

Message-Passing Programming

Cellular Automaton Exercise

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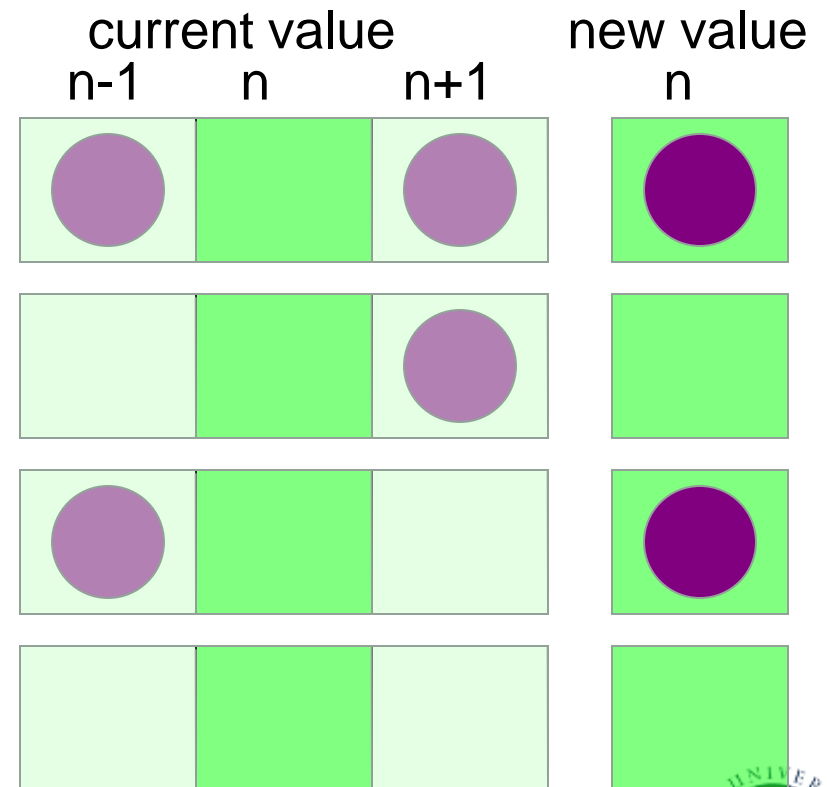
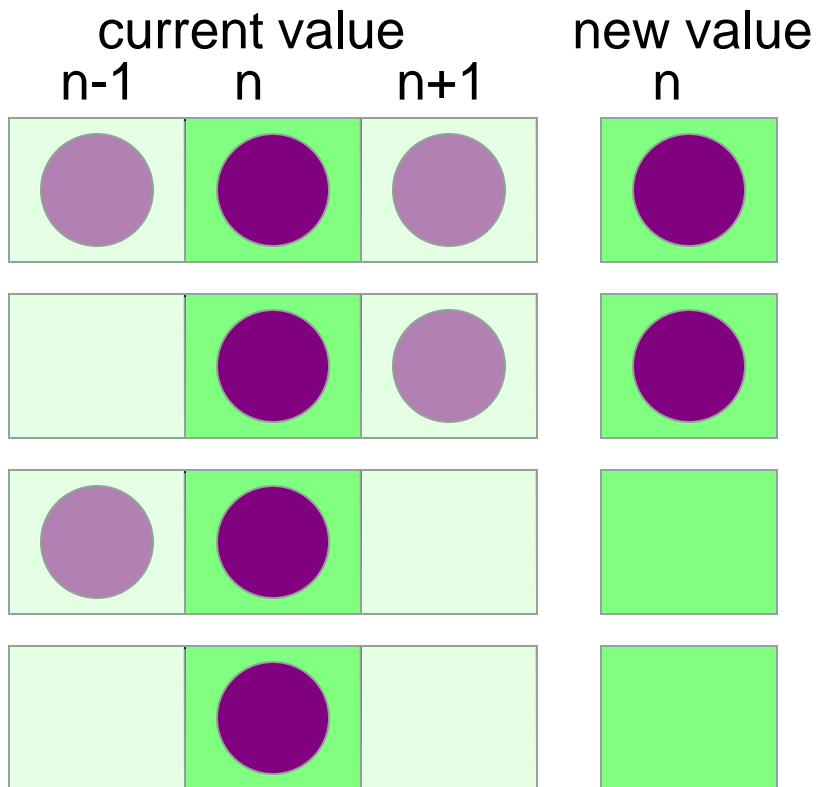
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Traffic simulation

- Update rules depend on:
 - state of cell
 - state of nearest neighbours in both directions



State Table

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

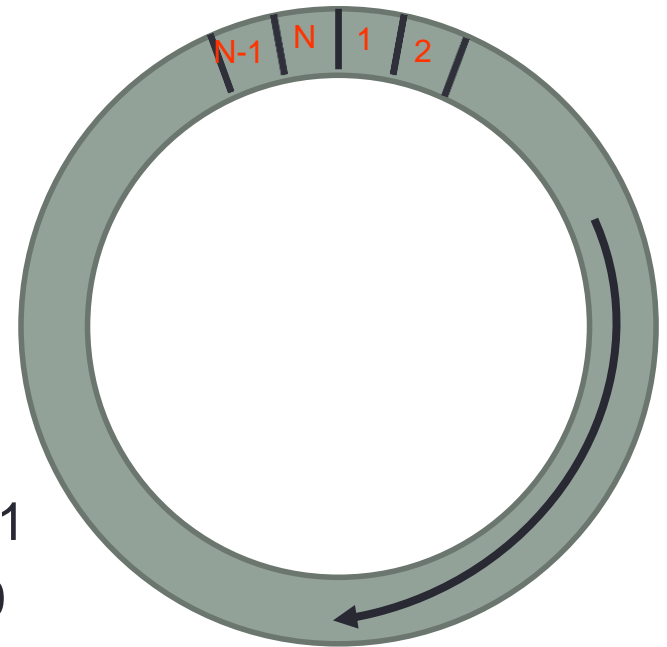
	$R^t(i-1) = 0$	$R^t(i-1) = 1$
$R^t(i+1) = 0$	0	1
$R^t(i+1) = 1$	0	1

- 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

Boundary conditions

- What happens if a car falls off the end of the road?
 - when does a car appear at the start?
- Consider a roundabout
 - periodic boundary conditions:
 - up from last cell N is first cell 1
 - down from first cell 1 is last cell N
- Implement with *ghost* or *halo* cells
 - road has $N+2$ cells 0, 1, 2, ..., $N-1$, N , $N+1$
 - copy cell 1 to cell $N+1$ and cell N to cell 0
 - then update cells 1 to N as normal

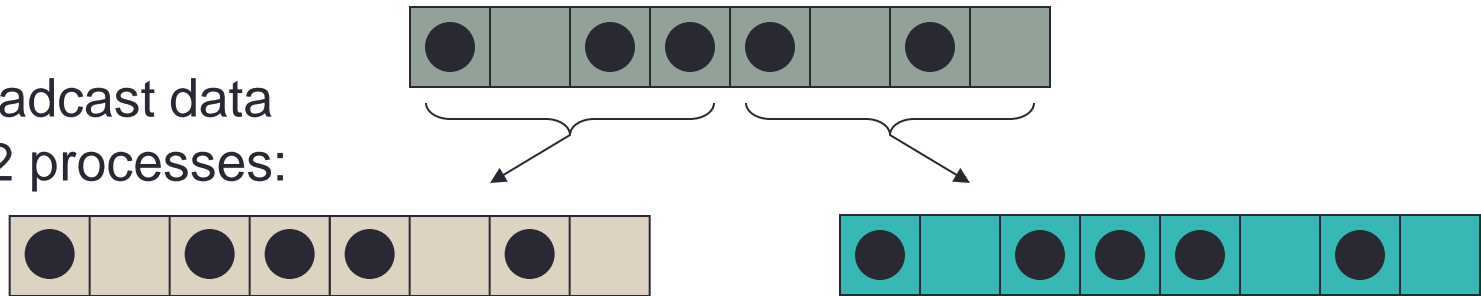


Pseudo Code

```
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
```

Parallelisation Strategy (1)

Broadcast data
to 2 processes:



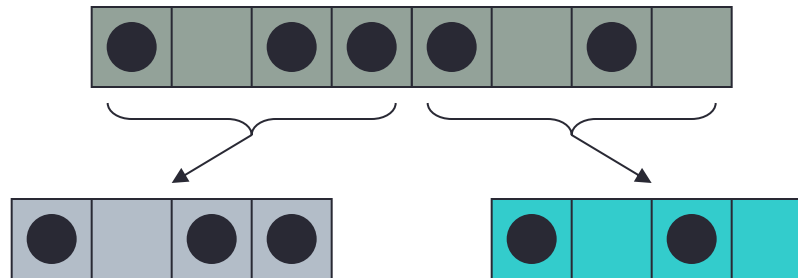
Split calculation
between 2 processes:



- 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

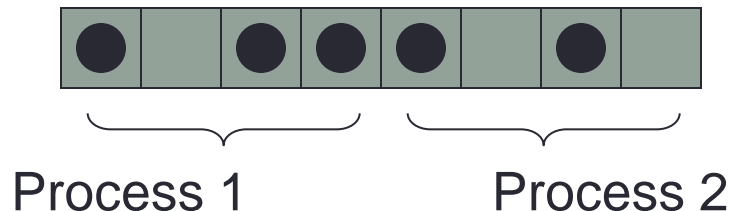
Parallelisation Strategy (2)

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.

Parallelisation

- 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

Message Passing Parallelisation

