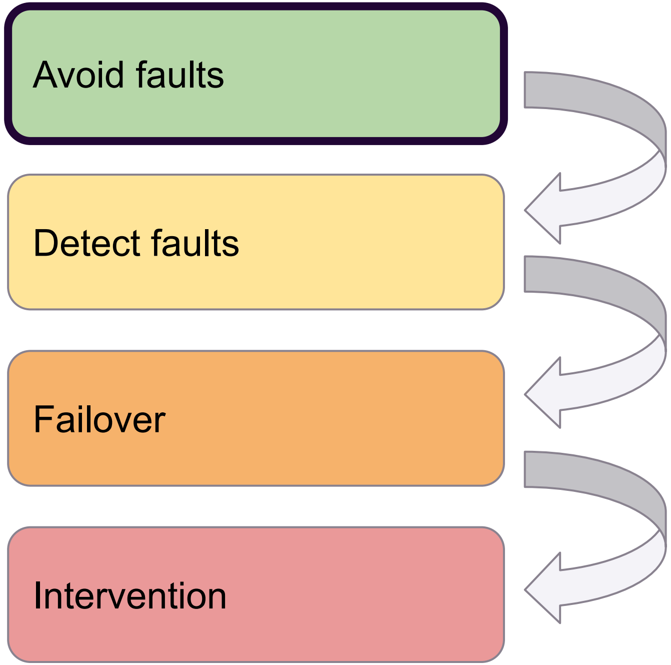
Fill out milestone demo availability form!

24: Safety best-practices

Escalation of safety



Avoid faults

Detect faults

Failover

Intervention

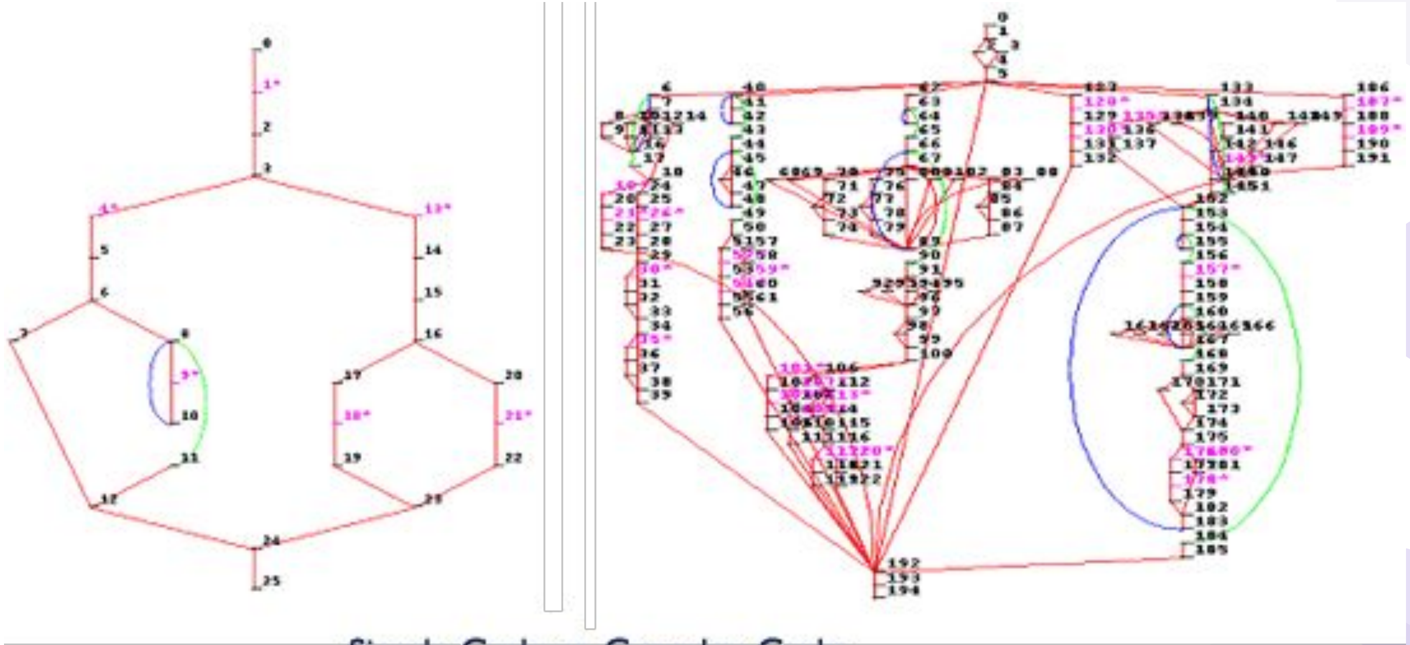
Code style

Spaghetti code

Special topics: global variables, floating point

Style guides

Which would you rather test/maintain?



Simple Code vs. Complex Code

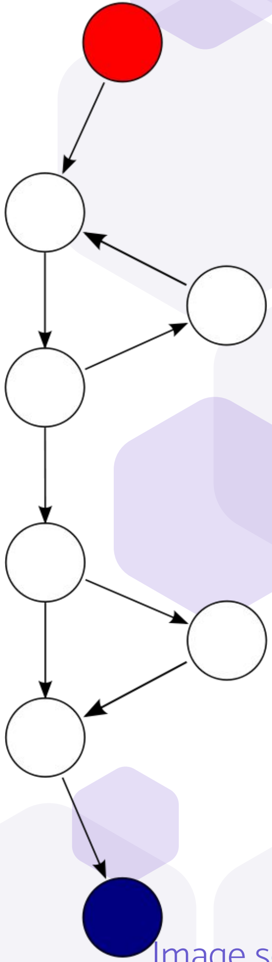
Image source

Spaghetti Code

Code whose structure is impossible to untangle

MCC (McCabe’s cyclomatic complexity)

- Measure of branching logic in code
- Easy way to compute: #1 of closed loops + 1
- Some standards impose limits on MCC



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Why would global variables be considered harmful?

Why would floating point be considered harmful (beyond floating point error)?

Floating point

Floating point error/imprecision

Portability

Not equally precise for representing all numbers

All comparisons with NaN return false (includes NaN == NaN)

NaNs propagate

Code style: MISRA C

- embedded.com article on MISRA C
- JPL C coding standard
- TI C coding standard

What, besides coding, should be part of a safety-oriented project culture?

Reasoning about hazards/possible failures

Hazop

Hazard and operability analysis

Break system into nodes

Examine wording of system requirements to reason about potential failures

Brake within 2s -> what happens if we brake after 2s?

FMEA

Failure mode and effects analysis

Worksheets to reason about potential failures from bottom-up

Causes, effects, probabilities, etc

Fault tree analysis

Use boolean logic to determine what low-level failures could cause an anticipated failure

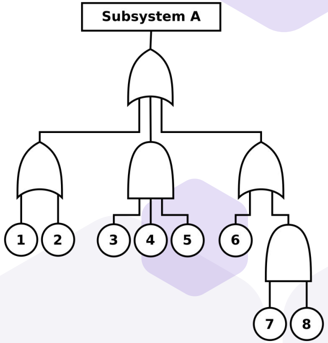
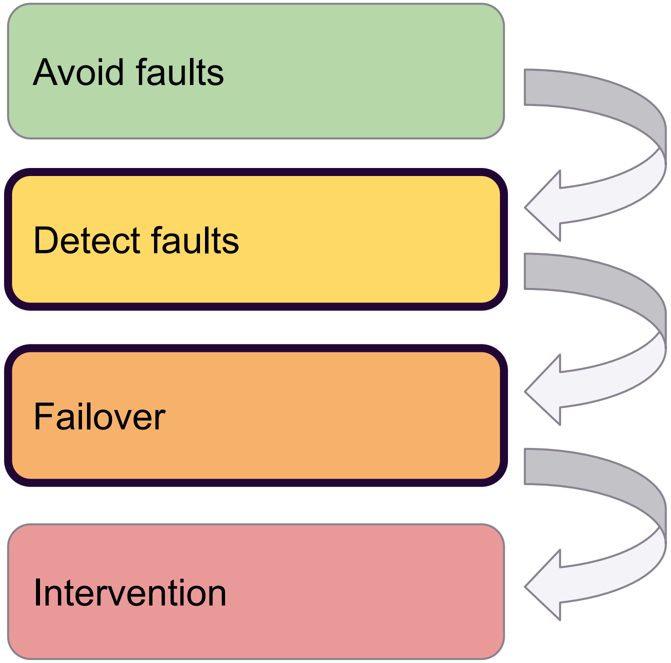


Image source

Escalation of safety-critical fault management



Avoid faults

Detect faults

Failover

Intervention

Single points of failure

A single point of failure happens when a failure of one component renders the entire system unsafe

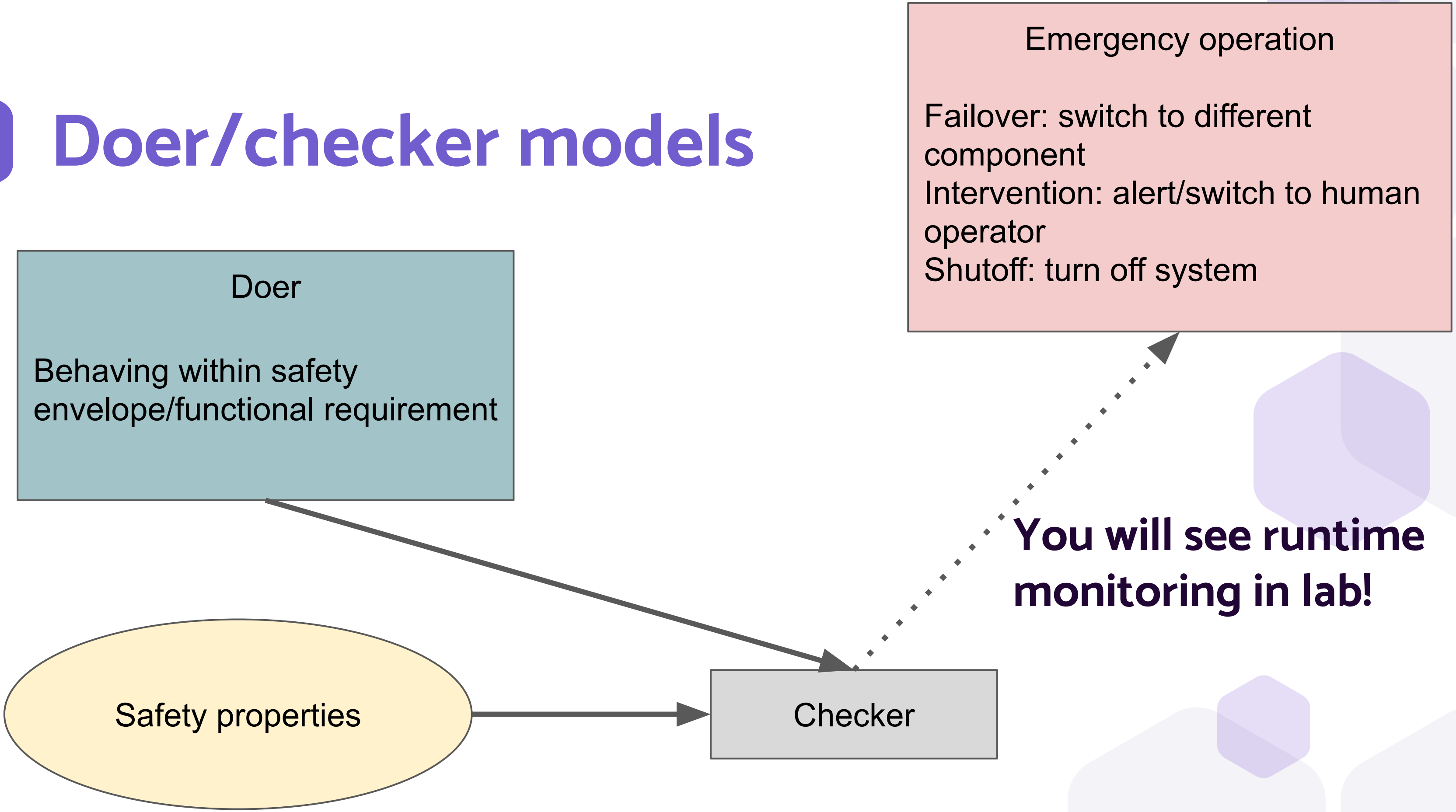
Avoid single points of failure by using redundancy:

- **Software**: doer/checker with failover
- **Hardware**: failure detection with redundancy

Components must truly be separate for true redundancy

Hidden sources of correlation: shared libraries, shared power, shared connections, shared defective requirements....

Doer/checker models



Doer

Behaving within safety envelope/functional requirement

Safety properties

Checker

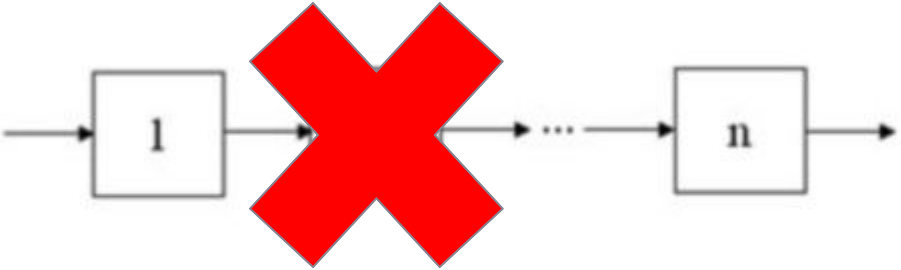
Emergency operation

Failover: switch to different component
Intervention: alert/switch to human operator
Shutoff: turn off system

You will see runtime monitoring in lab!

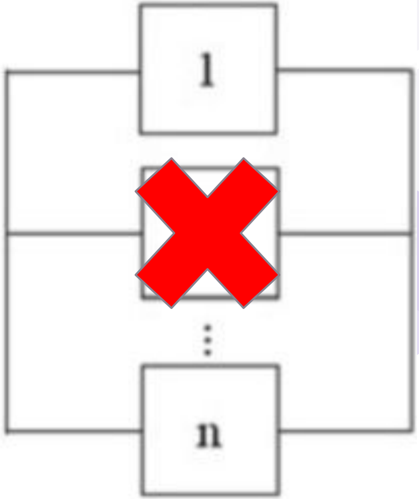
Redundancy

Entire system fails

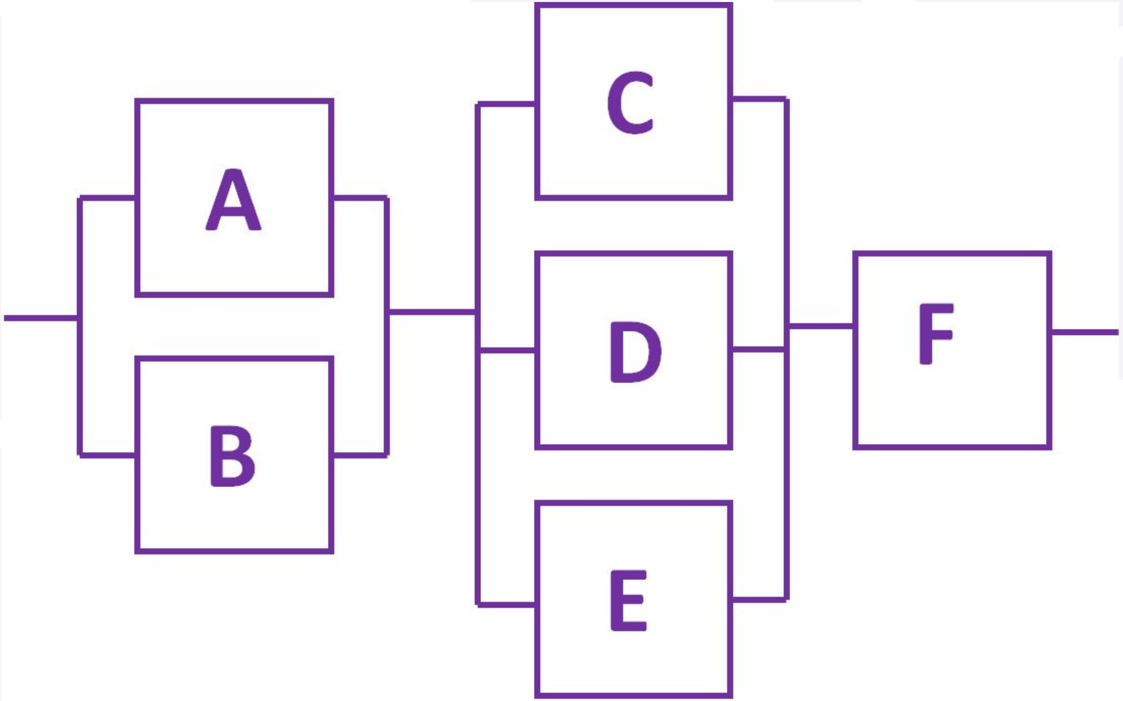


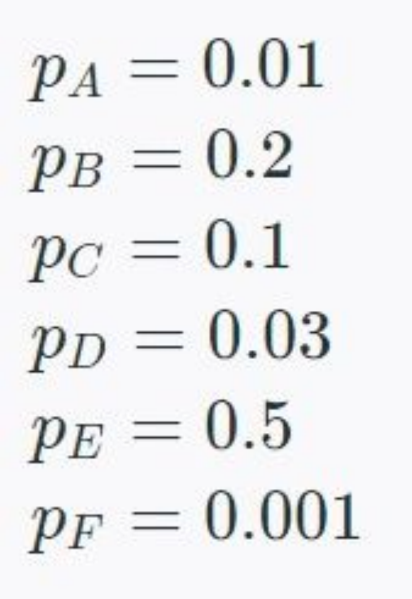
Series System

System can still operate in reduced capacity



Parallel System





$$p_A = 0.01$$
$$p_B = 0.2$$
$$p_C = 0.1$$
$$p_D = 0.03$$
$$p_E = 0.5$$
$$p_F = 0.001$$