Triple Modular Redundancy (TMR)

C1

C2

C3

Voter

2 or more out of the 3
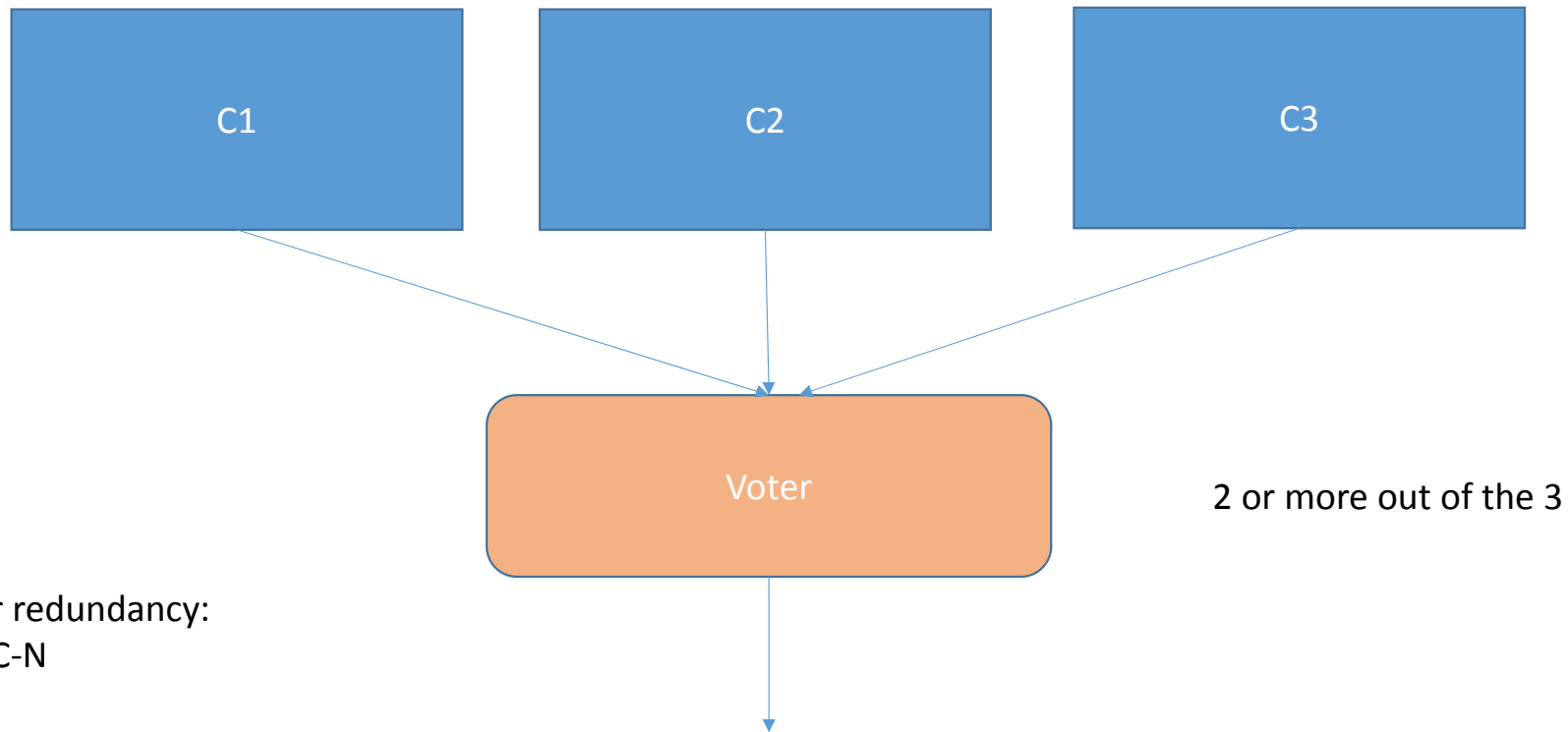
N modular redundancy:
C1, C2, ... C-N

Reliability of each component is R.
What is the reliability of the overall system? (TMR)

Reliability = Pr(Component/System operating correctly)

Ans:
Reliability of system = Pr(3 components working correctly) + Pr(2 components working correctly)
$= R^3 + C(3, 2)*R^2*(1-R)$
$= R^3 + 3R^2(1-R)$
$= R^3 + 3R^2 - 3R^3$
$= 3R^2 - 2R^3$

Dynamic Redundancy

1. Hot spares
2. Warm spares
3. Cold spares

C1, C2, C3: 0.99 * 0.95 * 0.90   Time: 10
C1, C2, !C3: 0.99 * 0.95 * 0.10   Time: 10
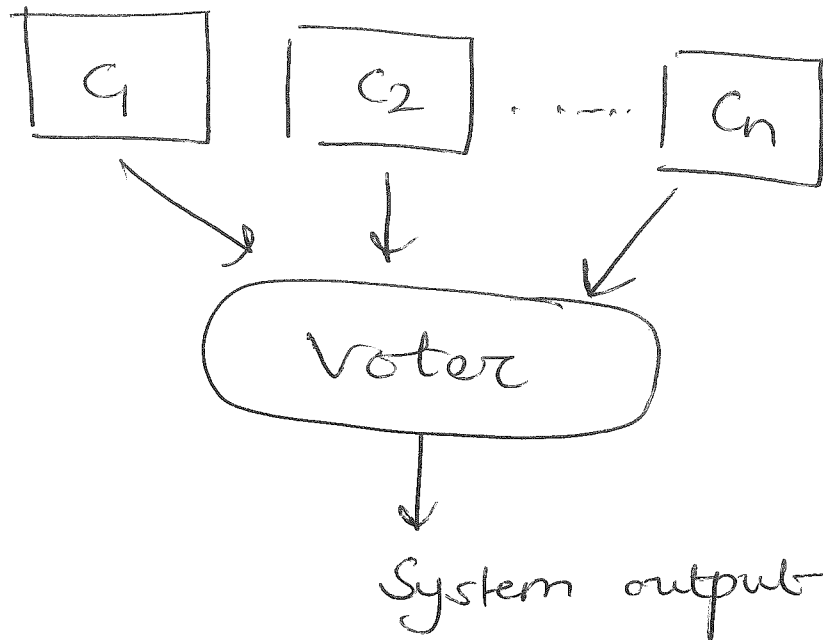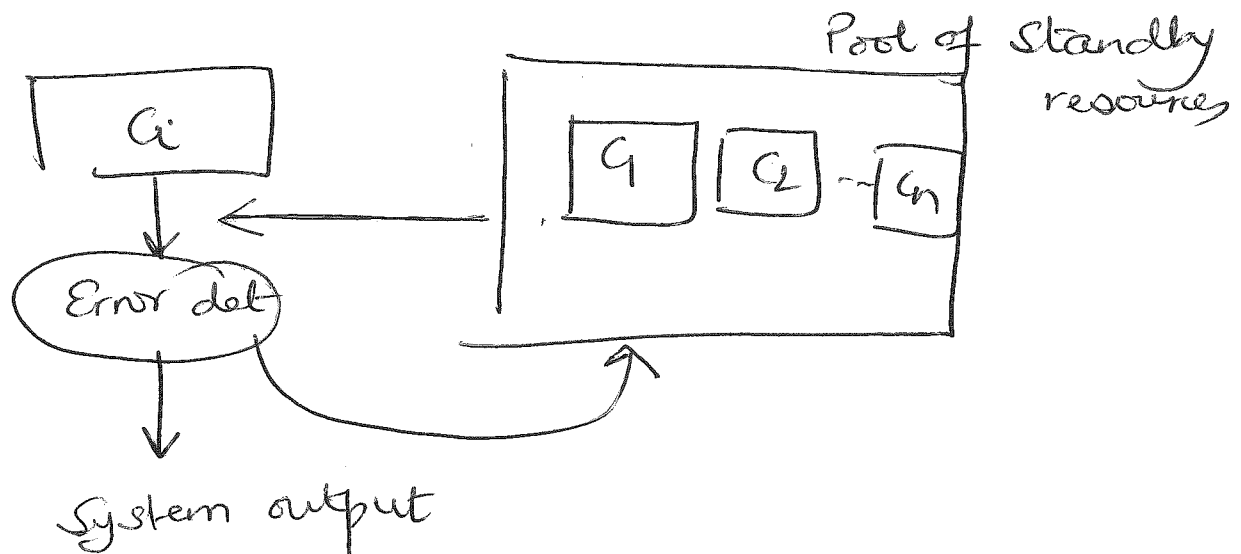!C1, C2, C3:   Time: 15
C1, !C2, C3:   Time: 15
...

Static redundancy
or Error masking

| c_1 | c_2 | .... | c_n |

Voter

↓

System output

Dynamic redundancy

| c_i |

Pool of Standby resources

| c_1 | c_2 | -- | c_n |

Error det

↓

System output

Static

	P(success)	Time to Completion
C_1	0.99	5
C_2	0.95	10
C_3	0.90	15

Voter's config = 2 of 3.

[1] Reliability of system = ?

[2] If system succeeds, what is the expected time to get a result from the system?

Soln

[1]

$$P(\text{success}) = P(\text{at least 2 out of 3 are correct})$$

$$= P(C_1, C_2 \text{ work } C_3 \text{ doesn't}) + P(C_1, C_3 \checkmark \ C_2 \times)$$

$$+ P(C_2, C_3 \checkmark \ C_1 \times) + P(C_1, C_2, C_3 \checkmark)$$

$$= \underline{0.9936}$$

[2]

Time to get result for each case : 10, 15, 15, 10.

$$= \frac{0.09405}{0.9936} \times 10 + \frac{0.04455}{0.9936} \times 15 + \frac{0.00855}{0.9936} \times 15$$

$$+ \frac{0.84645}{0.9936} \times 10.$$

$$= \frac{0.9405 + 0.66825 + 0.12825 + 8.4645}{0.9936} = \frac{10.2015}{0.9936}$$

$$= \underline{\underline{10.267}}$$

For the dynamic redundancy,
answer [1] and [2]

Come up with the best ordering of
c_1, c_2, c_3.