Example algorithm that is both stabilizing and robust

- Robustness and stabilization - to approaches to combat system faults
- guarded command language review
- alternating bit protocol ABP - robust but not stabilizing
- stabilizing ABP
- stabilizing ring token token circulation algorithm

Robust and stabilizing algorithms

- An algorithm is *robust* (*masking*) if the correct operation of the algorithm is ensured even at the presence of specified failures
- the algorithm is stabilizing if it is able to eventually start working correctly regardless of the initial state.
  - stabilizing algorithm does not guarantee correct behavior during recovery
  - stabilizing algorithm is able to recover from faults regardless of their nature (as soon as the influence of the failure stops)
- an algorithm can mask certain kinds of failures and stabilize from others
  - for example: an algorithm may mask message loss and stabilize from topology changes

Guarded Command Language (GCL)

```
*[
  guard1 ♦ command1
  []guard2 ♦ command2
  ⋮
]
```

- *[…] - execution repeats forever
- $guard_i$ - binary predicate on local vars, received messages, etc.;
- $command_i$ - list of assignment statements;

command is executed when corresponding *guard* is true;

guards are selected nondetermenistically,

Advantages:

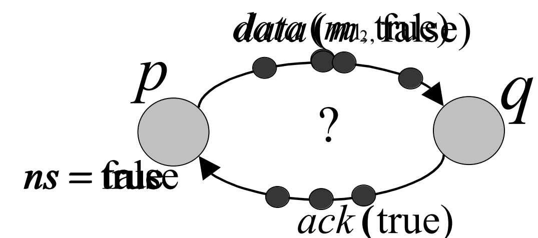
- GCL allows to easily reason about algorithms and their executions: the program counter position is irrelevant or less important;
- we don't have to consider execution starting in the middle of guard or command (*serializability property*);

Alternating Bit Protocol

```
process p
*[
  receive ack(i) ♦
     if i = ns then
        ns := ↓ns
        ms := get()
        send data(ms, ns)
 []
  timeout ♦
     send data(ms, ns)
 ]
process q
*[
  receive data(mr, i) ♦
     put(mr)
     send ack(i)
 ]
```

Objective: transmit data reliably from sender to receiver over unreliable channel

Invariant: no more than 2 msgs in system, correct message carries same number as *ns*



problems:

multiple messages in channel not allowed

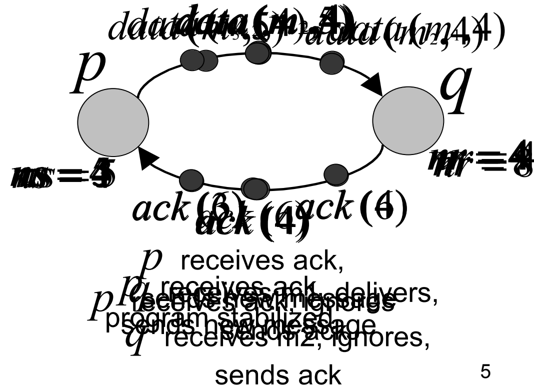
timeout needs to be long

Stabilizing Alternating Bit Protocol

```
process p
*[
   receive ack(i) ◆
      if i = ns then
         ns := ns + 1
         ms := get()
         send data(ms, ns)
 []
   timeout ◆
      send data(ms, ns)
 ]

process q
*[
   receive data(mr, i) ◆
      if i ? nr then
         put(mr)
         nr := i
      send ack(i)
 ]
```

Invariant: numbers carried by messages (and *nr*) monotonically decrease and no greater than *ns*



Dijkstra's K-State Token Circulation Algorithm

Objective: circulate a single token among processors

Processor ρ_0
*[
$s_0 = s_{k-1}$ ◆ $s_0 := (s_0 + 1) \bmod K$
]

Processor ρ_i $(0 < i < K)$
*[
s_i ? s_{i-1} ◆ $s_i := s_{i-1}$
]

- the system consists of a ring of *K* processors (*id*s 0 through *K*-1)
- each processor maintains a state variable *s*; a processor can see the state of it's left (smaller id) neighbor
- guard evaluates to **true** - processor has a privilege (token)
- all processors evaluate their guards, only **one at a time** changes state (C-Daemon)
- after the state change all processors re-evaluate the guards

Dijkstra's K-State Token Circulation Algorithm

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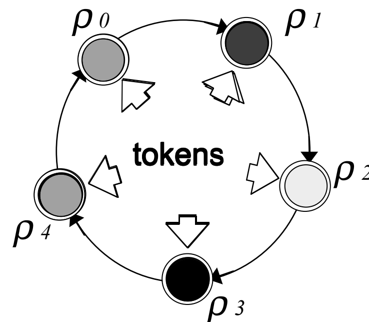

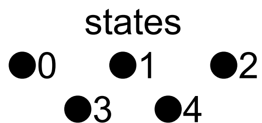

ρ_2 changes state from to

simulation