# Registers

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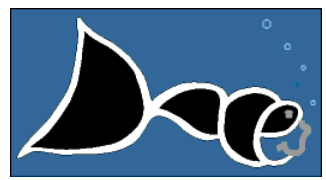


# *Register*

- A ***register*** has two operations: ***read()*** and ***write()***
- Sequential specification
  - ***read()***
    - return(x)
  - ***write(v)***
    - x <- v; return(ok)

# Space of registers

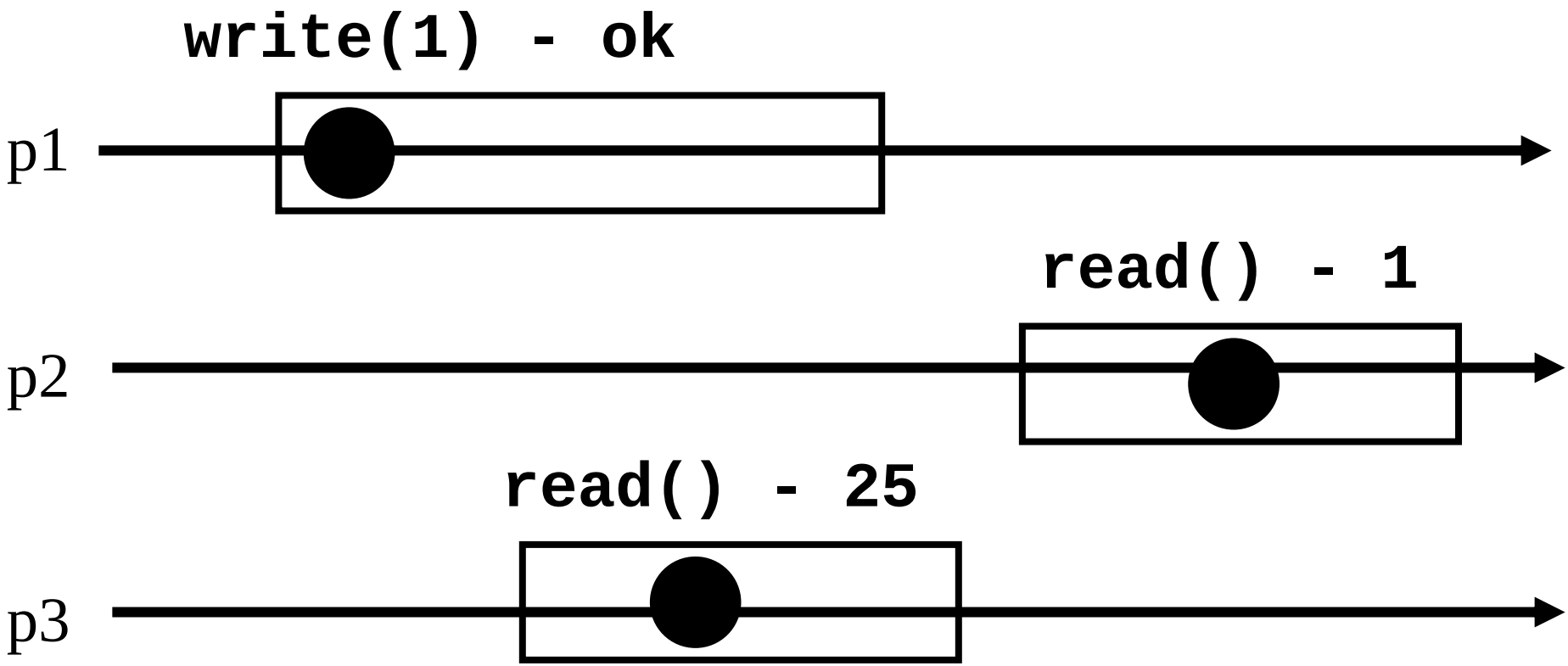
- Dimension 1: binary (boolean) – multivalued
- Dimension 2:  safe – regular – atomic
- Dimension 3: SRSW – MRSW – MRMW

# Space of registers

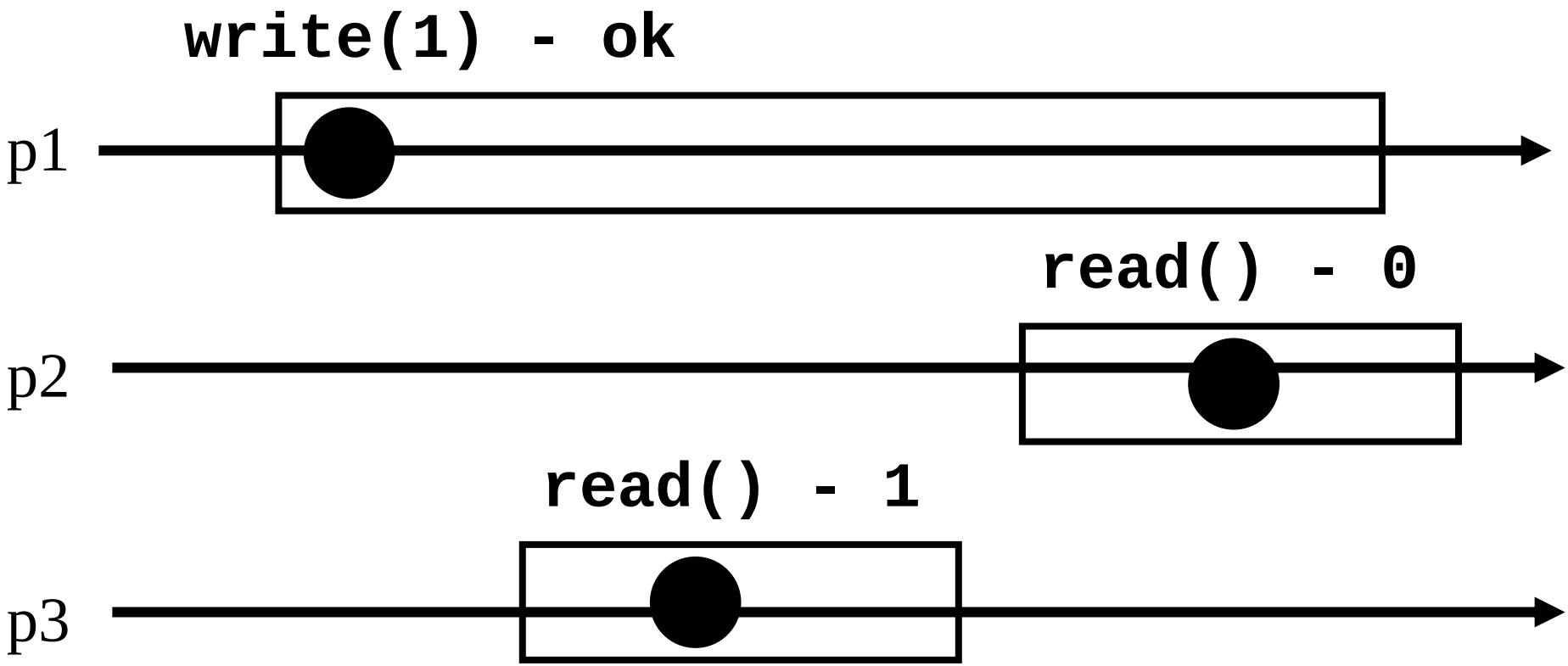
- Theorem: A multivalued MRMW atomic ***register*** can be implemented with binary SRSW safe ***register***

(2 decades of research in distributed computing)

# Safe execution



# Regular execution



# Simplifications

- We assume that ***registers*** contain only integers
- Unless explicitely stated otherwise, ***registers*** are initially supposed to contain 0
- The process executing the code is implicitely assumed to be pi
- (we assume a system of N processes)

# Conventions

- Shared registers are denoted ***Reg***
- The operations to be implemented are denoted ***Read()*** and ***Write()***
- Those of the base registers are denoted ***read()*** and ***write()***
- We omit the ***return(ok)*** instruction at the end of ***Write()*** implementations

# From (binary) SRSW safe to (binary) MRSW safe

- We use an array of SRSW ***registers***

  Reg[1,..,N]

- **Read()**
  - return (Reg[i].read());

- **Write(v)**
  - for j = 1 to N
    - Reg[j].write(v);

# From (binary) SRSW safe to (binary) MRSW safe

- The transformation works also for multi-valued ***registers*** and regular ones
- It does not however work for atomic ***registers***

# From Binary MRSW safe to Binary MRSW regular

- We use one MRSW safe register
- **Read()**
  - return(Reg.read());

- **Write(v)**
  - if old ≠ v then
    - Reg.write(v);
    - old := v;

# From Binary MRSW safe to Binary MRSW regular

- The transformation works for single reader ***registers***
- It does not work for multi-valued ***registers***
- It does not work for atomic ***registers***

# From binary to M-Valued MRSW regular

- We use an array of MRSW ***registers*** Reg[0,1,..,M] init to [1,0,..,0]

- **Read()**
  - for j = 0 to M
    - if Reg[j].read() = 1 then return(j)
- **Write(v)**
  - Reg[v].write(1);
  - for j=v-1 downto 0
    - Reg[j].write(0);

# From binary to M-Valued MRSW regular

- The transformation would not work if the Write() would first write 0s and then 1
- The transformation works for ***regular*** but ***NOT*** for ***atomic*** registers

# From SRSW regular to SRSW atomic

- We use one SRSW ***register*** Reg and two local variables t and x

- **Read()**
  - (t′,x′) = Reg.read();
  - if t′ > t then t:=t′; x:=x′;
  - return(x)
- **Write(v)**
  - t := t+1;
  - Reg.write(v,t);

# From SRSW regular to SRSW atomic

- The transformation would not work for multiple readers
- The transformation would not work without timestamps (variable t representing logical time)

# From SRSW atomic to MRSW atomic

- We use N*N SRSW atomic ***registers*** RReg[(1,1),(1,2),..,(k,j),..(N,N)] to communicate among the readers
  - In RReg[(k,j)] the reader is pk and the writer is pj
- We also use n SRSW atomic ***registers*** WReg[1,..,N] to store new values
  - the writer in all these is p1
  - the reader in WReg[k] is pk

# From SRSW atomic to MRSW atomic (cont'd)

- **Write(v)**
  - t1 := t1+1;
  - for j = 1 to N
    - WReg.write(v,t1);

# From SRSW atomic to MRSW atomic (cont'd)

- **Read()**
  - for j = 1 to N do
    - (t[j],x[j]) = RReg[i,j].read();
  - (t[0],x[0]) = WReg[i].read();
  - (t,x) := highest(t[..],x[..]);
  - for j = 1 to N do
    - RReg[j,i].write(t,x);
  - return(x)

# From SRSW atomic to MRSW atomic (cont'd)

- The transformation would not work for multiple writers
- The transformation would not work if the readers do not communicate (i.e., if a reader does not write)

# From MRSW atomic to MRMW atomic

- We use N MRSW atomic ***registers*** Reg[1,..,N]; the writer of Reg[j] is pj

- **Write(v)**
  - for j = 1 to N do
    - (t[j],x[j]) = Reg[j].read();
  - (t,x) := highest(t[..],x[..]);
  - t := t+1;
  - Reg[i].write(t,v);

# From MRSW atomic to MRMW atomic (cont'd)

- **Read()**
  - for j = 1 to N do
    - (t[j],x[j]) = Reg[j].read();
  - (t,x) := highest(t[..],x[..]);
  - return(x)