Traffic Model

Parallel Solutions

The Model

- Consider a road with *N* cells

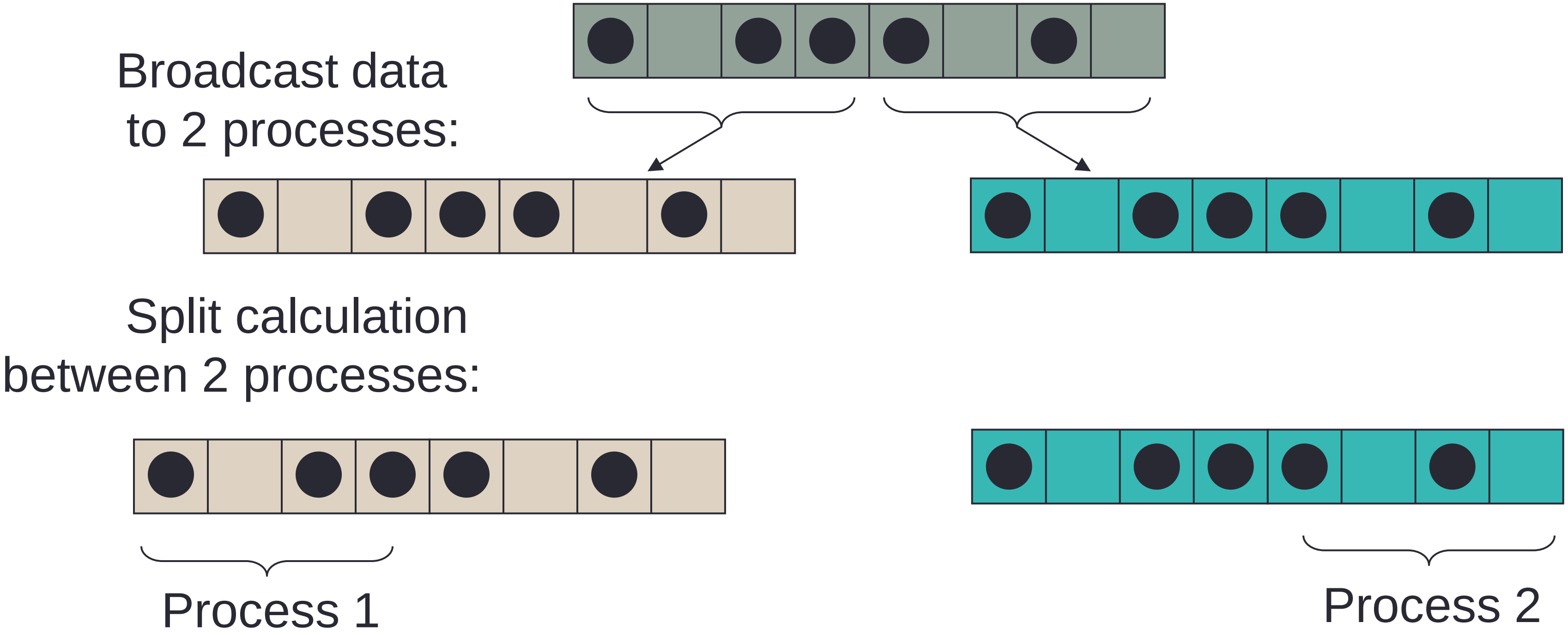
- Simulate traffic on a ***roundabout***
  - i.e. periodic boundary counditions

- If a car moves off the right it reappears on the left
  - i.e. identify cell N+1 with cell 1, and cell 0 with cell N

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
```

Message-Passing Strategy (1)



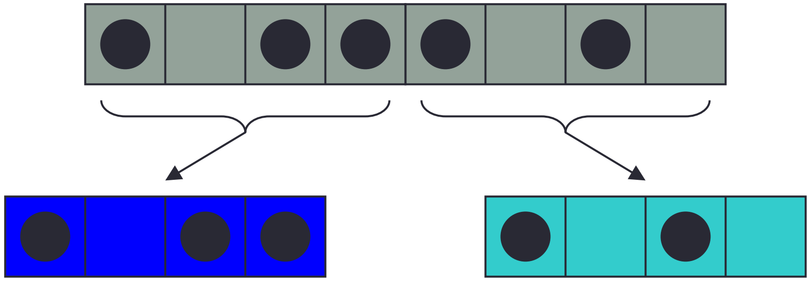
Broadcast data to 2 processes:

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

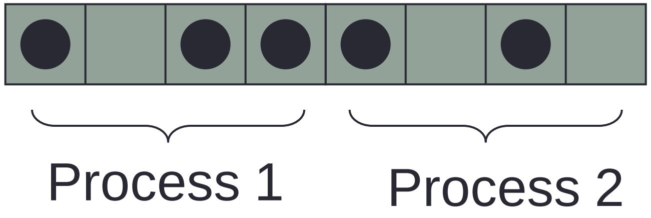
Parallelisation Strategy (2)

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:

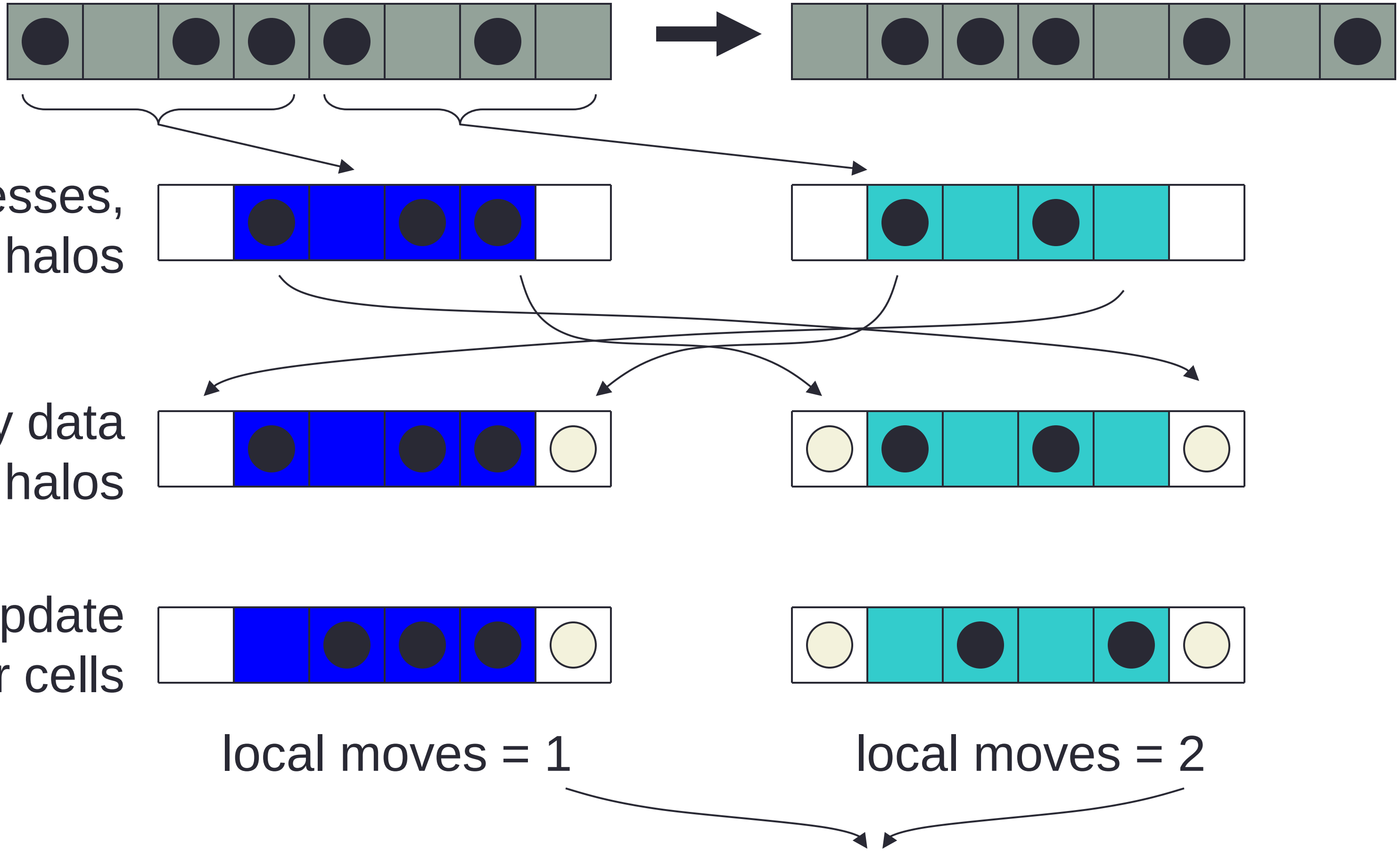


- Each process must know which part of roadway it is updating.
- Synchronise at completion of each iteration and obtain total number of moves

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

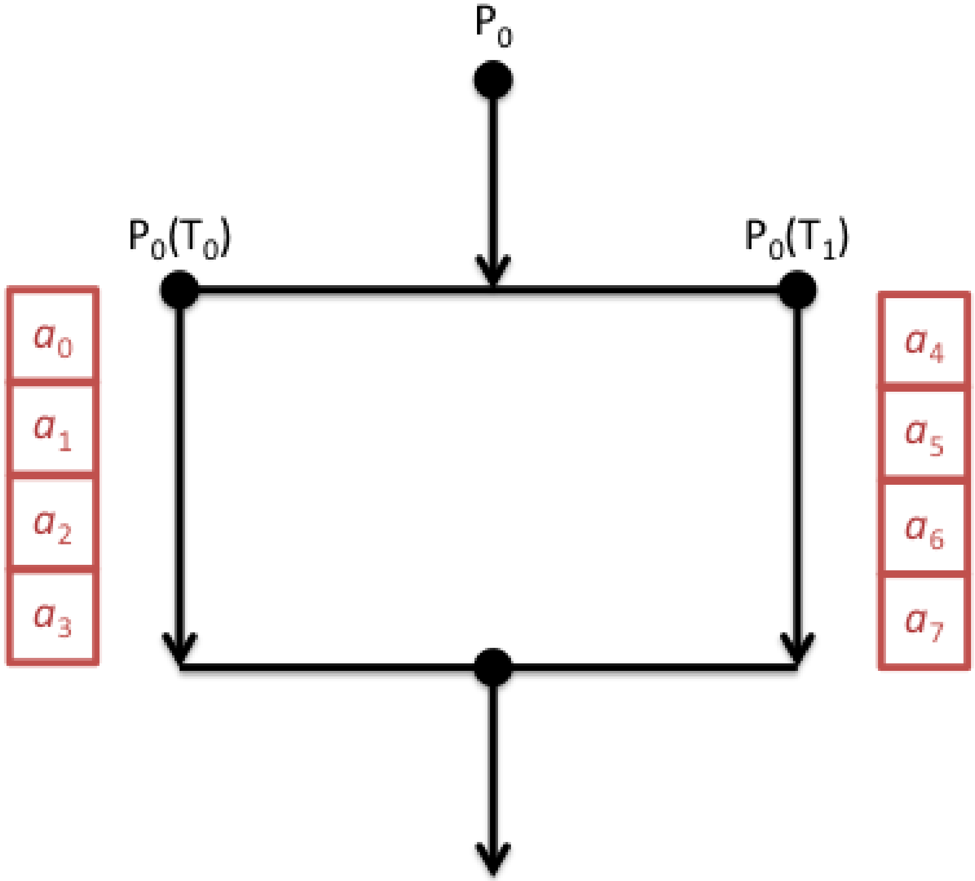


global moves = 3

Threads Parallelisation

- Load balance not an issue
  - updates take equal computation regardless of state of road
  - split the road into equal pieces of size *N*/*T* (for *T* threads)
- For each piece
  - rule for cell *i* depends on cells *i*-1 and *i*+1
  - can parallelise as we are updating new array based on old
- Synchronisation required
  - to ensure threads do not start until boundary data is updated
  - to produce a global sum of the number of cars that move
  - to ensure that all threads have finished before next iteration

Fork-Join Model



Shared Variables Parallelisation

```
serial: initialise old(i) for i = 1,2,...,N-1,N
serial: loop over iterations
  serial: set old(0) = old(N) and set old(N+1) = old(1)
  parallel: loop over i = 1,...,N
              if old(i) = 1
                if old(i+1) = 1 then ...
              if old(i) = 0
                if old(i-1) = 1 then ...
              end loop over i
  synchronise
  parallel: set old(i) = new(i) for i = 1,2,...,N-1,N
  synchronise
end loop over iterations
```

- private: i; shared: old, new, N
  - reduction operation to compute number of moves