# Be explicit

Get all of the assumptions out on the table.

conditional failure rate, h(t)

time, t

error

undetectable error

detectable error

undetected error

detected error

unmaskable error

maskable error

unmasked error

masked error

untolerated error

tolerated error
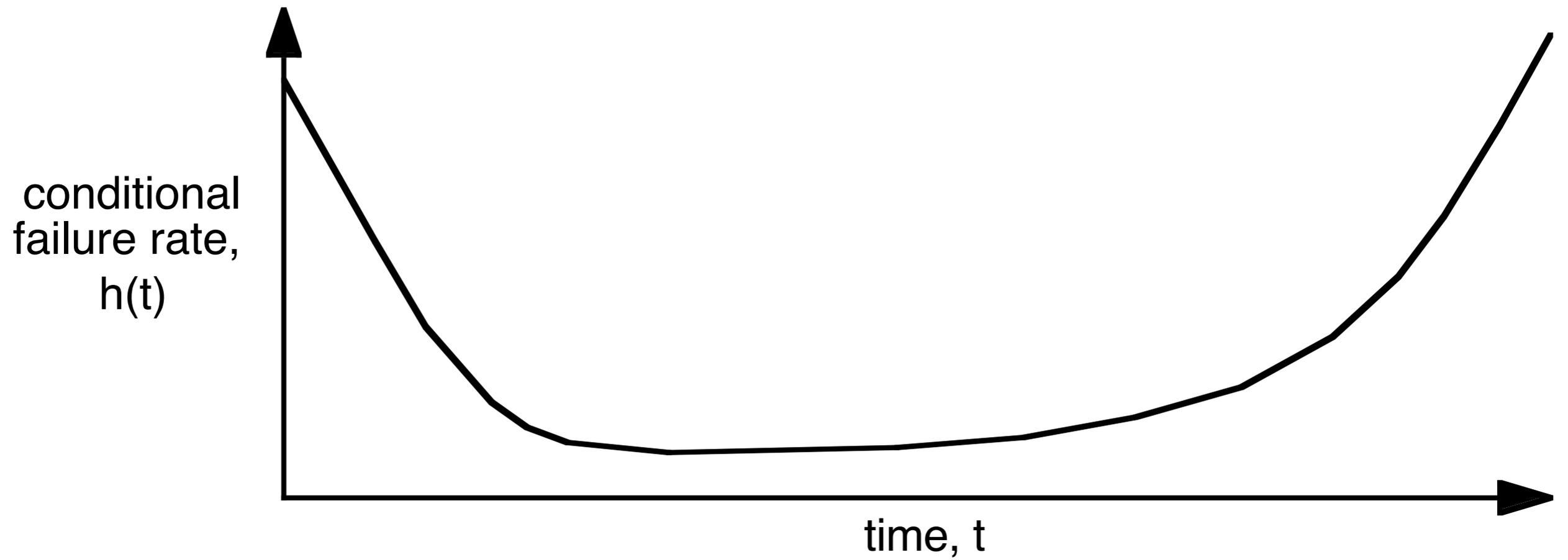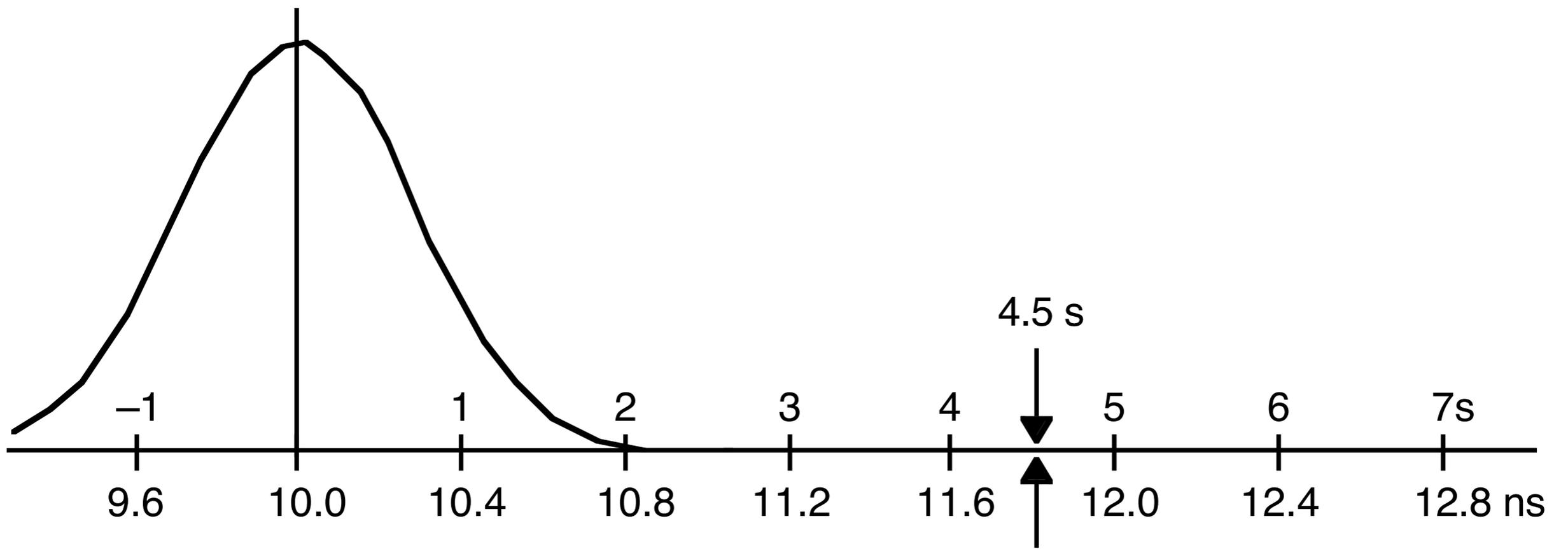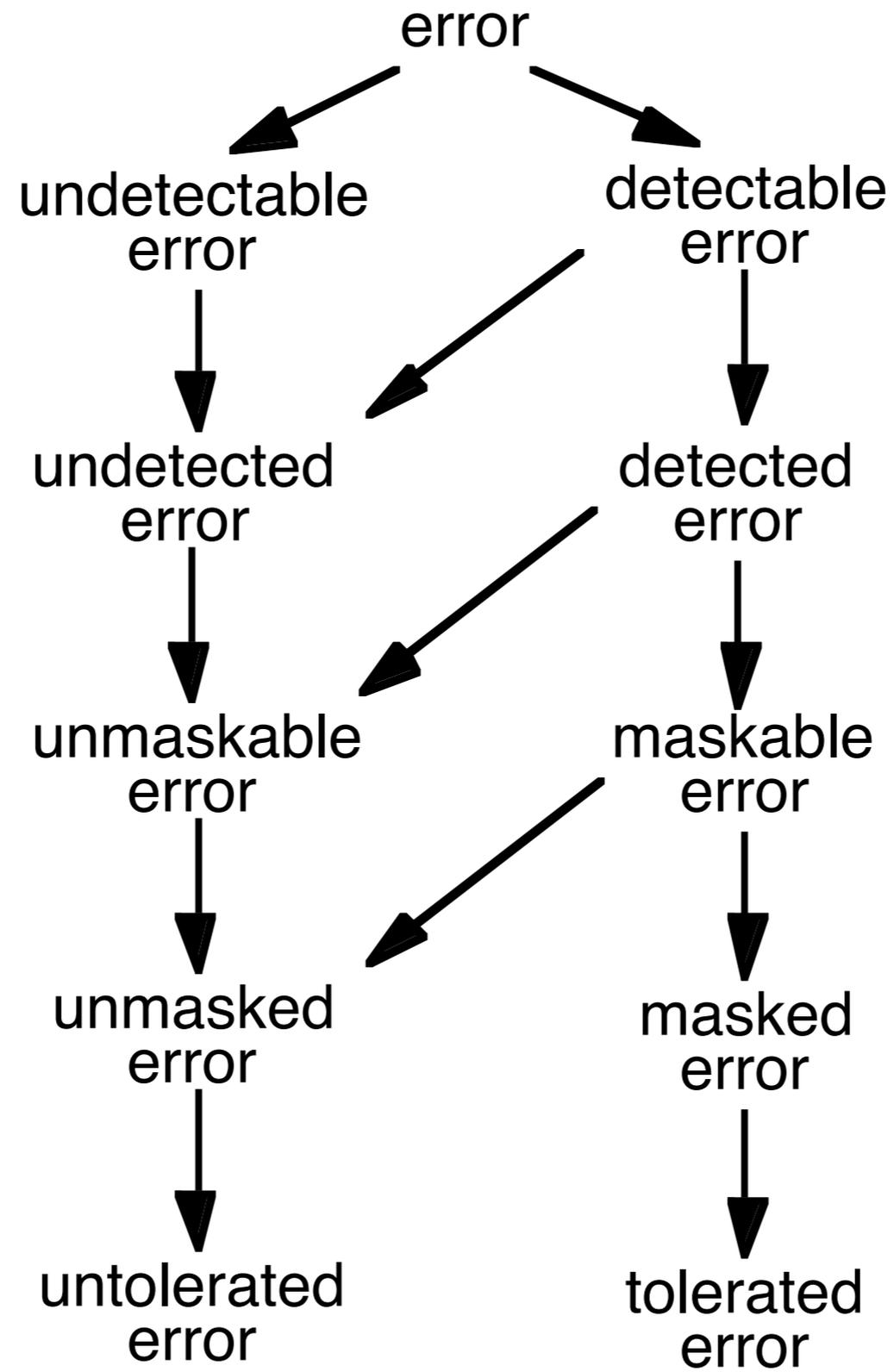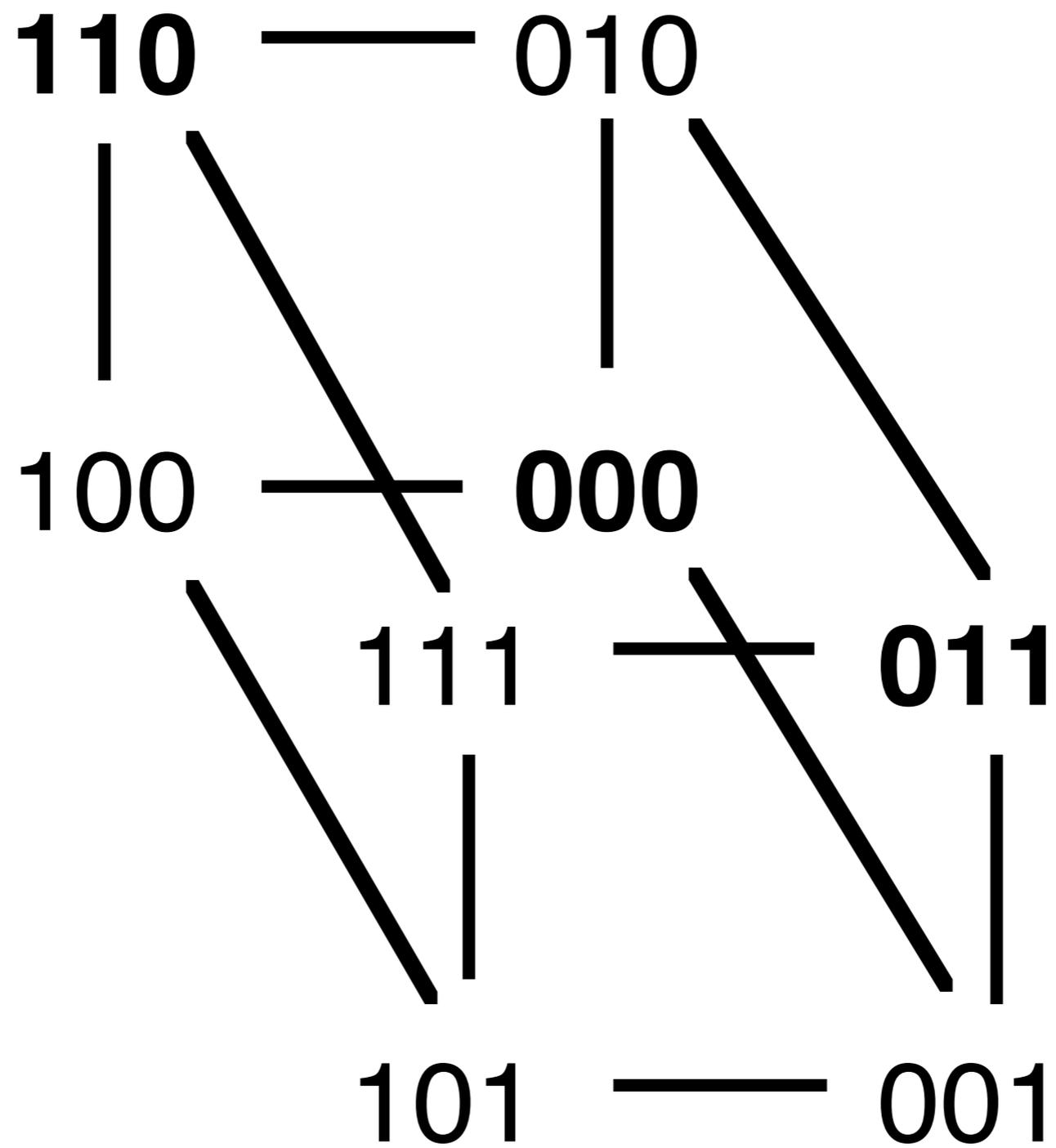
Choose P_1 so XOR of every other bit $(P_7 \oplus P_5 \oplus P_3 \oplus P_1)$ is 0

Choose P_2 so XOR of every other pair $(P_7 \oplus P_6 \oplus P_3 \oplus P_2)$ is 0

Choose P_4 so XOR of every other four $(P_7 \oplus P_6 \oplus P_5 \oplus P_4)$ is 0

bit	P_7	P_6	P_5	P_4	P_3	P_2	P_1
	$\oplus$		$\oplus$		$\oplus$		$\oplus$
	$\oplus$	$\oplus$			$\oplus$	$\oplus$	
	$\oplus$	$\oplus$	$\oplus$	$\oplus$			

new sector

old sector

data 1

data 2

data 3

data 4

parity

data 1

data 2

data 3

data 4

parity

parity $\oplus$ old $\oplus$ new

Reliability

previous
figure

0.25 single engine
0.15 three engines

Mission time, in units of MTTF
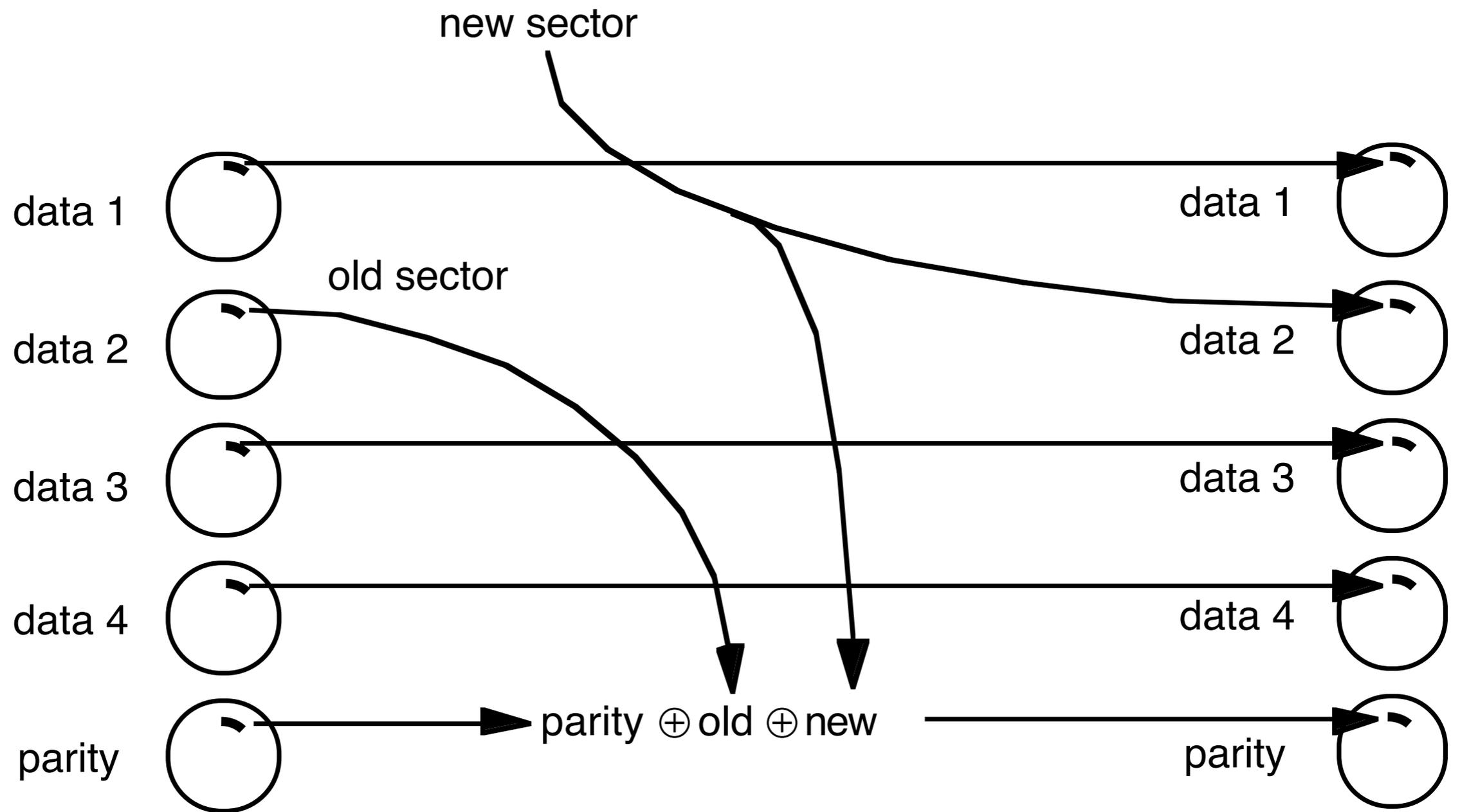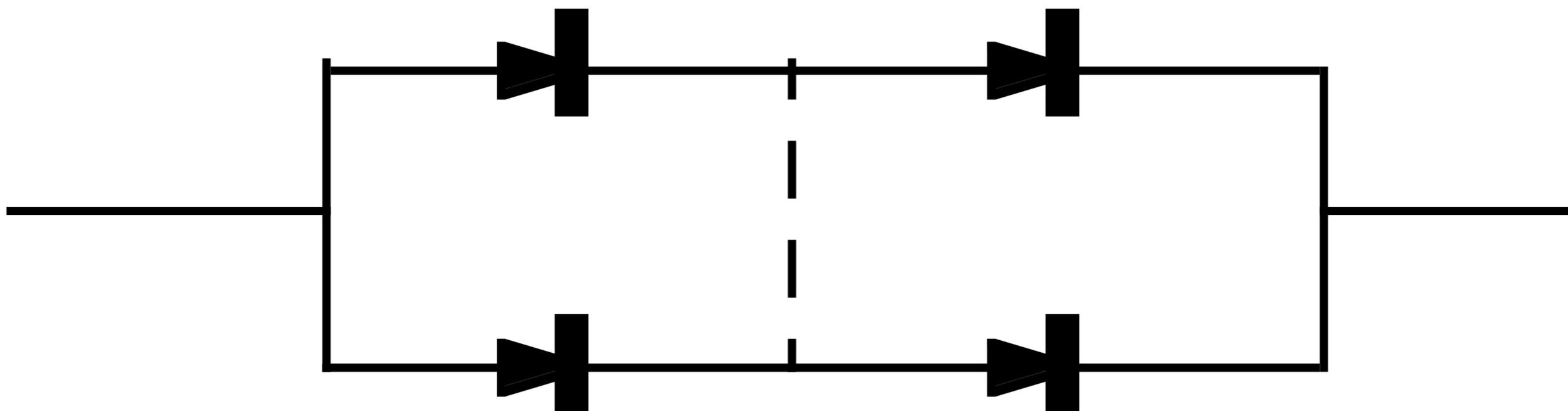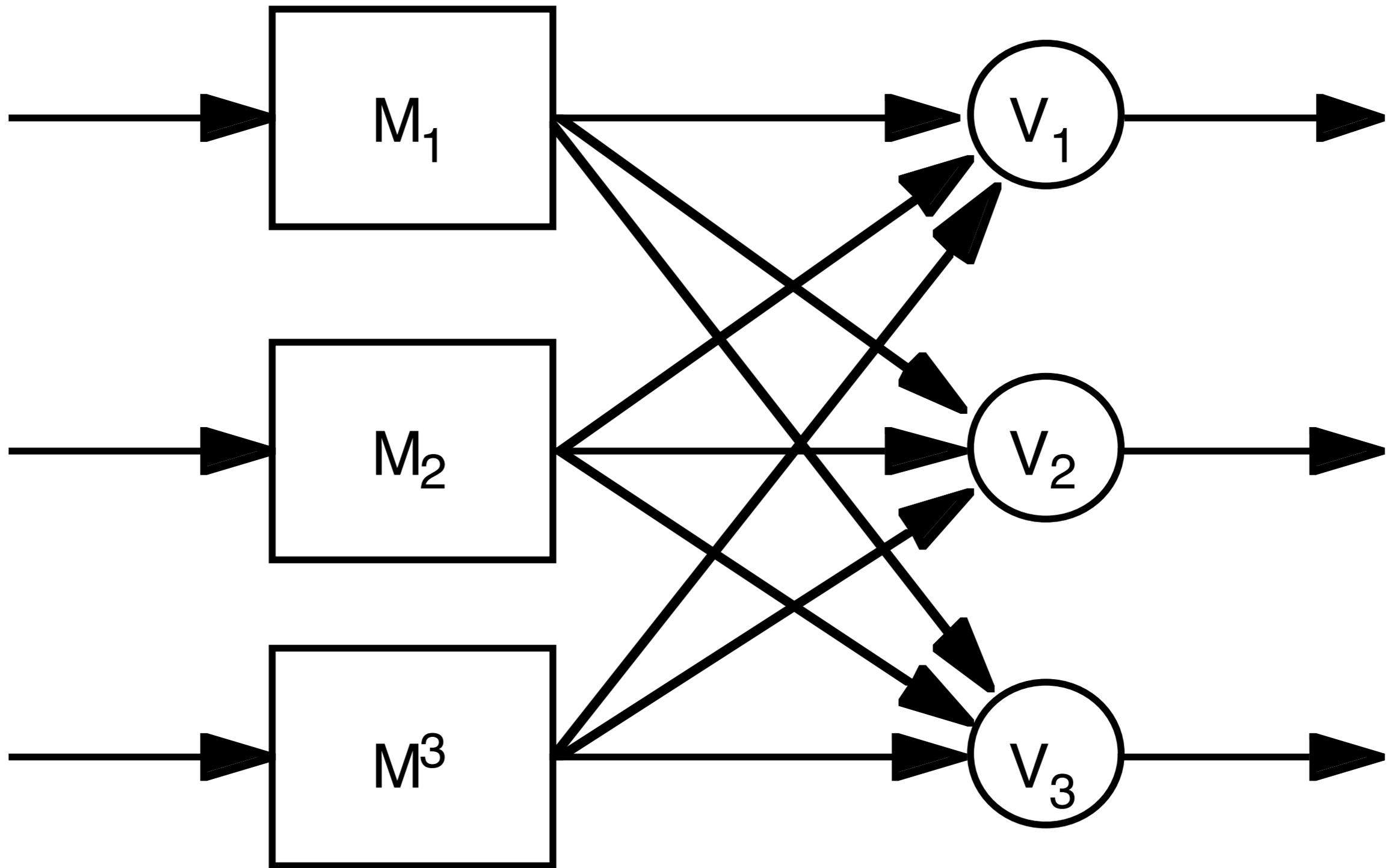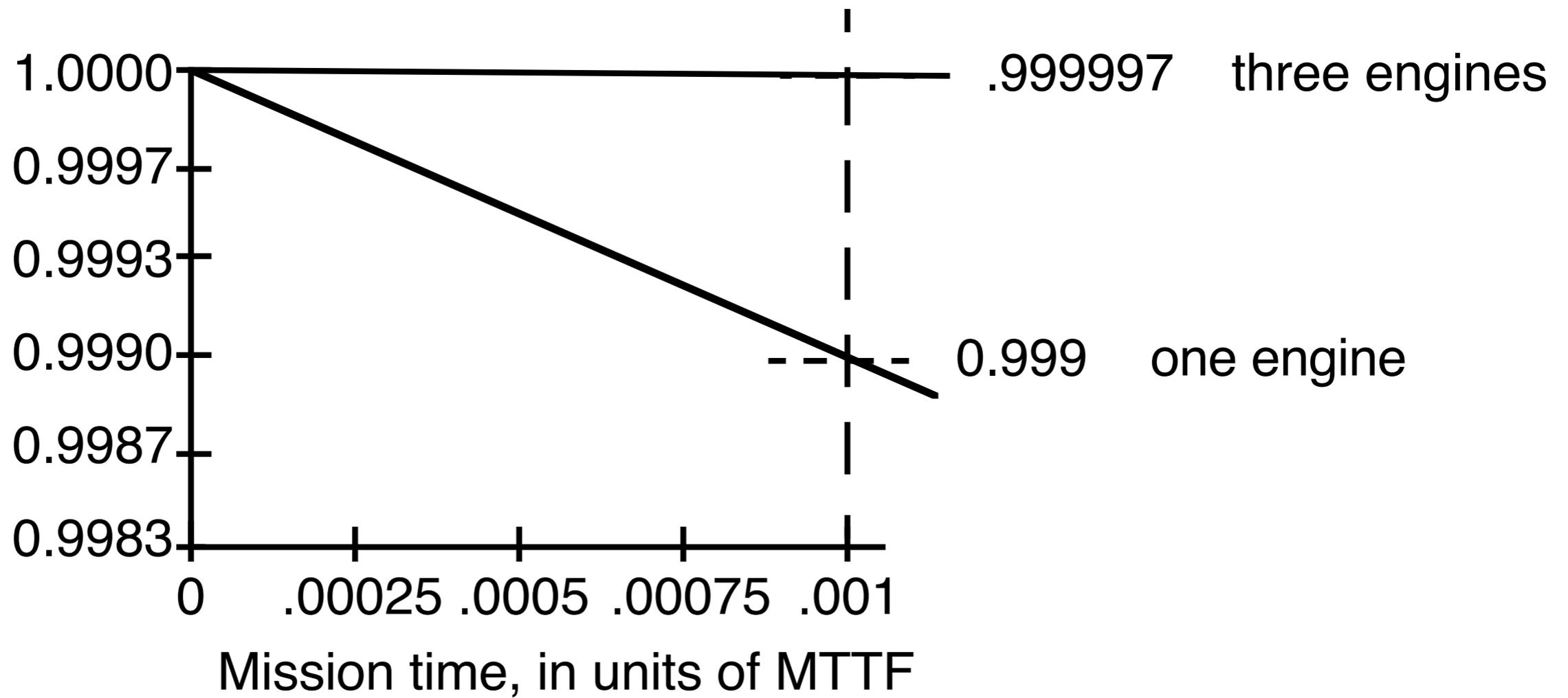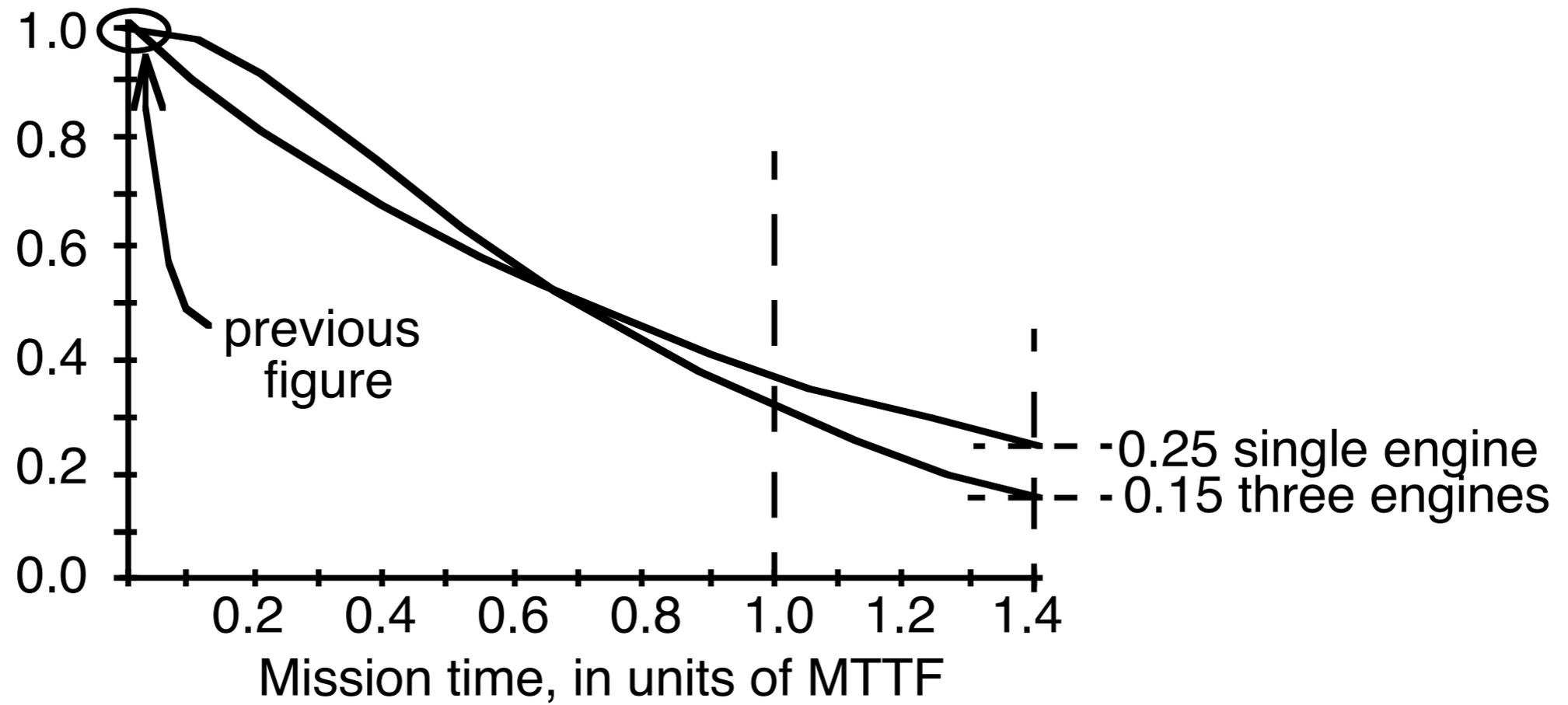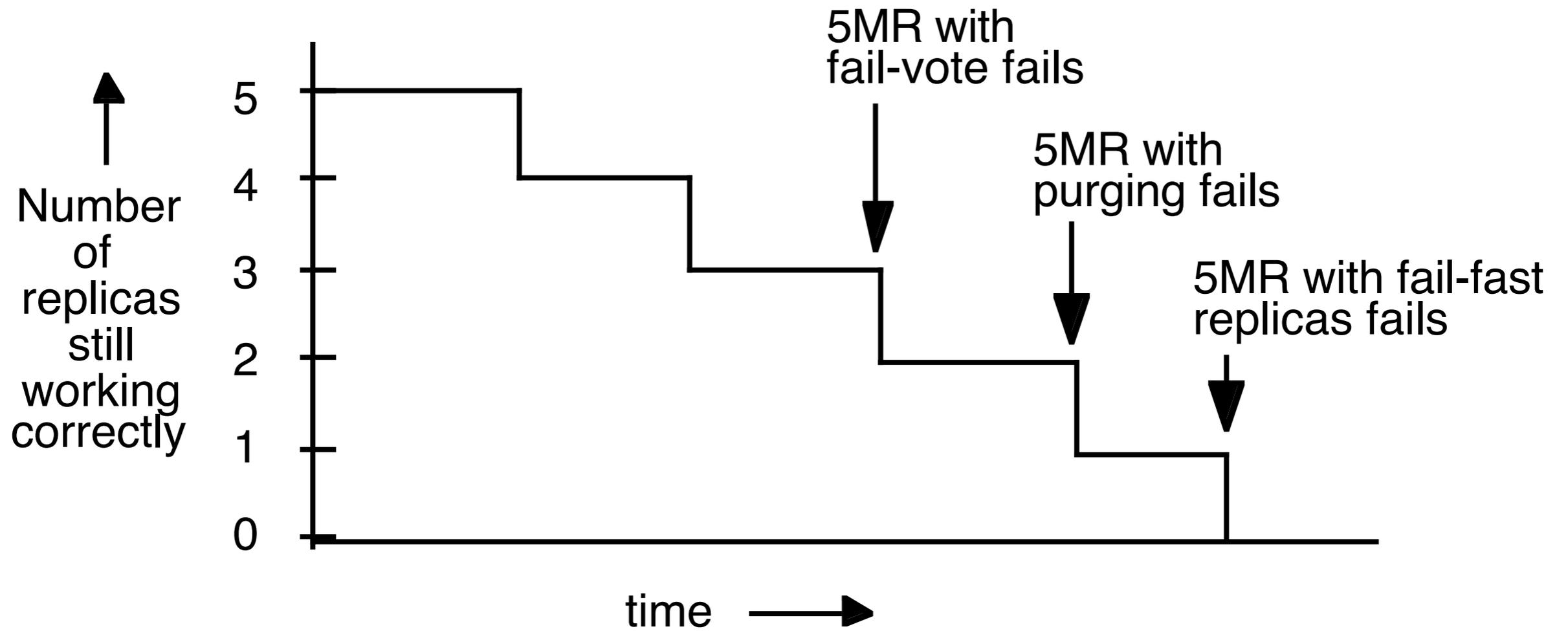
procedure CAREFUL_GET (*data*, *sector_number*)
    for *i* **from** 1 **to** NTRIES **do**
        if FAIL_FAST_GET (*data*, *sector_number*) = OK **then**
            return OK
    return BAD

procedure CAREFUL_PUT (*data*, *sector_number*)
    for *i* **from** 1 **to** NTRIES **do**
        if FAIL_FAST_PUT (*data*, *sector_number*) = OK **then**
            return OK
    return BAD

	raw layer	fail-fast layer	careful layer	durable layer	more durable layer
soft read, write, or seek error	failure	detected	masked		
hard read, write error	failure	detected	detected	masked	
power failure interrupts a write	failure	detected	detected	masked	
single data decay	failure	detected	detected	masked	
multiple data decay spaced in time	failure	detected	detected	detected	masked
multiple data decay within T_d	failure	detected	detected	detected	failure*
undetectable decay	failure	failure	failure	failure	failure*
system crash corrupts write buffer	failure	failure	failure	failure	detected

Avoid rarely used components

Deterioration and corruption accumulate unnoticed—until the next use.