of the branching complexity of functions
- Computed by counting the number of *linearly-independent* paths through a function

Cyclomatic complexity

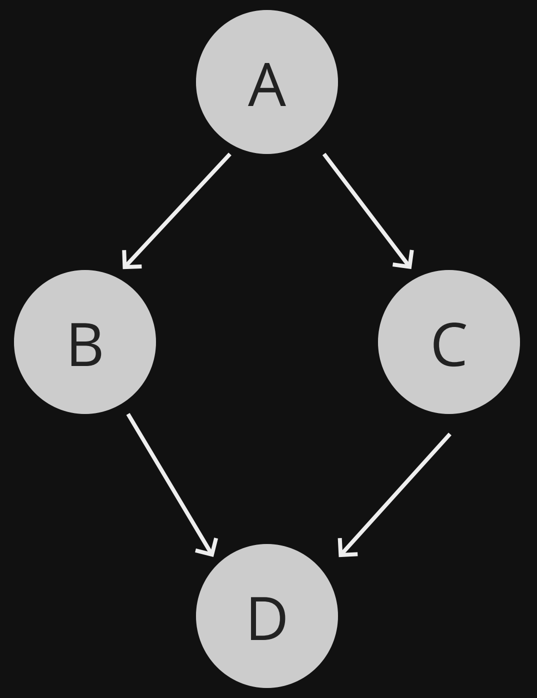
- To compute:
  1. Convert function into a control flow graph
  2. Calculate the value of the formula

$$V(G) = e - n + 2$$

where e is the number of edges and n is the number of nodes

Example 1

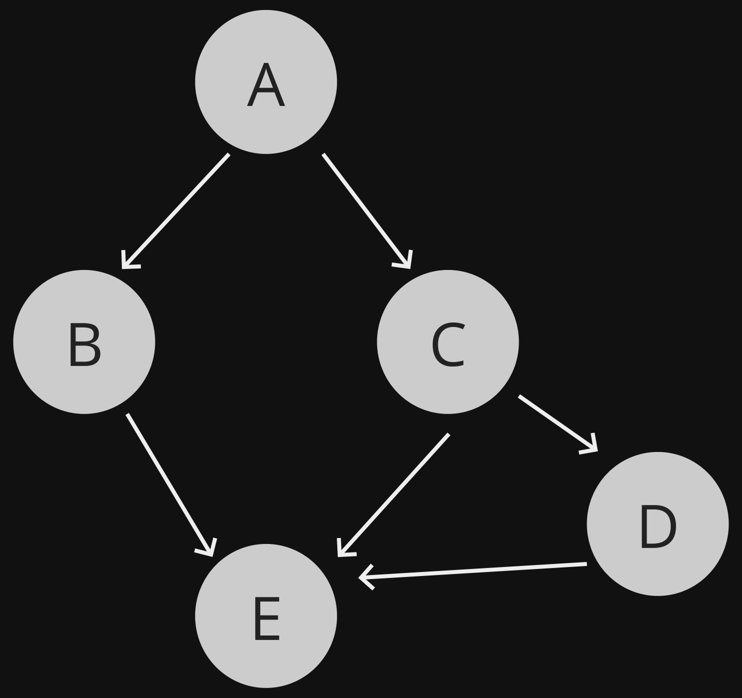
```python
def foo():
    if A():
        B()
    else:
        C()
    D()
```



$$V(G) = 4 - 4 + 2 = 2$$

Example 2

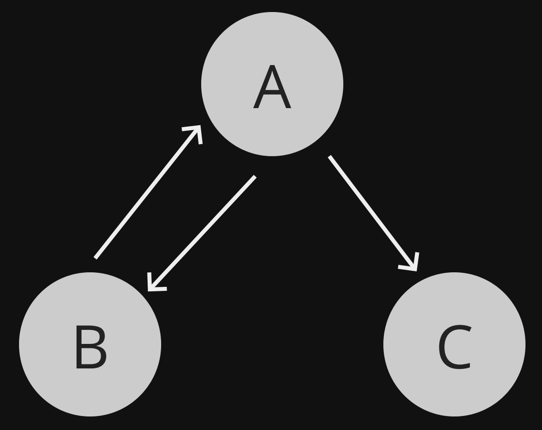
```python
def foo():
    if A():
        B()
    else:
        if C():
            D()
    E()
```



$$V(G) = 6 - 5 + 2 = 3$$

Example 3

```python
def foo():
    while A():
        B()
    C()
```



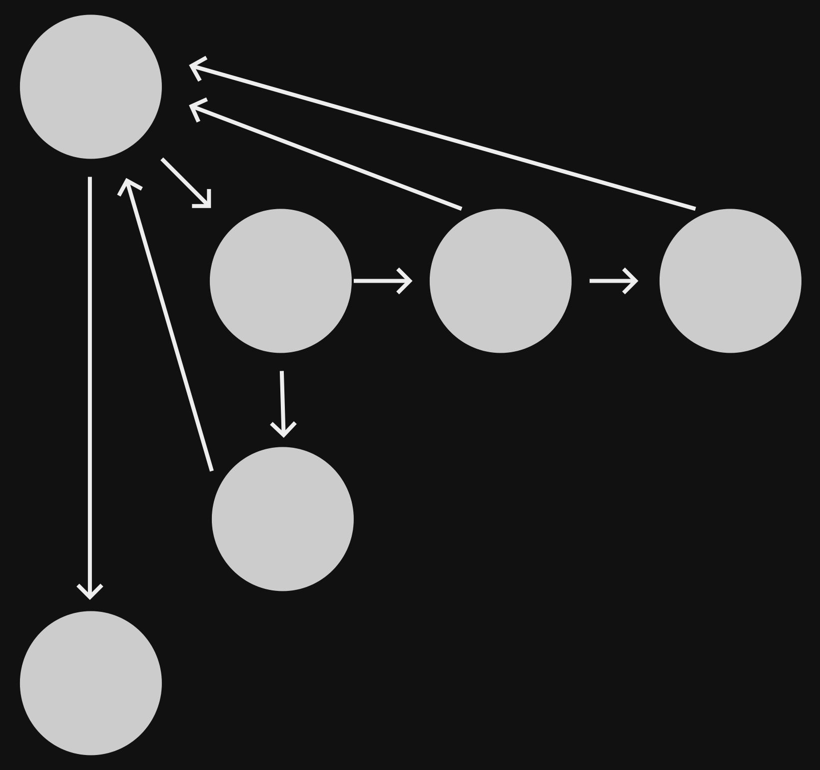
$$V(G) = 3 - 3 + 2 = 2$$

Example 4

```python
def day_to_year(days):
    year = 1970

    while days > 365:
        if is_leap_year(year):
            if days > 366:
                days -= 366
                year += 1
        else:
            days -= 365
            year += 1

    return year
```



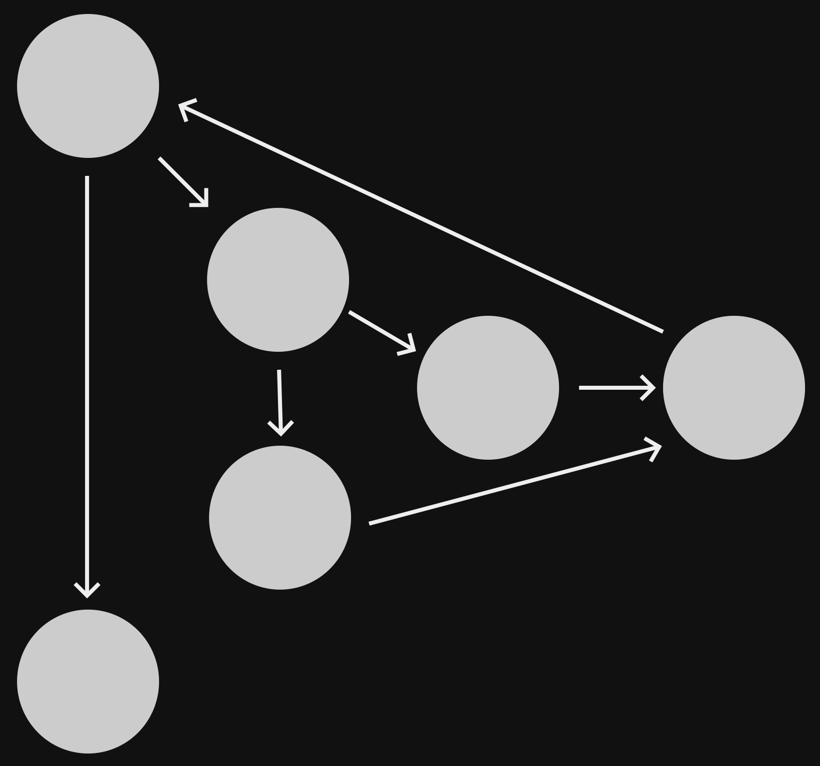
$$V(G) = 8 - 6 + 2 = 4$$

Example 5

```python
def day_to_year(days):
    year = 1970

    while days > 0:
        if is_leap_year(year):
            days -= 366
        else:
            days -= 365
        year += 1

    return year - 1
```



$$V(G) = 7 - 6 + 2 = 3$$

Usage

- A simple understandable measure of function complexity
- Some people argue 10 should be the maximum cyclomatic complexity of a function where others argue for 8

Drawbacks

- Assumes non-branching statements have no complexity
- Keeping cyclomatic complexity low encourages splitting functions up, regardless of whether that really makes the code more understandable

Automatic calculation

- http://pylint.pycqa.org/en/latest/technical_reference/extensions.html#design-checker
- NOTE: May get different results compared to doing it by hand as the extension generates a more complex CFG