Algorithms

Characteristics / properties

Centralised

- centralized (single-source) / decentralized (multi-source)
- number of initiators

Topology

- ring, tree, star, clique, ...

Starting information

- identification of processes
- neighbourhood
- interconnection types (bidirectional/unidirectional)

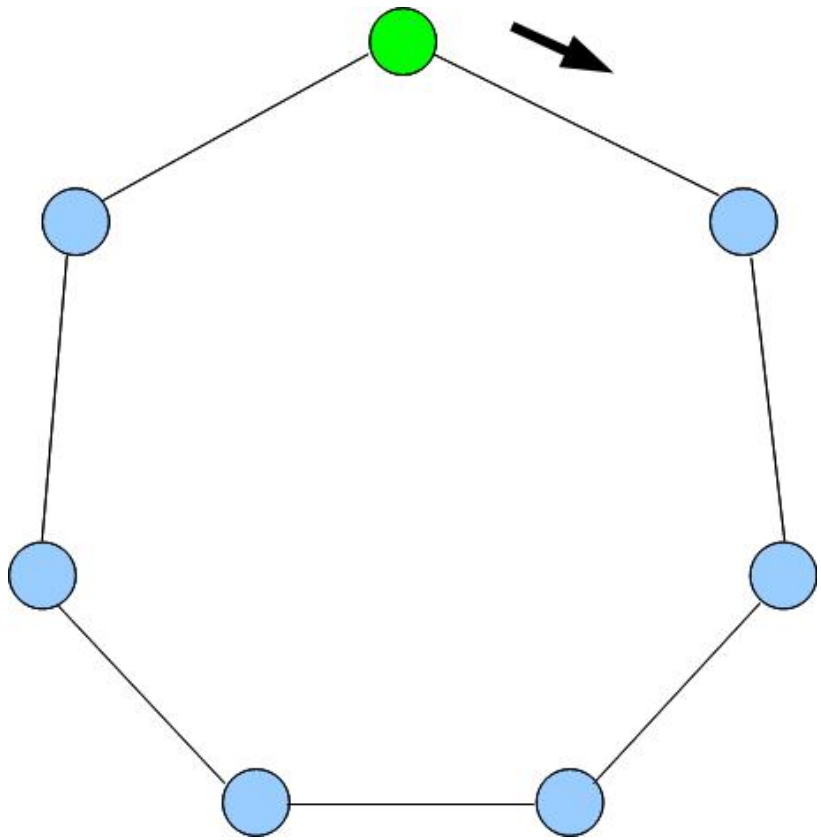
Computing termination

- in a single process
- in more or all processes

Complexity

- number of messages, steps of computation

Simple wave algorithm on the ring



Simple wave algorithm on the ring

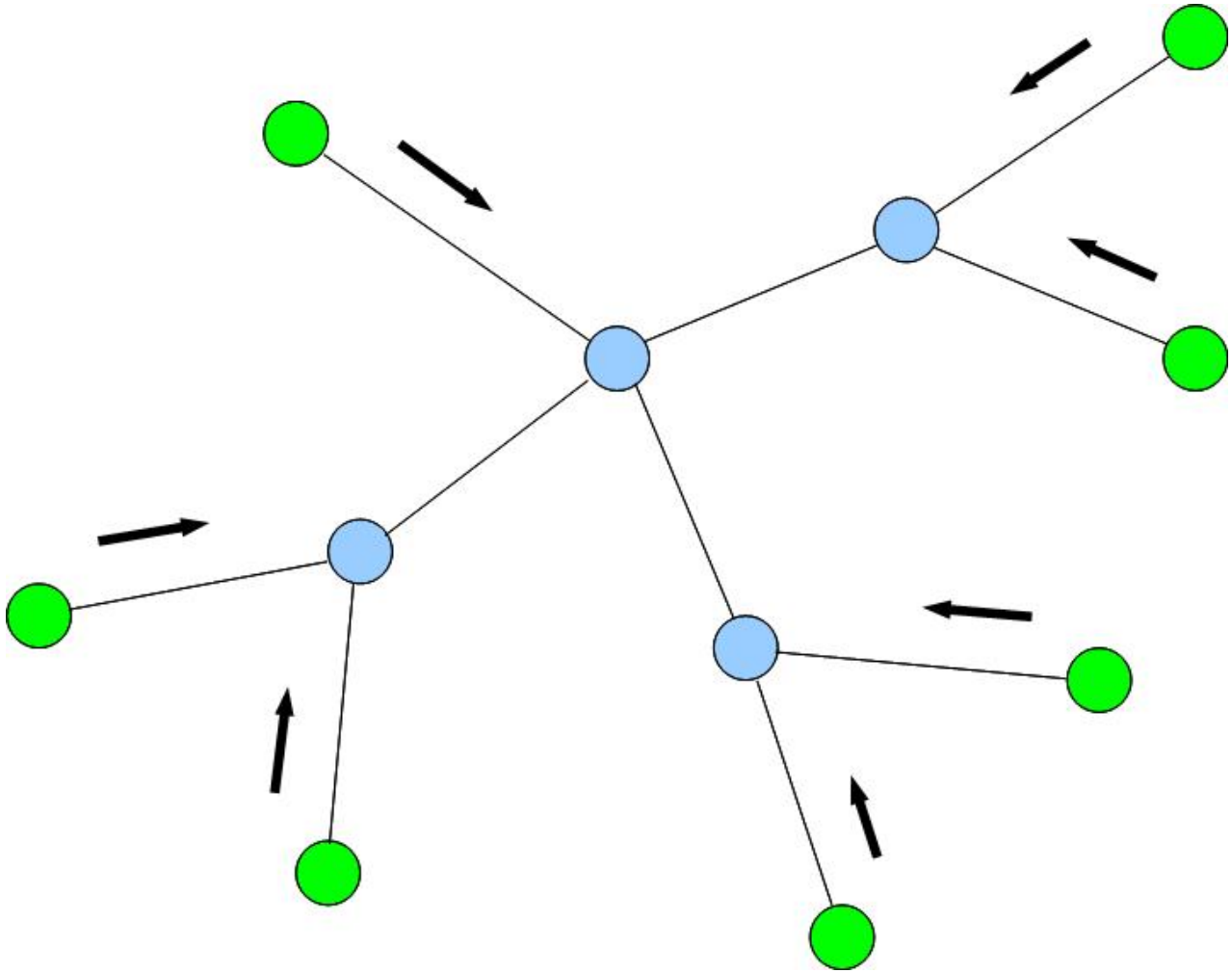
Starting process (initiator)

begin send (**tok**) to $Next_p$; receive (**tok**); *decide* . . . **end**

Other processes (non-initiators)

begin receive (**tok**); send (**tok**) to $Next_p$ . . . **end**

Simple wave algorithm on the tree



Simple wave algorithm on the tree

All proceses p

var $rec_p[q]$ for each $q \in Neigh[p]$: boolean **init** false;
(* $rec_p[q]$ is *true* when p has received a message from q *)

begin
while $\#\{q : rec_p[q] \text{ is false}\} > 1$ **do**
begin receive (**tok**) from q ; $rec_p[q]$:= true **end** ;

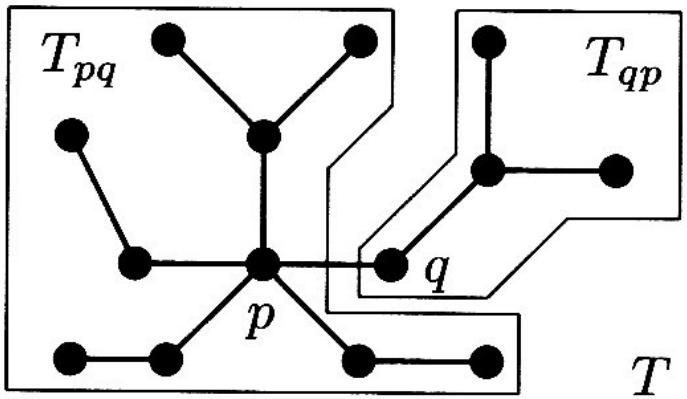
send (**tok**) to q_0 with $rec_p[q_0]$ is false ;
x: receive(**tok**) from q_0 ; $rec_p[q_0]$:= true ;
decide

(* Inform other processes of decision :
forall $q \in Neigh[p], q \neq q_0$ **do** send (**tok**) to q *)

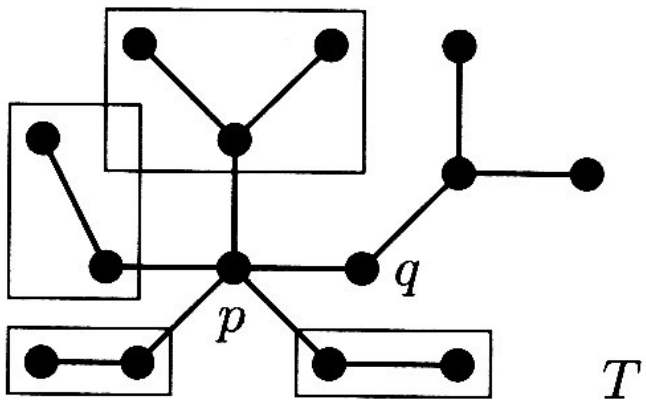
end

Simple wave algorithm on the tree

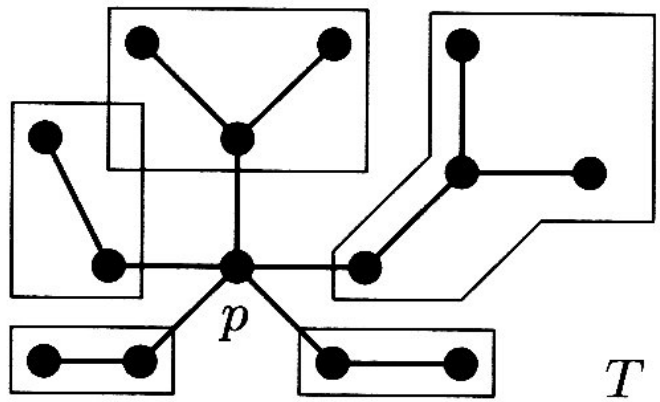
Example of computing



T_{pq} and T_{qp}



Decomposition of T_{pq}



Decomposition of T

Traversal algorithms

Definition

A traversal algorithm is an algorithm that satisfies the following three requirements:

1. In each computation there is a one initiator, which starts the algorithm by sending out exactly one message.

2. A process, upon receip of a message, either sends out one message or decides.

3. The algorithm terminates in the initiator and when this happens, each process has sent a message at least once.

Traversal algorithms

Sequential polling algorithm

var rec_p : integer **init** 0 ; (* for initiator only *)

For the initiator:

(* Write $Neigh_p = \{q_1, q_2, \ldots, q_{N-1}\}$ *)

begin while $rec_p < \#Neigh_p$ **do**

begin send $\langle$ **tok** $\rangle$ to q_{rec_p+1} ;

receive $\langle$ **tok** $\rangle$; $rec_p := rec_p + 1$

end ;

decide

end

For non-initiators:

begin receive $\langle$ **tok** $\rangle$ from q ; send $\langle$ **tok** $\rangle$ to q **end**

Selection algorithms

Symmetric algorithms

- same code and its execution (not the same state)
- high communication and computing requirements

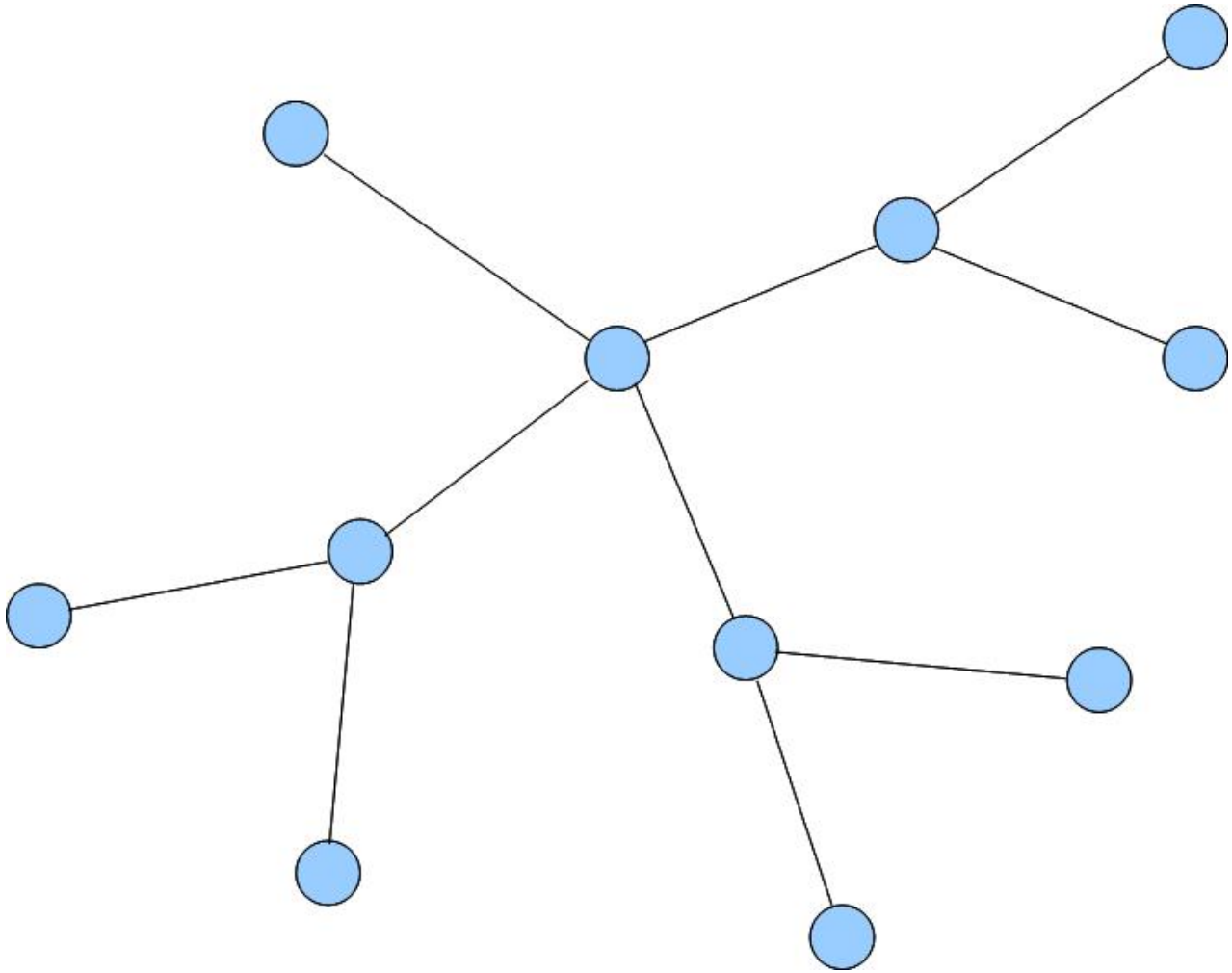
Code symmetry

- same code
- starting by selecting of a process that will work as the server
- (possibility to repeat the selection - effectiveness, failures)

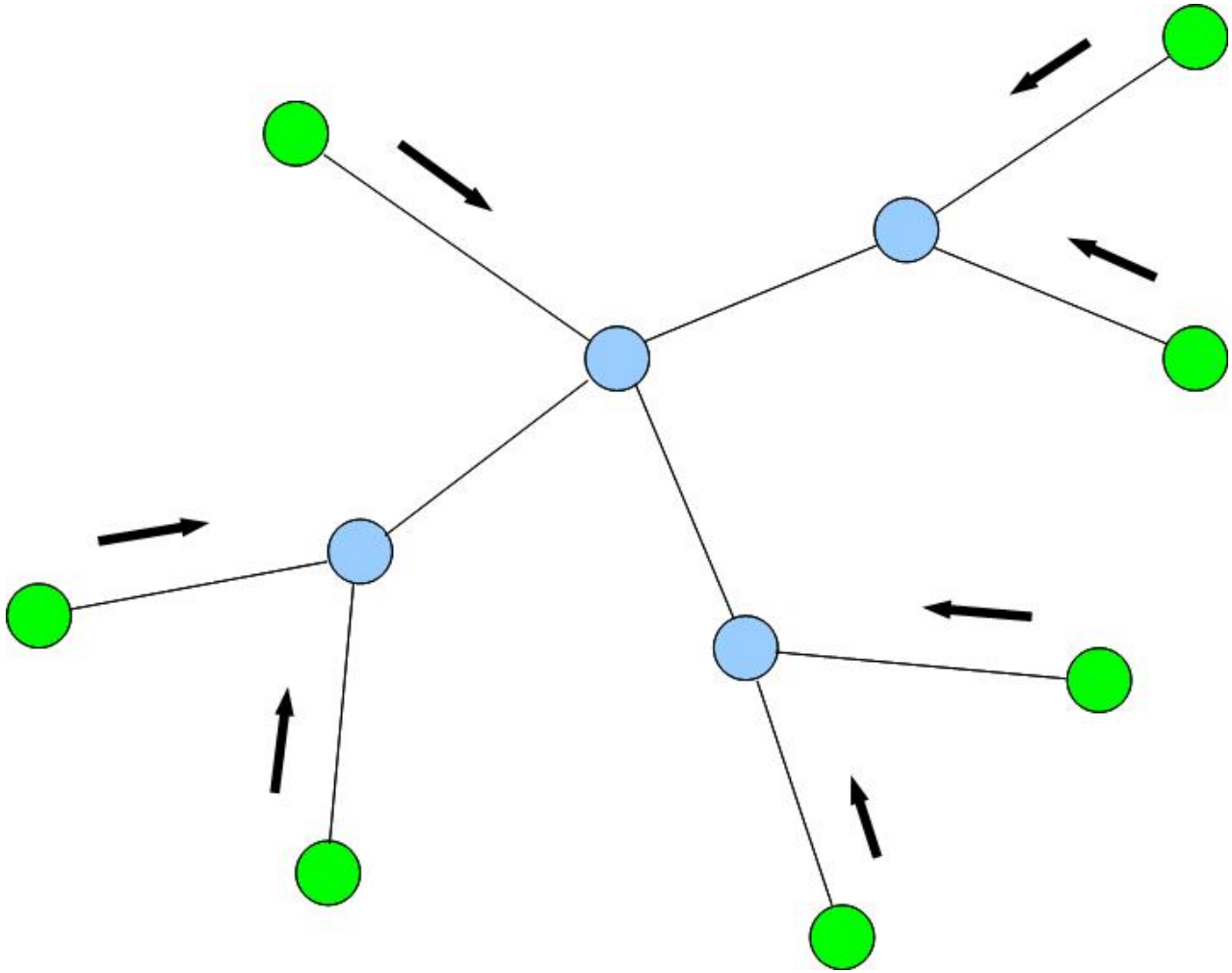
Asymmetric algorithms

- different code of processes (typically client-server)
- lower requirements for communication and computing
- (needs to solve failures -> cloud technologies)

Selection of the server on the tree



Selection of the server on the tree



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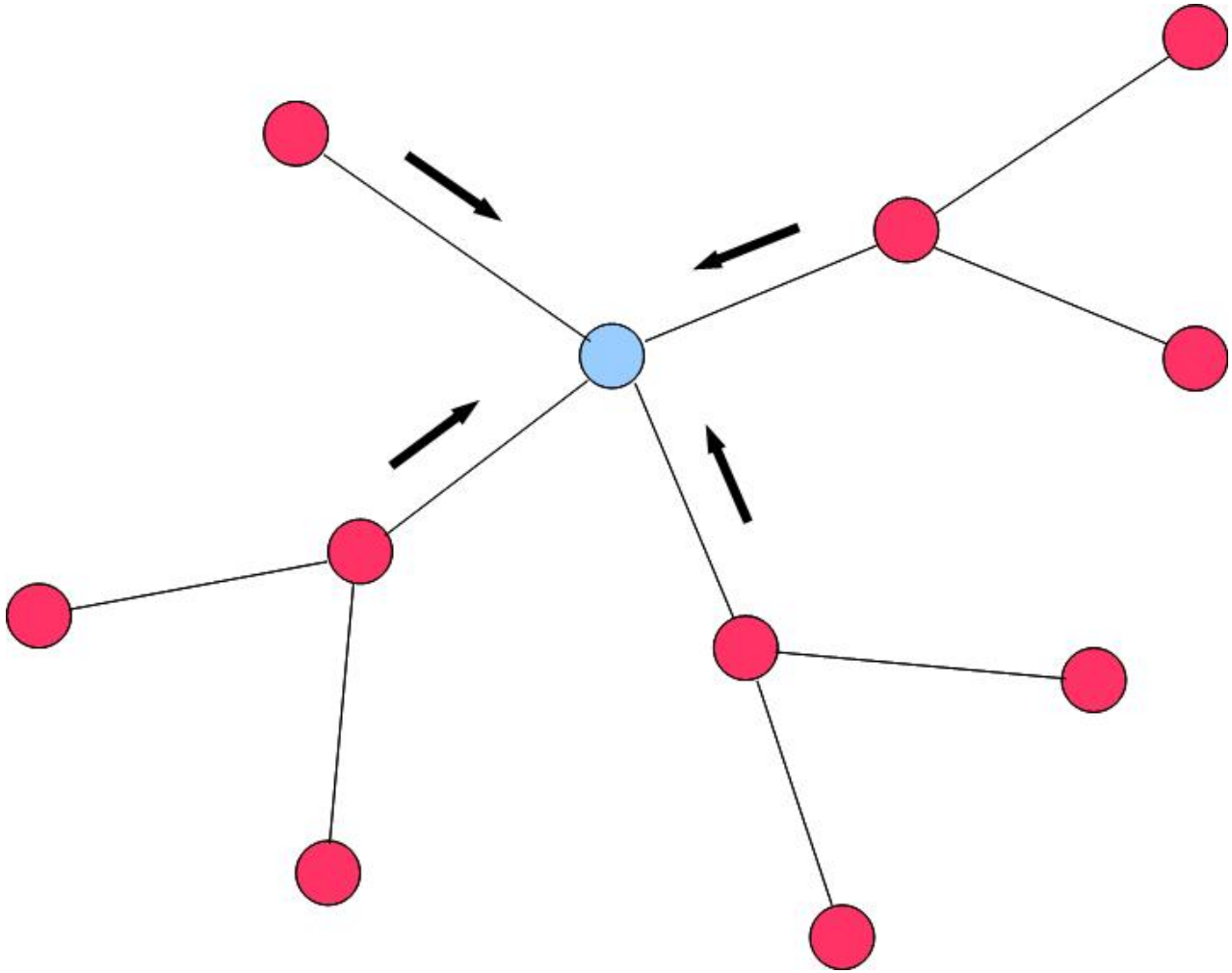

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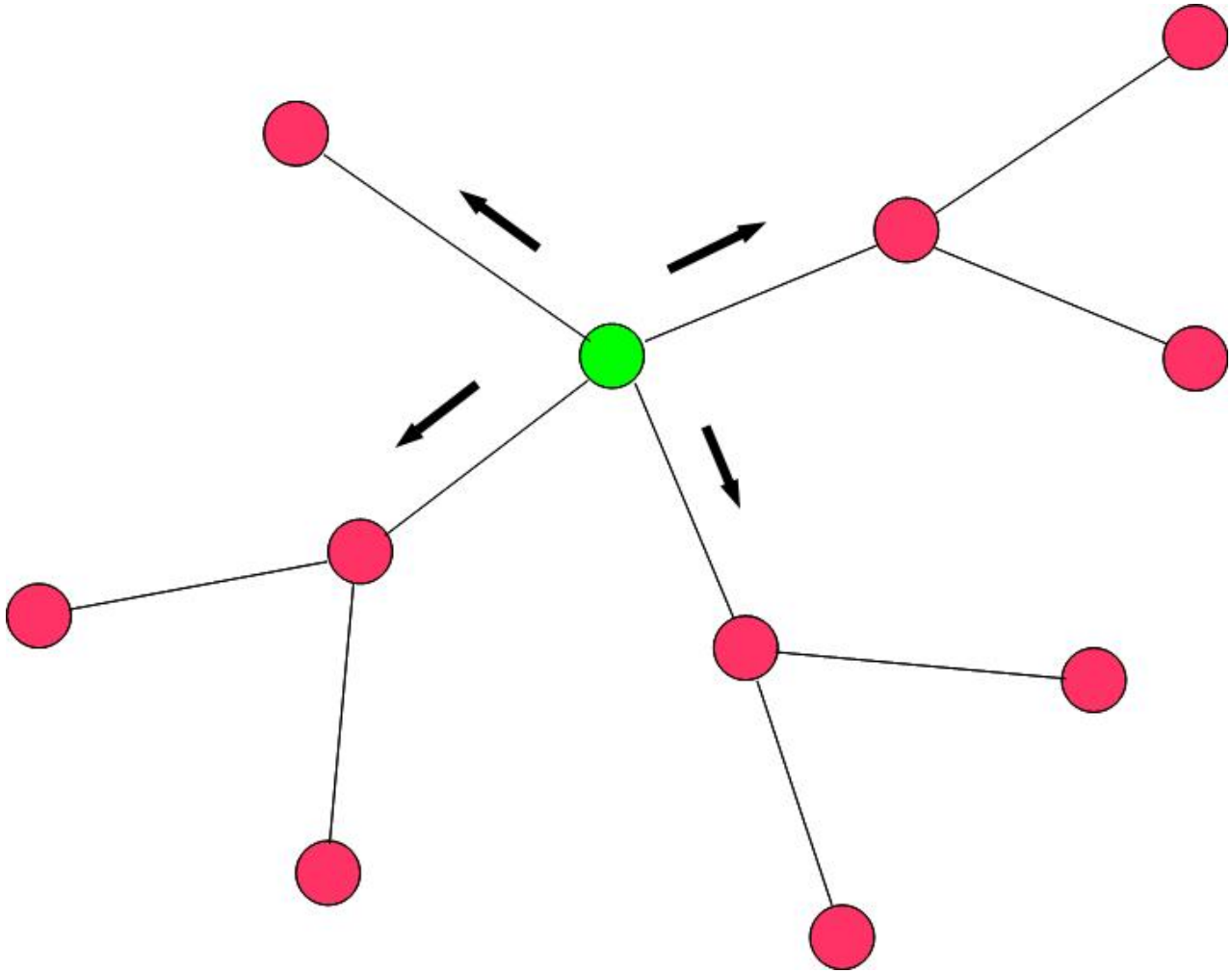


Selection of the server on the tree

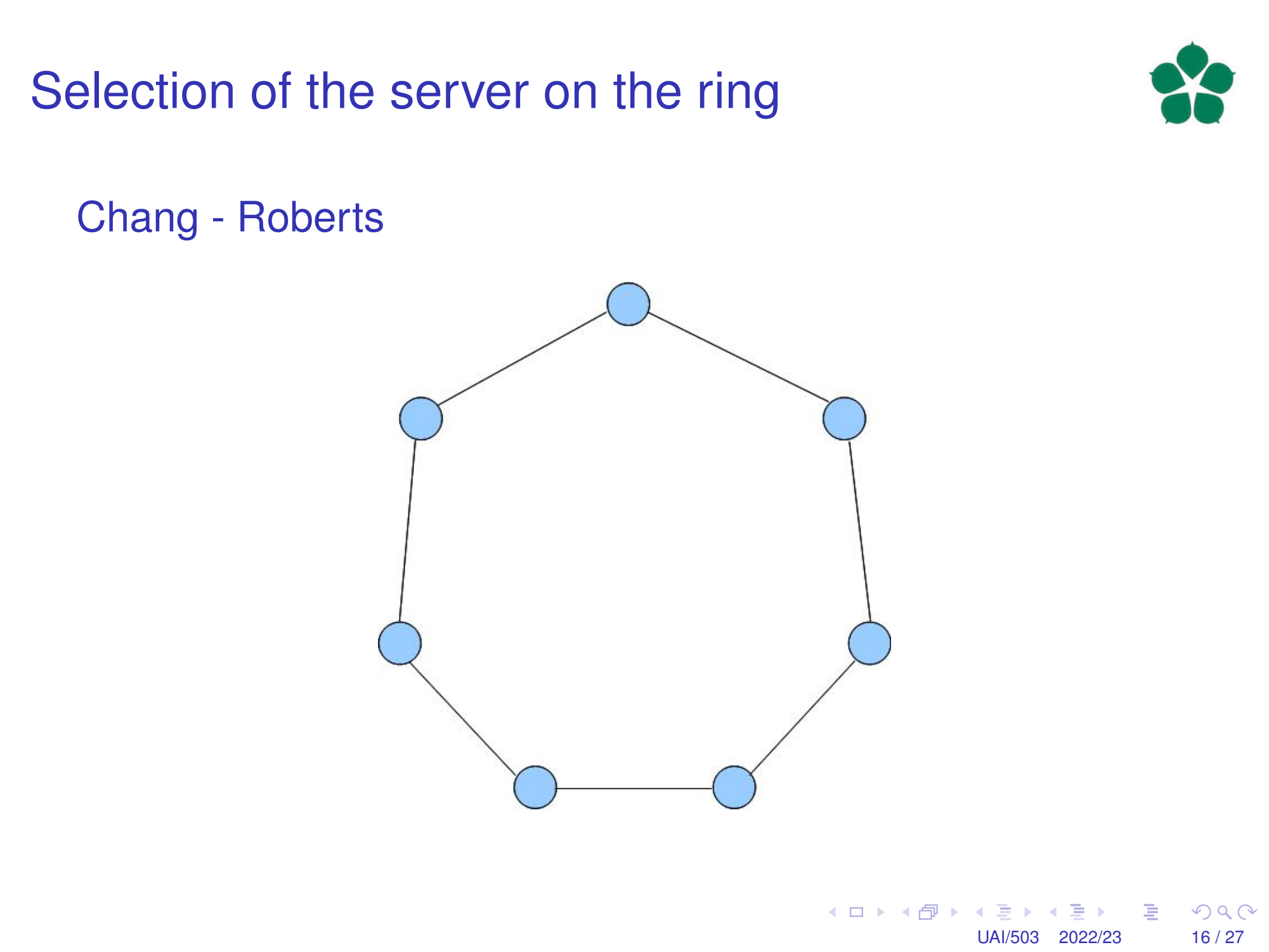
```
var   ws_p :      boolean;              init false;
      wr_p :      boolean;              init 0;
      rec_p[q]:   boolean;              init false;
      v_p :       P;                    init p;
      state_p :   {sleep,leader,lost};  init sleep;

begin if p is initiator then
      begin ws_p := true;
          forall q in Neigh_p do send (wakeup) to q
      end;
      while wr_p <#Neigh_p do
          begin receive (wakeup); wr_p := wr_p +1;
              if not ws_p then
                  begin ws_p := true;
                      forall q in Neigh_p do send (wakeup) to q
                  end
          end;
```

Selection of the server on the tree

```
        while #{q : ~rec_p[q]} > 1 do
            begin receive(tok,r) from q; rec_p[q] := true;
                v_p := min(v_p,r)
            end;
        send(tok,v_p) to q_0 with ~rec_p[q_0];
        receive(tok,r) from q_0;
        v_p := min(v_p,r);
        if v_p=p then state := leader else state := lost;
        forall q in Neigh_p, q≠q_0 do send(tok,v_p) to q
end
```

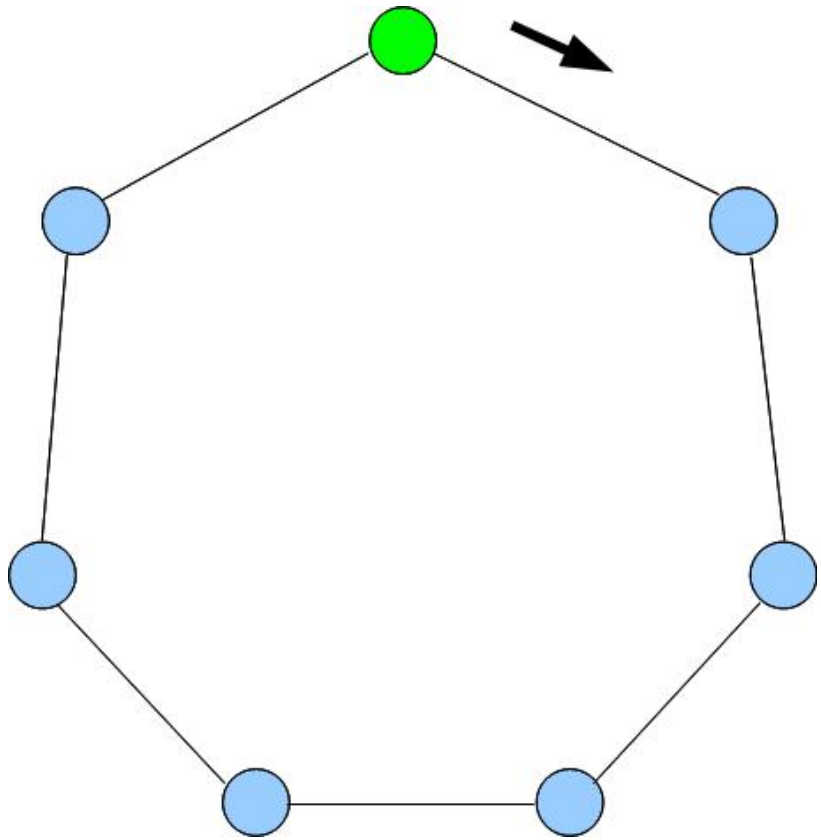
Selection of the server on the ring



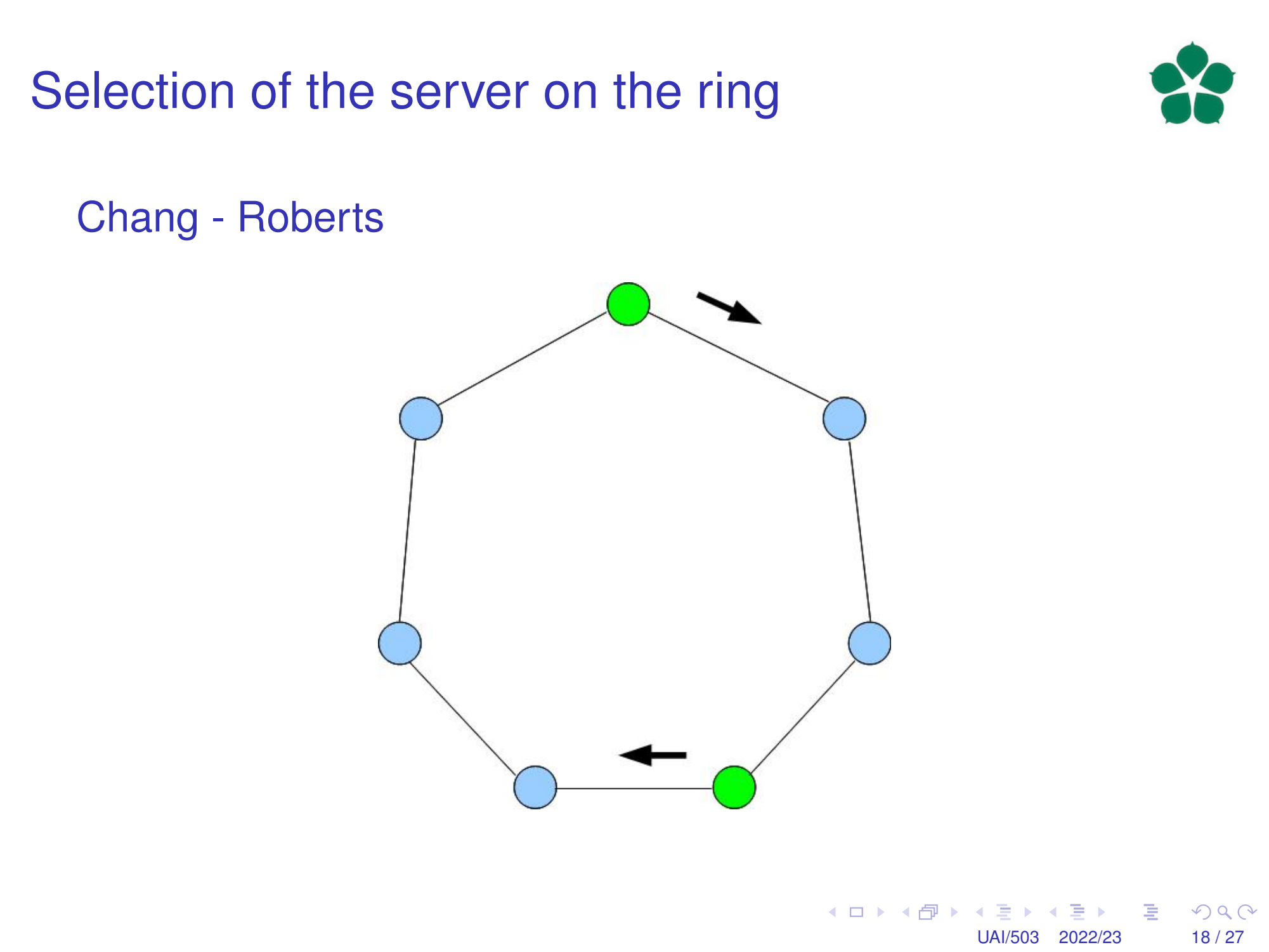
Chang - Roberts

Selection of the server on the ring

Chang - Roberts



Selection of the server on the ring



Chang - Roberts

Selection of the server on the ring

Chang - Roberts

```
var   Voting;
      Coordinator;

when decision INITIATE_ELECTION do          { rozhodnutí volit }
      begin
          Voting:=T;
      sendl ELECTION(i)
      end
```

Selection of the server on the ring

Chang - Roberts

```
when received ELECTION(j) do                    { příjem zprávy ELECTION }
        begin
            if j>i then
                begin
                    sendl ELECTION(j);
                    Voting:=T
                end;
            if j<i and not Voting then
                begin
                    sendl ELECTION(MyNumber);
                    Voting:=T
                end;
            if j=i then
                begin
                    sendl ELECTED(i)
                end
        end
```

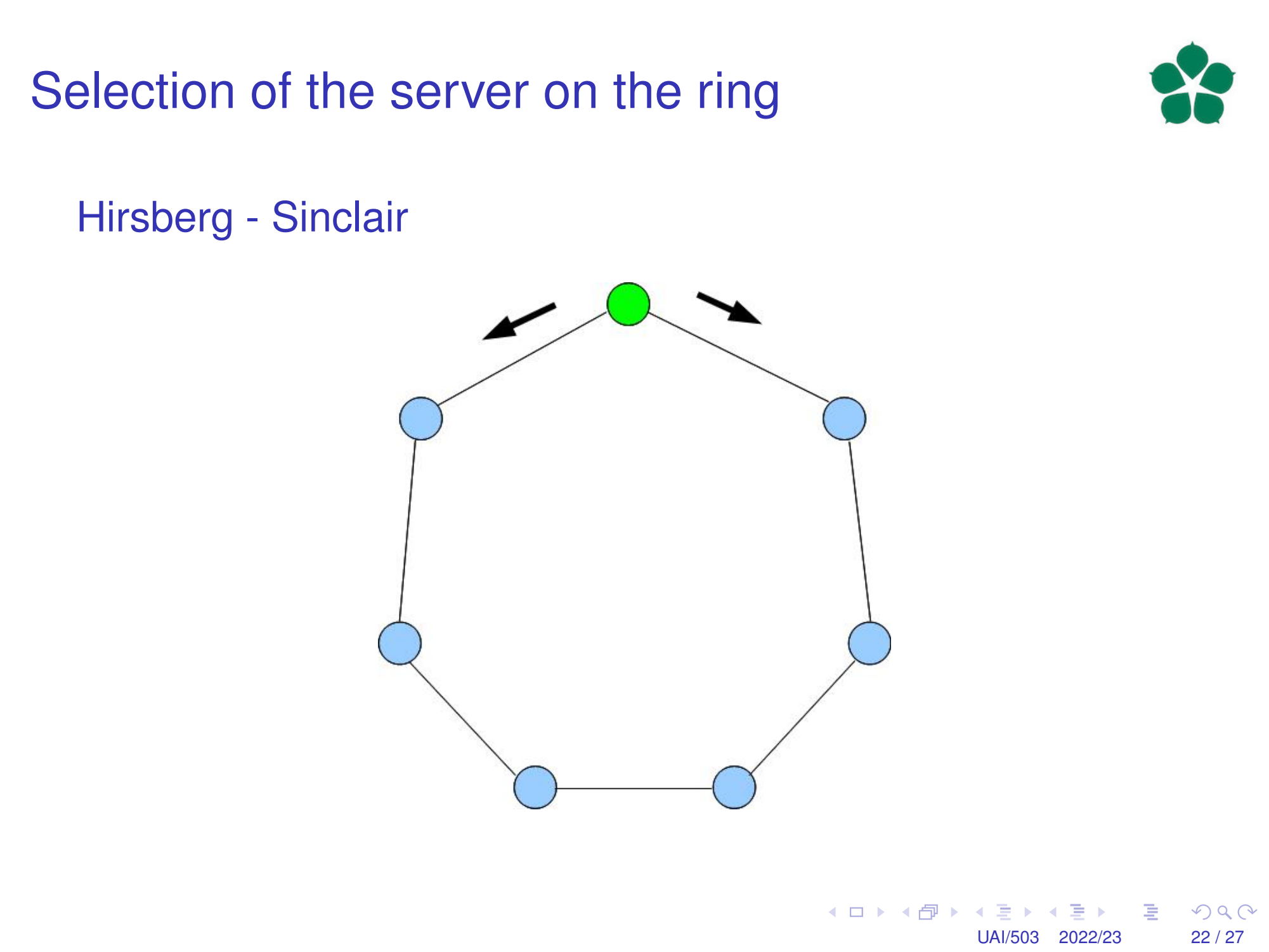
Selection of the server on the ring

Chang - Roberts

```
when received ELECTED(j) do                    { příjem zprávy ELECTED }
        begin
            Coordinator:=j;
            Voting:=F;
            if j<>i then sendl ELECTED(j)
        end

begin                                          { inicializace }
        Voting:=F; Coordinator:=0
end
```

Selection of the server on the ring



Hirsberg - Sinclair

Selection of the server on the ring

Hirsberg - Sinclair

```
when decision INITIATE_ELECTION do rozhodnutí volit
    begin
        State := CANDIDATE;
        lmax := 1;
        while State=CANDIDATE do
            begin
                Nresp := 0;
                RespOK := T;
                sendlr CANDIDATURE(i,0,lmax);
                wait NResp=2;
                if not RespOK then State := LOST;
                lmax := 2*lmax
            end
    end

when received RESPONSE(r,j) do příjem zprávy RESPONSE
    if j=i  then
        begin
            Nresp := NResp+1;
            RespOK := RestOK and r
        end
    else
        pass RESPONSE(r,j]
```

Selection of the server on the ring

Hirsberg - Sinclair

```
when received CANDIDATURE(j,l,lmax) do příjem zprávy CANDIDATURE
    begin
        if j<i then
            begin
                respond RESPONSE(F,j);
                if State=NOT_INVOLVED then INITIATE_ELECTION
            end;
        if j>i then
            begin
                State := LOST;
                l := l+1;
                if l<lmax then pass CANDIDATURE(j,l,lmax)
                else respond RESPONSE(T,j)
            end;
        if j=i then
            begin
                if State<>ELECTED then State:=ELECTED;
                Winner := i;
                pass ELECTED(i)
            end
    end
```

Selection of the server on the ring

Hirsberg - Sinclair

```
when received ELECTED(j) do příjem zprávy ELECTED
    if Winner<>j then
        begin
            pass ELECTED(j);
            Winner := j;
            State := NOT_INVOLVED
        end

begin                                   inicializace
    Nresp := 0; RespOK := T
end
```

Selection of the server on the ring

Dolev, Klawe, Rodeh

- two requests sent in the same (clockwise) direction
- one to the neighbourgh, second to the neighbourgh's neighbourgh
- similar to Hirsberg-Sinclairova algorithm