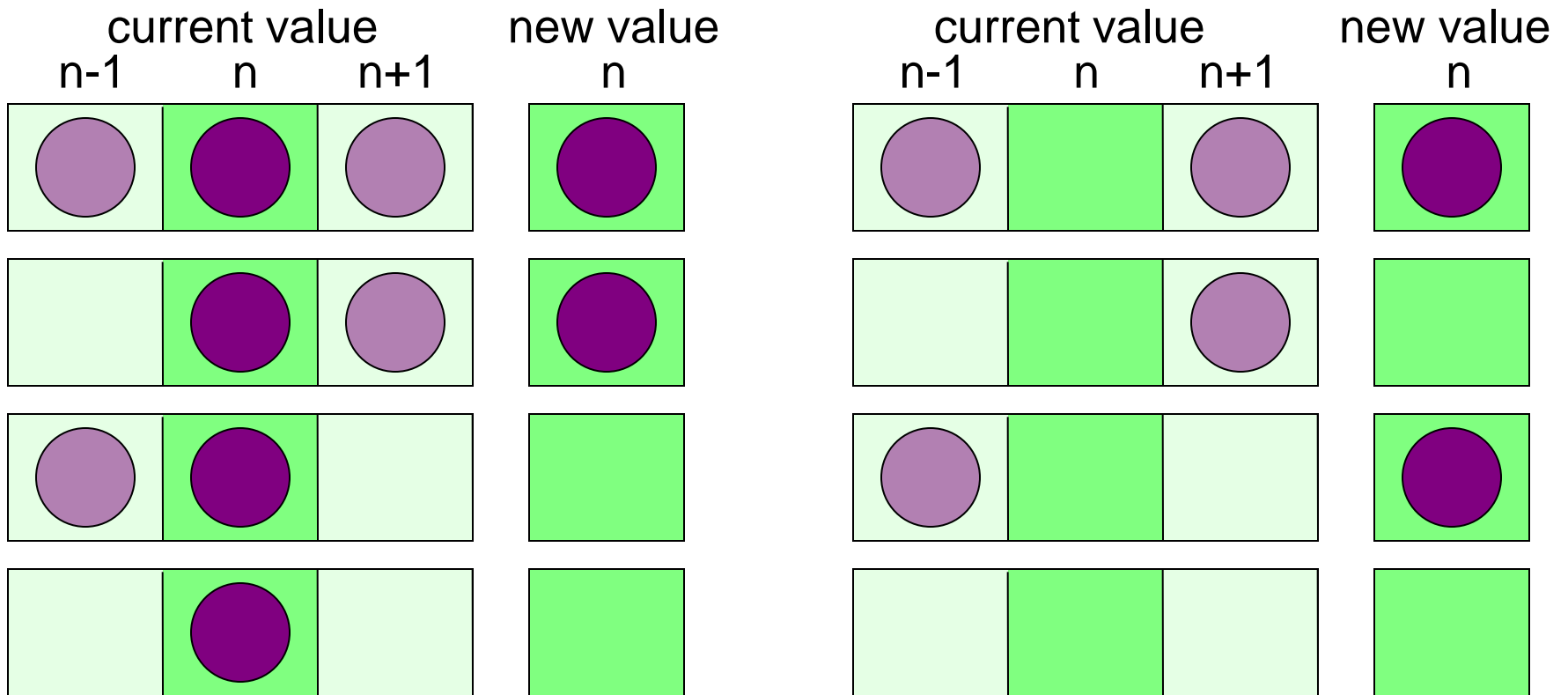


# Message-Passing Programming

## Cellular Automaton Exercise

– Update rules depend on:

- state of cell
- state of nearest neighbours in both directions



▶ If  $R^t(i) = 0$ , then  $R^{t+1}(i)$  is given by:

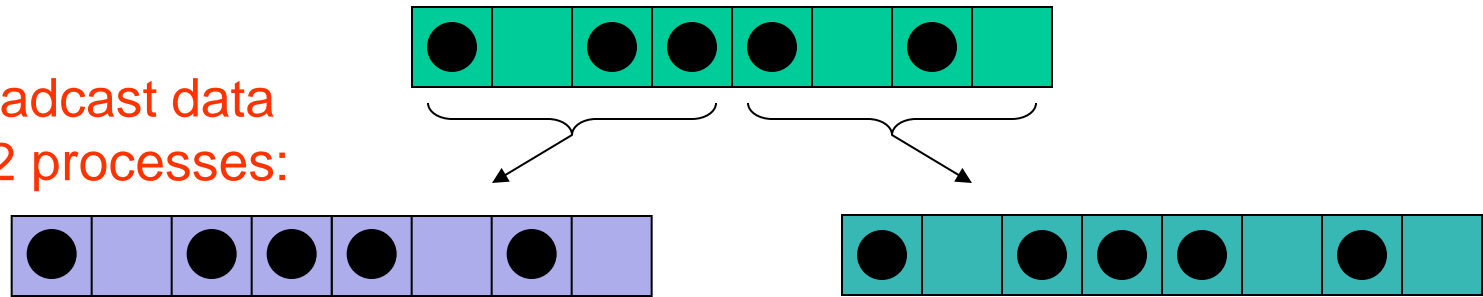
–	$R^t(i-1) = 0$	$R^t(i-1) = 1$
– $R^t(i+1) = 0$	0	1
– $R^t(i+1) = 1$	0	1

▶ If  $R^t(i) = 1$ , then  $R^{t+1}(i)$  is given by:

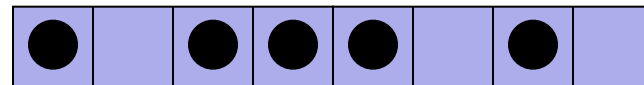
–	$R^t(i-1) = 0$	$R^t(i-1) = 1$
– $R^t(i+1) = 0$	0	0
– $R^t(i+1) = 1$	1	1

```
declare arrays old(i) and new(i), i = 0,1,...,N,N+1
initialise old(i) for i = 1,2,...,N-1,N (eg randomly)
loop over iterations
  set old(0) = old(N) and set old(N+1) = old(1)
  loop over i = 1,...,N
    if old(i) = 1
      if old(i+1) = 1 then new(i) = 1 else new(i) = 0
    if old(i) = 0
      if old(i-1) = 1 then new(i) = 1 else new(i) = 0
  end loop over i
  set old(i) = new(i) for i = 1,2,...,N-1,N
end loop over iterations
```

Broadcast data  
to 2 processes:



Split calculation  
between 2 processes:



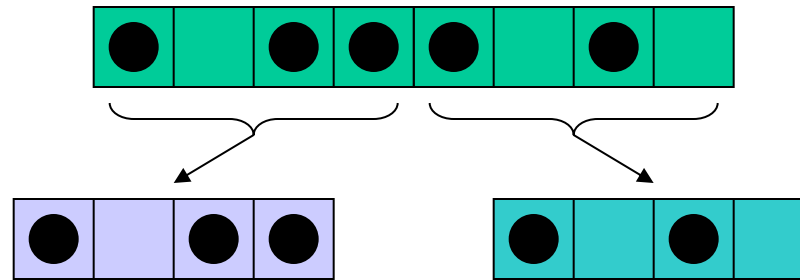
Process 1



Process 2

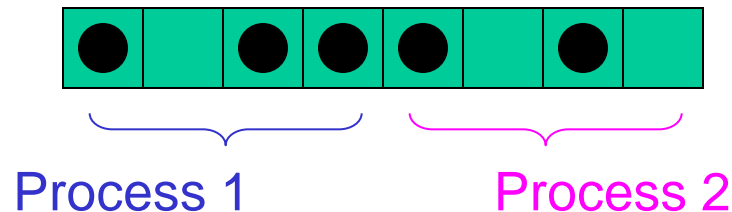
- Globally resynchronise all data after each move
  - a **replicated data** strategy
- Every process stores the entire state of the calculation
  - e.g. any process can compute total number of moves

Scatter data  
between 2 processes:  
**distributed data** strategy



- Internal cells can be updated independently.
- Must communicate with neighbouring processes to update edge cells.
- Sum local number of moves on each process to obtain total number of moves at each iteration.

Split calculation  
between 2 processes:



- Each process must know which part of roadway it is updating.
- Synchronise at completion of each iteration and obtain total number of moves.

- ▶ Load balance not an issue
  - updates take equal computation regardless of state of road
  - split the road into equal pieces of size  $N/P$
- ▶ For each piece
  - rule for cell  $i$  depends on cells  $i-1$  and  $i+1$
  - the  $N/P - 2$  interior cells can be updated independently in parallel
  - however, the edge cells are updated by other processors
    - similar to having separate rules for boundary conditions
- ▶ Communications required
  - to get value of edge cells from other processors
  - to produce a global sum of the number of cars that move

