Computing with anonymous processes

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Counter (sequential spec)

- A ***counter*** has two operations ***inc()*** and ***read()*** and maintains an integer *x init to 0*
- ***read():***
  - return(x)
- ***inc():***
  - x := x + 1;
  - return(ok)

Counter (atomic implementation)

- The processes share an array of SWMR registers Reg[1,..,n] ; the writer of register Reg[i] is pi
- ***inc():***
  - temp := Reg[i].read() + 1;
  - Reg[i].write(temp);
  - return(ok)

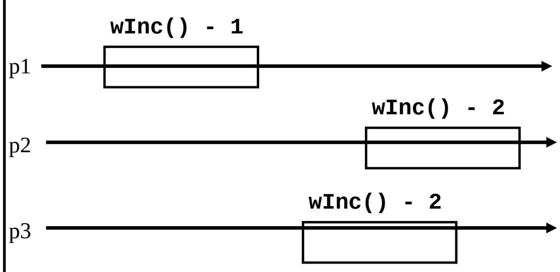
Counter (atomic implementation)

- ***read():***
  - sum := 0;
  - for j = 1 to n do
    - sum := sum + Reg[j].read();
  - return(sum)

Weak Counter

- A ***weak counter*** has one operation ***wInc()***
- ***wInc():***
  - x := x + 1;
  - return(x)
- correctness: if an operation precedes another, then the second returns a value that is larger than the first one (regularity vs atomicity)

Weak counter execution



Weak Counter (lock-free implementation)

- The processes share an (infinite) array of MWMR registers Reg[1,..,n,..,], init to 0
- ***wInc():***
  - i := 0;
  - while (Reg[i].read() ≠ 0) do
    - i := i + 1;
  - Reg[i].write(1);
  - return(i);

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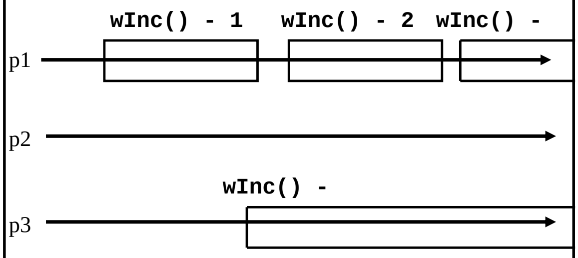
Weak counter execution



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Weak Counter (wait-free implementation)

- The processes also use a MWMR register L
- ***wInc():***
  - i : = 0;
  - while (Reg[i].read() ≠ 0) do
  - if L has been updated n times then
    - return the largest value seen in L
    - i := i + 1;
  - L.write(i);
  - Reg[i].write(1);
  - return(i);

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Weak Counter (wait-free implementation)

- ***wInc():***
  - t:= l := L.read(); i := 0;
  - while (Reg[i].read() ≠ 0) do
  - if L.read() ≠ l then
      - l := L.read(); t := max(t,l); i := i+1;
      - if k = n then return(t)
    - L.write(i);
  - Reg[i].write(1);
  - return(i);

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Snapshot (sequential spec)

- A ***snapshot*** has operations ***update()*** and ***scan()*** and maintains an array *x* of size *n*
- ***scan():***
  - return(x)
- NB. No component is devoted to a process
- ***update(i,v):***
  - x[i] := v;
  - return(ok)

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Key idea for atomicity & wait-freedom

- The processes share a ***Weak Counter***: Wcounter, init to 0;
- The processes share an array of ***registers*** Reg[1,..,N] that contains each:
  - a value,
  - a timestamp, and
  - a copy of the entire array of values

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Key idea for atomicity & wait-freedom (cont'd)

- To ***scan***, a process keeps collecting and returns a collect if it did not change, or some collect returned by a concurrent ***scan***
  - Timestamps are used to check if a scan has been taken in the meantime

- To ***update***, a process ***scans*** and writes the value, the new timestamp and the result of the scan

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Snapshot implementation

Every process keeps a local timestamp ts

- ***update(i,v):***
  - ts := Wcounter.wInc();
  - Reg[i].write(v,ts,self.scan());
  - return(ok)

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Snapshot implementation

- ***scan():***
  - ts := Wcounter.wInc();
  - while(true) do
    - If some Reg[j] contains a collect with a higher timestamp than ts, then return that collect
    - If n+1 sets of reads return identical results then return that one

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Consensus (obstruction-free)

- We consider binary consensus

- The processes share two infinite arrays of registers: Reg_0[i] and Reg_1[i]

- Every process holds an integer i init to 1

- Idea: to impose a value v, a process needs to be fast enough to fill in registers Reg_v[i]

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Consensus (obstruction-free)

- ***propose(v):***
  - while(true) do
    - If Reg_{1-v}[i] = 0 then
    - Reg_v[i] := 1;
    - if i > 1 and Reg_{1-v}[i-1] = 0 then return(v);
    - else v:= 1-v;
    - i := i+1;

    end

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Consensus (solo process)

q(1)

Reg0(1)=0

Reg1(1):=1

Reg0(2)=0

Reg1(2):=1

Reg0(1)=0

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Consensus (lock-step)

q(1)	p(0)
Reg0(1)=0	Reg1(1)=0
Reg1(1):=1	Reg0(1):=1
Reg0(2)=0	Reg1(2)=0
Reg1(2):=1	Reg0(2):=1
Reg0(1)=1	Reg0(1)=1

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Consensus (binary)

- ***propose(v):***
  - while(true) do
    - If $Reg_{1-v}[i]$ = 0 then
    - $Reg_v[i]$:= 1;
    - if i > 1 and $Reg_{1-v}[i-1]$ = 0 then return(v);
    - else if $Reg_v[i]$ = 0 then v:= 1-v;
    - if v = 1 then wait(2i)
    - i := i+1;

    end

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