Flow control on IEEE 802.3x switch

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M. Baldi, P. Nicoletti, "Switched LAN", McGraw-Hill, 2002, ISBN 88-386-3426-2

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Half or full duplex?

- LANs are intrinsecally half-duplex:
  - Only a station at a time can transmit
- Switching strongly reduces shared medium role:
  - often transmissive medium become point to point: only a station is linked to switch
- Point to point transmissive media can be full-duplex:
  - both stations can transmit at same time
  - Trasmissions take place on different physical channels

Full duplex and 802.3x standard

- 802.3x standard define full duplex functioning modes
- Modes are negotiated between equipment and stored in the 4th register

Technology Ability Field

D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
rsvd	rsvd	rsvd	rsvd	rsvd	FD	HD	PS1	PS2	rsvd	rsvd	rsvd	RF1	RF2	Ack	NP

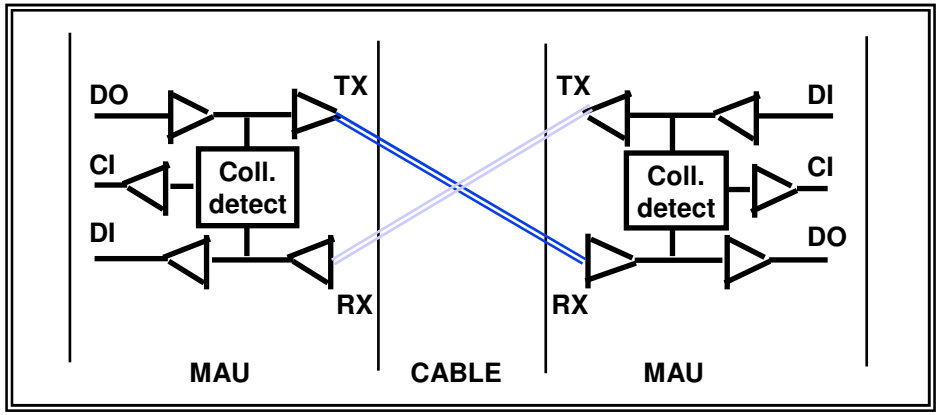
0	1	Half Duplex
1	0	Full Duplex

0	0	No error, Link OK
0	1	Offline
1	0	Link Failure
1	1	Auto-Negotiation Error

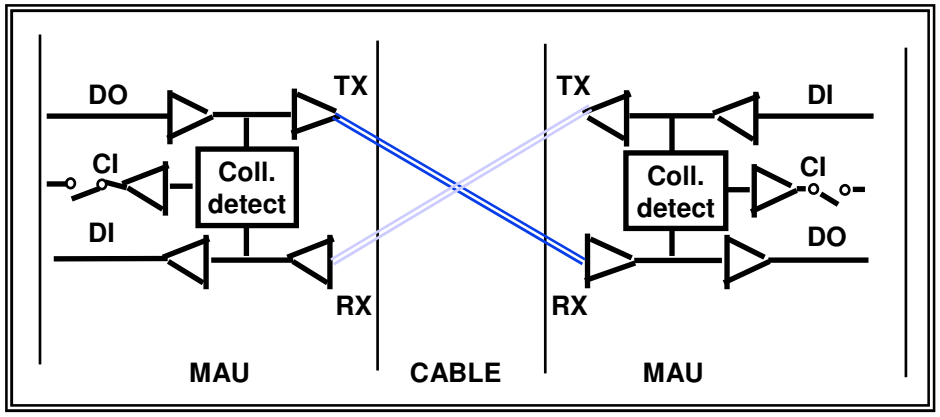
Full duplex functioning modes

- MAC CSMA-CD is no longer used
  - Packets are immediately transmitted by Ethernet stations without sensing the channel
- Always used on switch-switch links, less on switch-station links
- Special transceiver are needed because collision mustn't be detected:
  - ordinary transceiver send a collision signal to the interface when contemporary TX and RX activities are present
- Distance between two Ethernet full-duplex station
  - depends on transmissive channel features only
  - is independent from collision diameter domain

Half and full duplex transceivers



links between traditional transceiver



links between Full-Duplex transceiver

DO = Data Output DI = Data Input CI = Collision Input

Distance limits

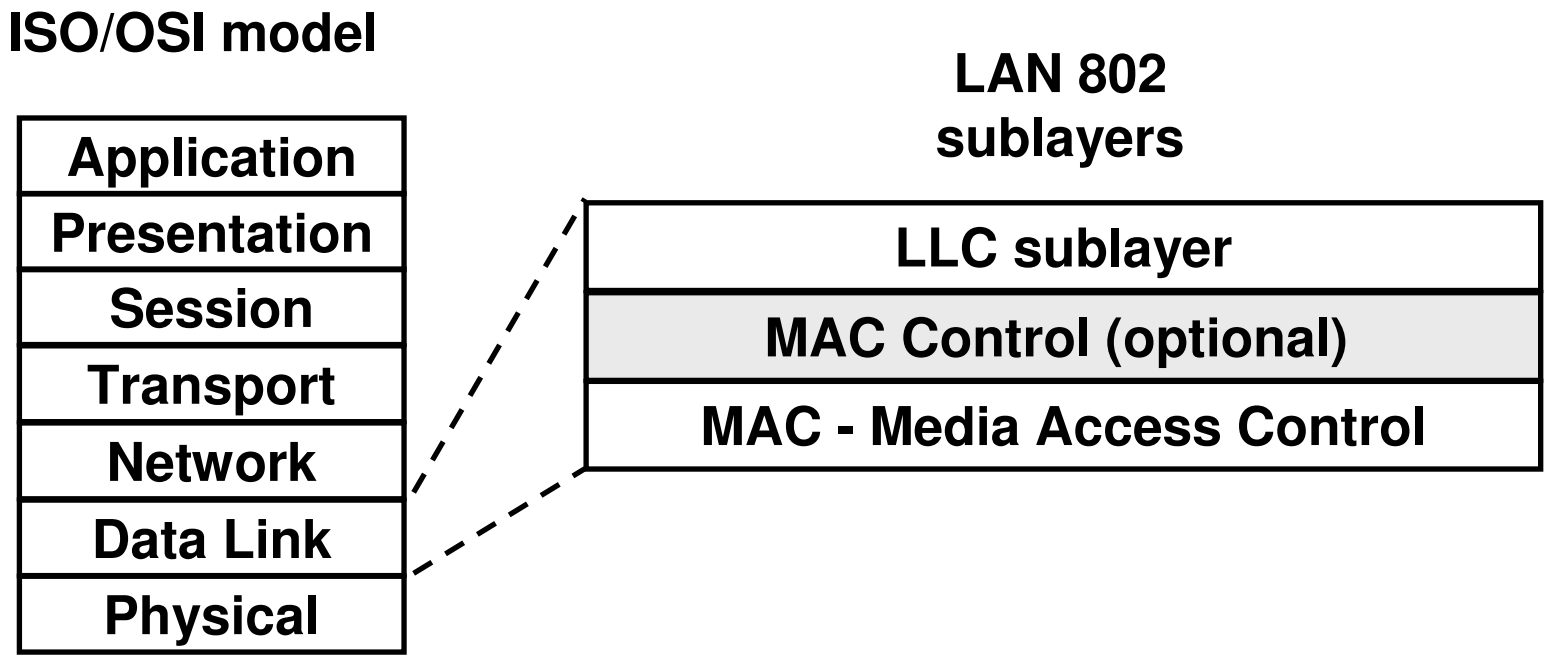
- In full-duplex Ethernet :
  - 100 m for telephone twisted pair
  - 2 Km for 62.5/125 μm multimode optic fiber
  - in case of monomode optic fiber and transceiver equipped with category II laser (as in FDDI and Fast-Ethernet), the maximum distance can be 50 Km
  - in Gigabit Ethernet with high power laser:
    - 75 Km for monomode fiber
    - 100 Km for dispertion-shift monomode fiber

Flow control: IEEE 802.3x

- Define:
  - MAC IEEE 802.3 necessary changes in order to support Full-Duplex mode
  - flow control mechanism for Full-Duplex links
  - available for all Ethernet networks (10/100/1000 Mb/s)
- Mandatory for Gigabit Ethernet, optional for Ethernet and Fast Ethernet

OSI model and IEEE 802.3x

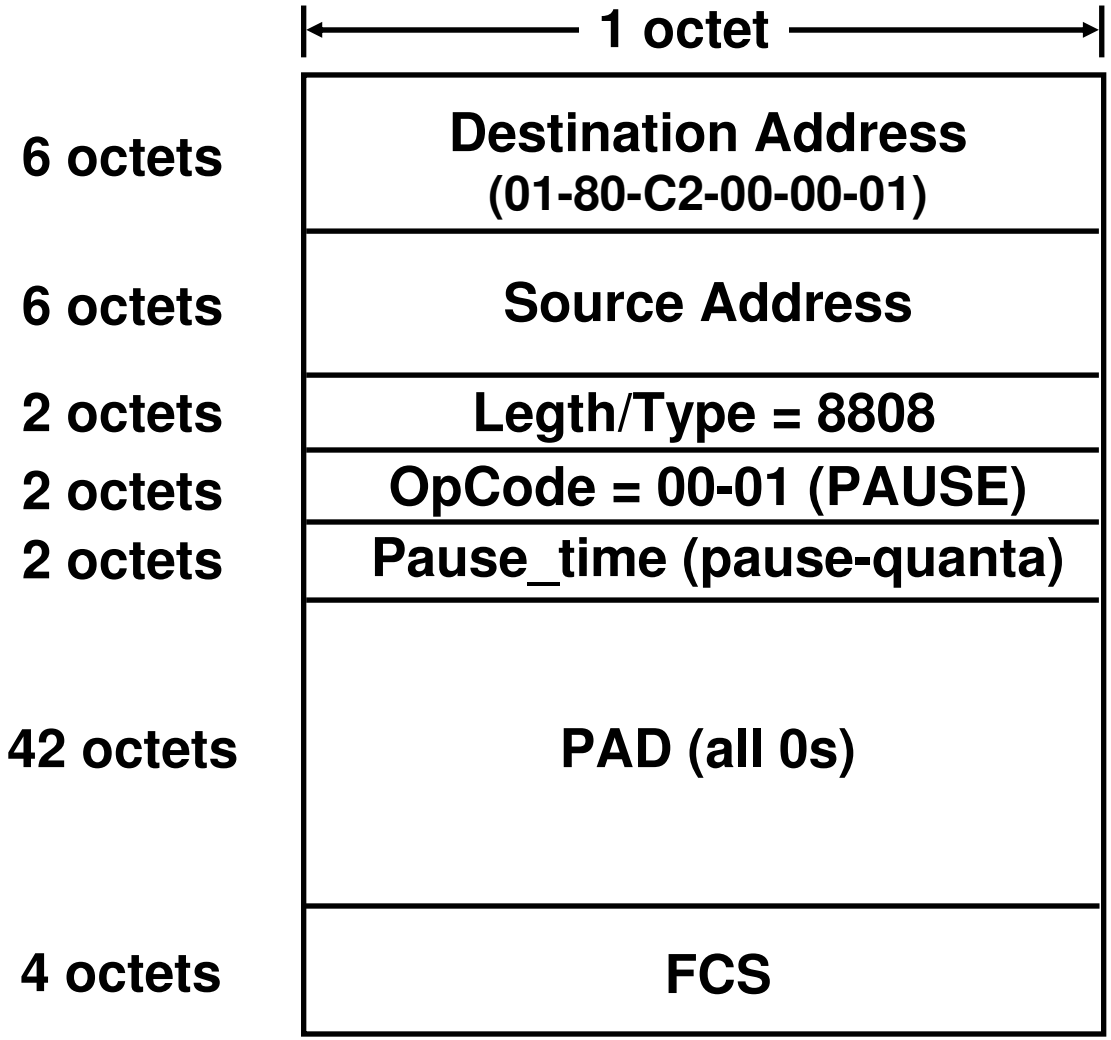
- IEEE 802.3x introduce a sublayer (MAC Control) between MAC 802.3 and higher sublayer (Bridge Relay Entity, LLC, ...)



Flow control

- Control flow mechanism is defined in IEEE 802.3x:
  - The device willing to stop transmission send a PAUSE packet in multicast to every partner concerned in the trasmission
    - packet contains the amount of time (numbero of slot time) that each partner must stop transmission
    - the times can be extended or aborted by sending another PAUSE packet

PAUSE packet



Pause time

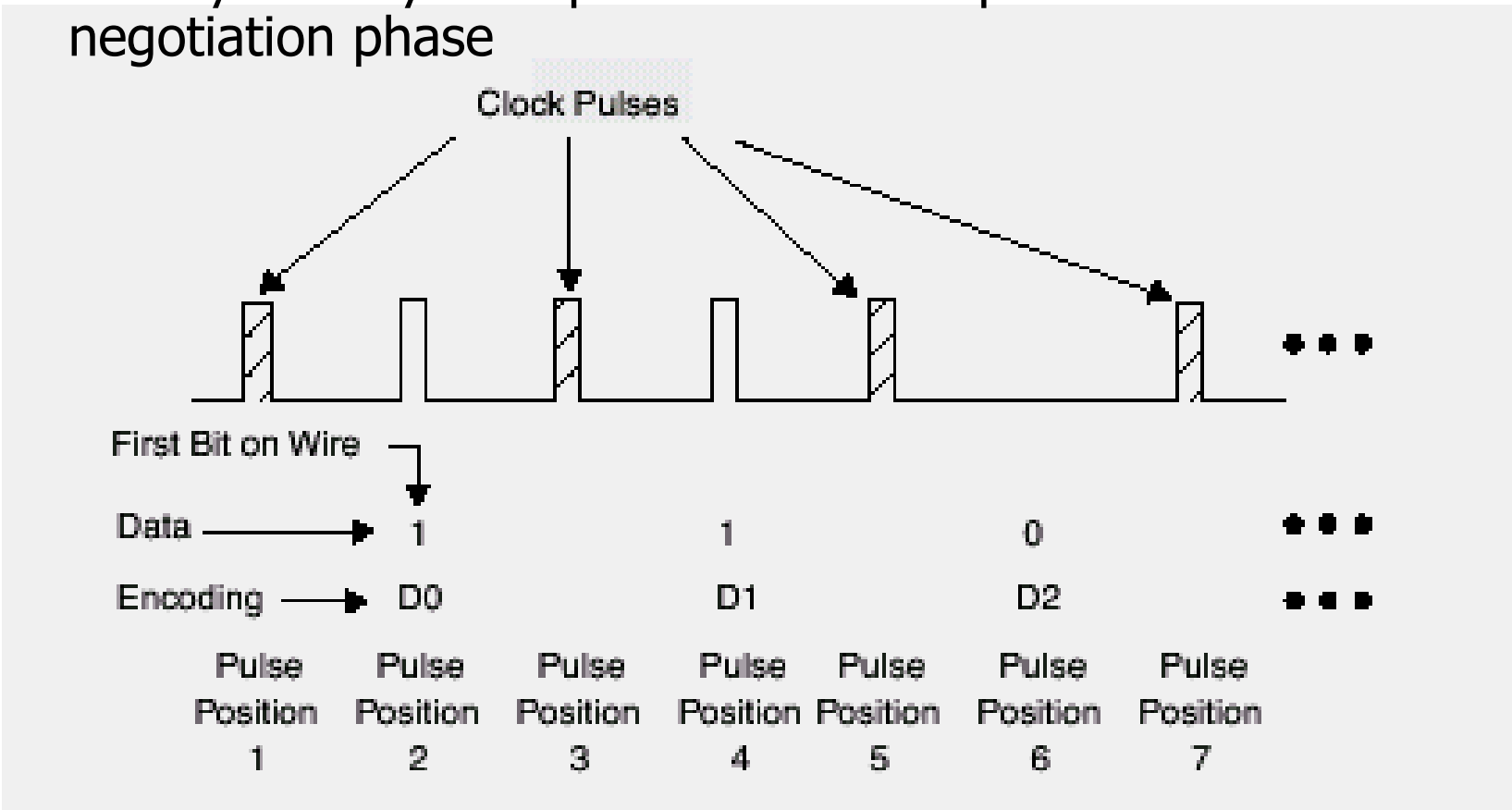
- Pause_time field: number of pause-quanta (from 0 to 65535) which indicate the pause time
  - pause-quanta = 512 bit time
  - speed equal or less than 100 Mb/s
    - T-Pause in bit time = pause-quanta * 512
  - Speed greather than 100 Mb/s
    - T-Pause in bit time = pause-quanta * 512 * 2

IEEE 802.3x: flow control modes

- Two flow controls mechanism:
  - asimmetric mode
    - only one equipmet send pause packet, the other just receive the packet and stop transmitting
  - simmetric mode
    - both equipment at link's edge can transmit and receive the pause packet

Flow Control negotiation

- Flow control negotiation using Burst FLP (Fast Link Pulse) coding
  - initially sent by both partners in link's parameter negotiation phase



Flow control: FLP Reg.4 encoding

Technology Ability Field

D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
rsvd	rsvd	rsvd	rsvd	rsvd	FD	HD	PS1	PS2	rsvd	rsvd	rsvd	RF1	RF2	Ack	NP

0	0	No Pause
0	1	Asymmetric Pause to link partner
1	0	Symmetric Pause
1	1	Symmetric Pause e Asymmetric Pause (tipo “*Both*”) to local device

0	0	No error, Link OK
0	1	Offline
1	0	Link Failure
1	1	Auto-Negotiation Error

Flow control: FLP Reg.4 encoding

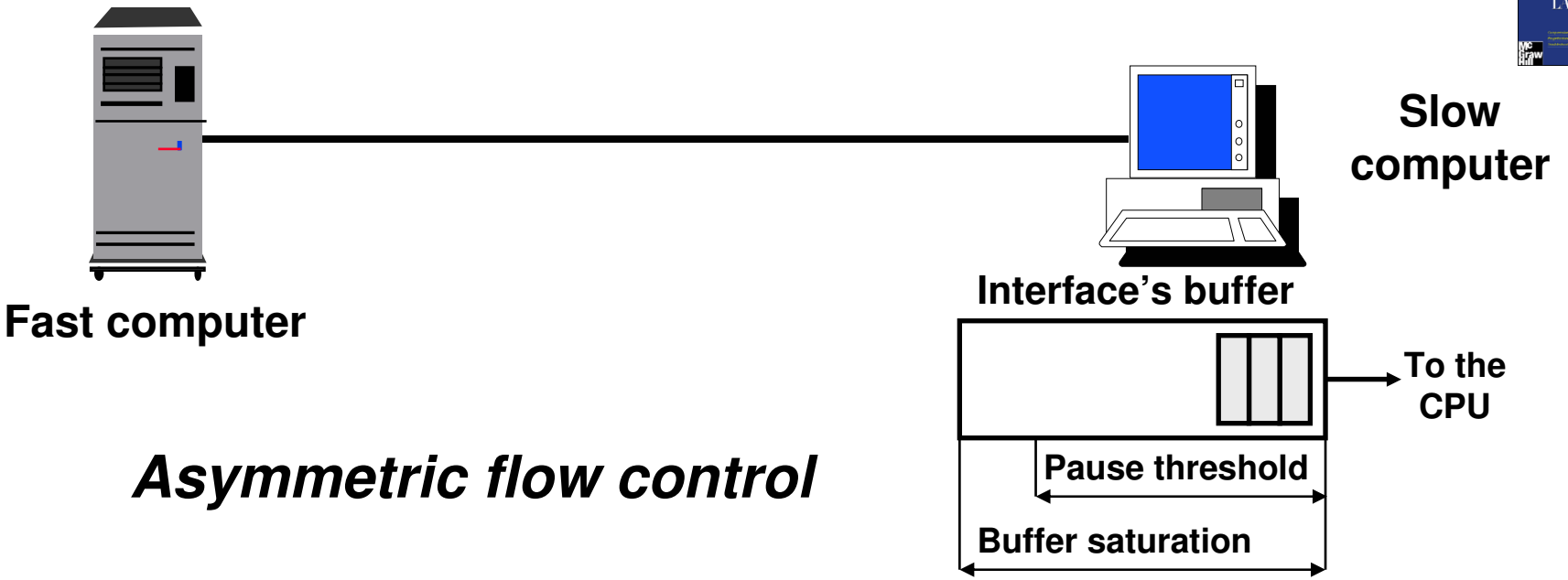
Register 4: Auto-Negotiation Advertisement Register

Bit(s)	Name	Description	Default	R/W
15	Next Page	Constant 0 = page transmissione with primary capacity	0	RO
14	Reserved	Reserved. Must be set to 0	0	RO
13	Remote Fault	1 = malfunctioninig at link's opposite side 0 = nessun malfunzionamento	0	RW
12:5	Technology Ability Field	8 bit field containing info on tecnologies' specific functionalities identified by selector field	00101111	RW
4:0	Selector Field	5 bit field which identifies the kind of message sended for the negotiation. In the Intel 82559 circuitery this field is read-only and contains 00001b value which stand for IEEE 802.3 standard.	00001	RO

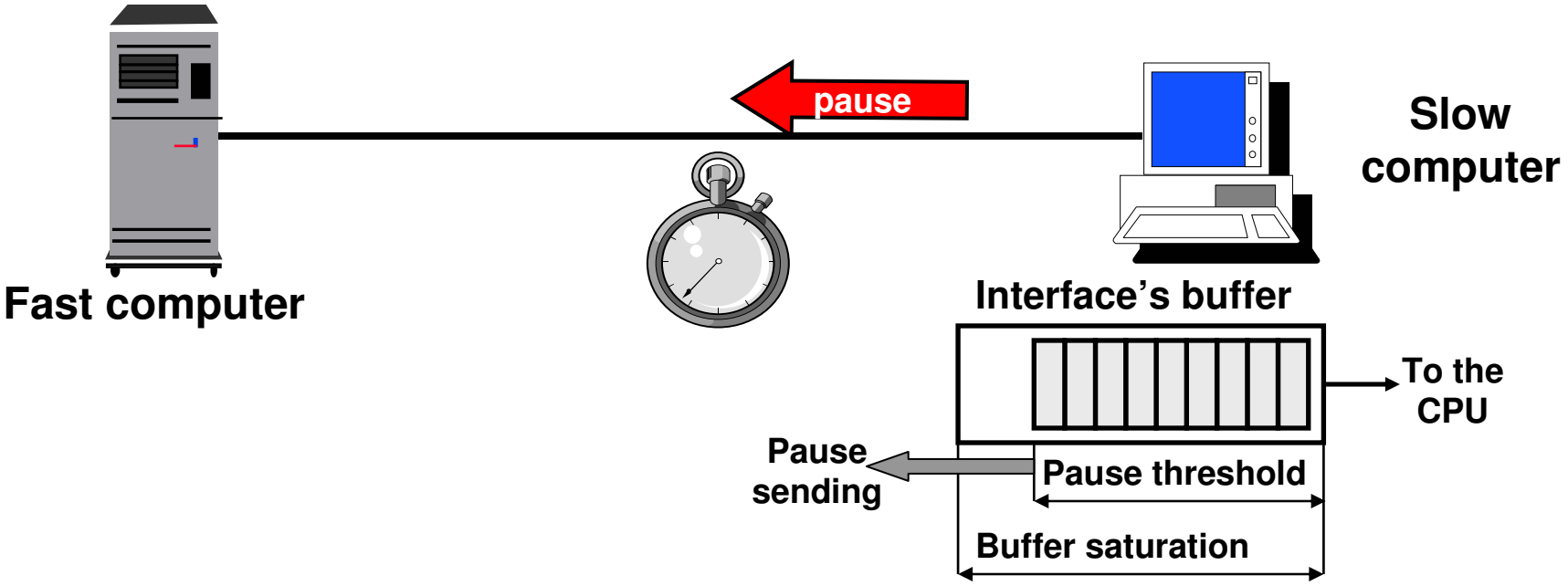
Local Device		Link Partner		Local Device resolution	Link Partner resolution
Bit - PS1	**Bit - PS2**	**Bit - PS1**	**Bit - PS2**		
0	0	Don't care	Don't care	Disable PAUSE TX & RX	Disable PAUSE TX & RX
0	1	0	Don't care	Disable PAUSE TX & RX	Disable PAUSE TX & RX
0	1	1	0	Disable PAUSE TX & RX	Disable PAUSE TX & RX
0 Asymmetric PAUSE	**1**	**1** Both Sym & Asym Pause	**1**	**Enable PAUSE TX** Disable PAUSE RX	**Enable PAUSE RX** Disable PAUSE TX
1	0	0	Don't care	Disable PAUSE TX & RX	Disable PAUSE TX & RX
1 Symmetric or Both	Don't care	**1** Symmetric or Both	Don't care	**Enable PAUSE TX & RX**	**Enable PAUSE TX & RX**
1	1	0	0	Disable PAUSE TX & RX	Disable PAUSE TX & RX
1 Both Sym & Asym Pause	**1**	**0** Asymmetric PAUSE	**1**	**Enable PAUSE RX** Disable PAUSE TX	**Enable PAUSE TX** Disable PAUSE RX

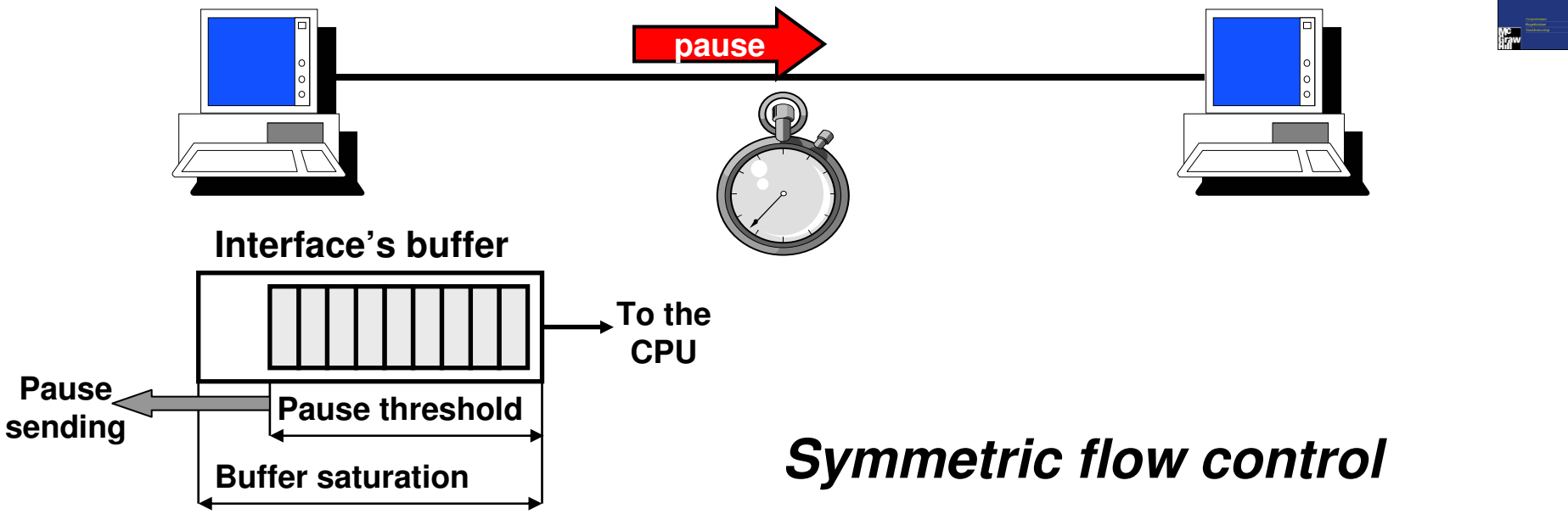
Switch's flow control: output buffer

- Switch with output buffer and input port connection
  - output buffer saturation cause the sending of Pause on input port linked with traffic flow
  - solution not implemented by vendors because has more drawback than benefit
  - Pause packet on link between two switches penalize also the traffic flows which don't congest output buffers
- Vendors' solution:
  - switch blocks transmission on port if it receive the Pause packet, but it can't send the pause packet

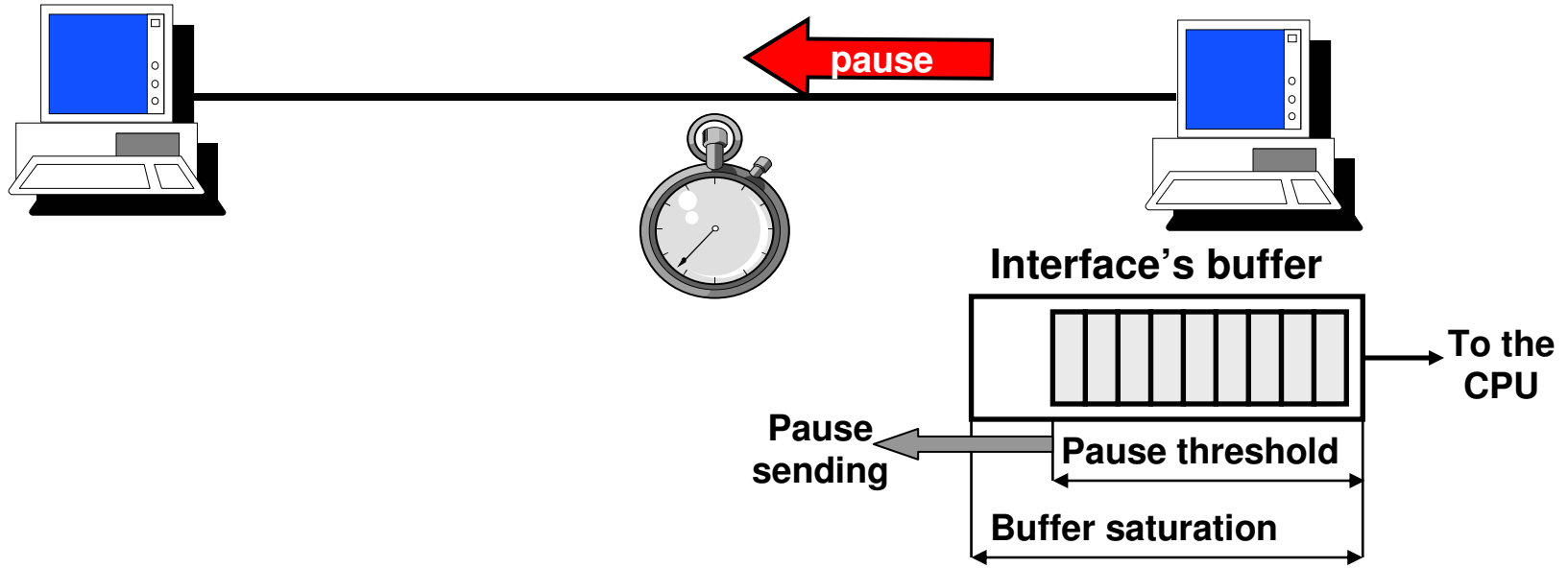


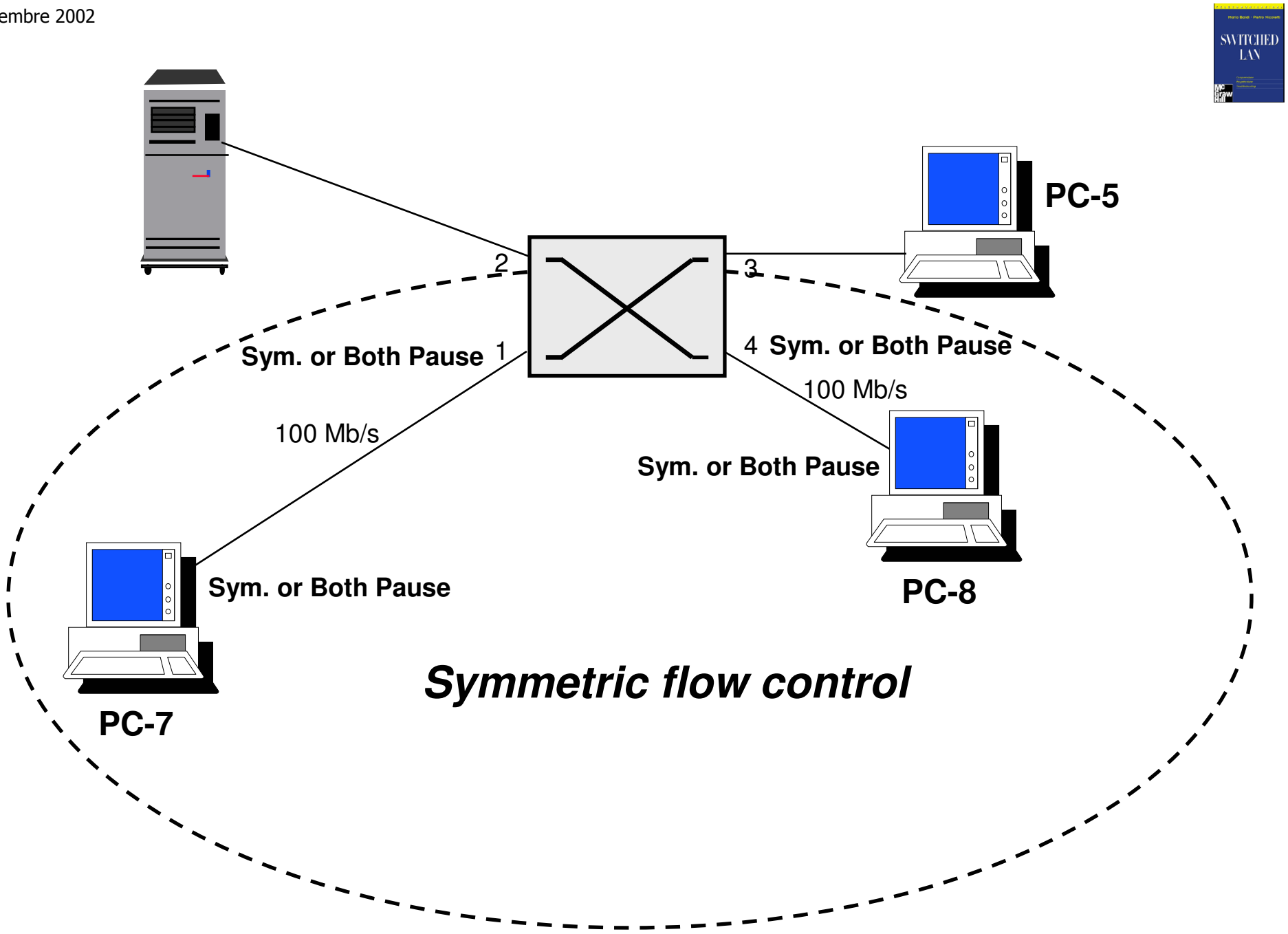
Asymmetric flow control

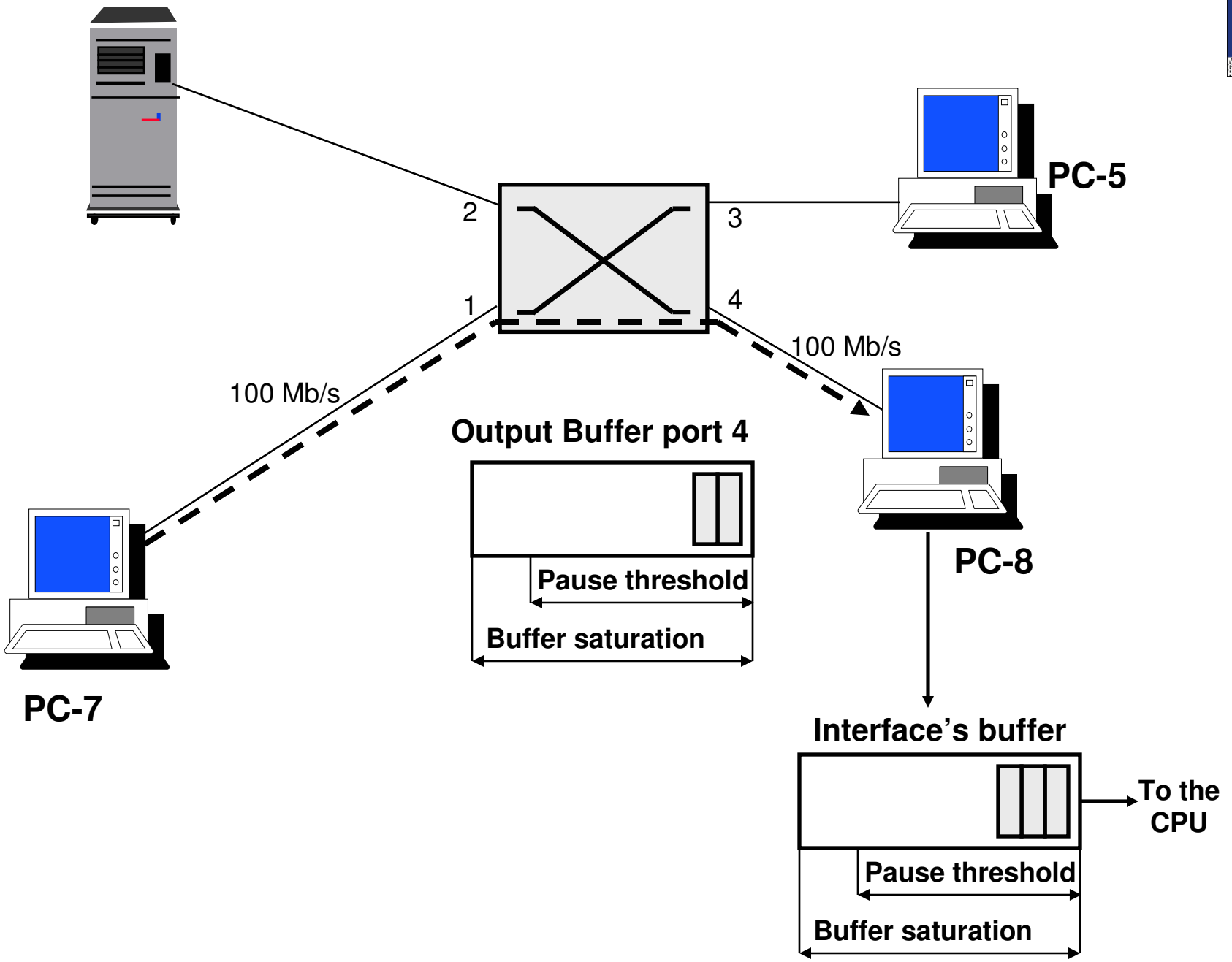


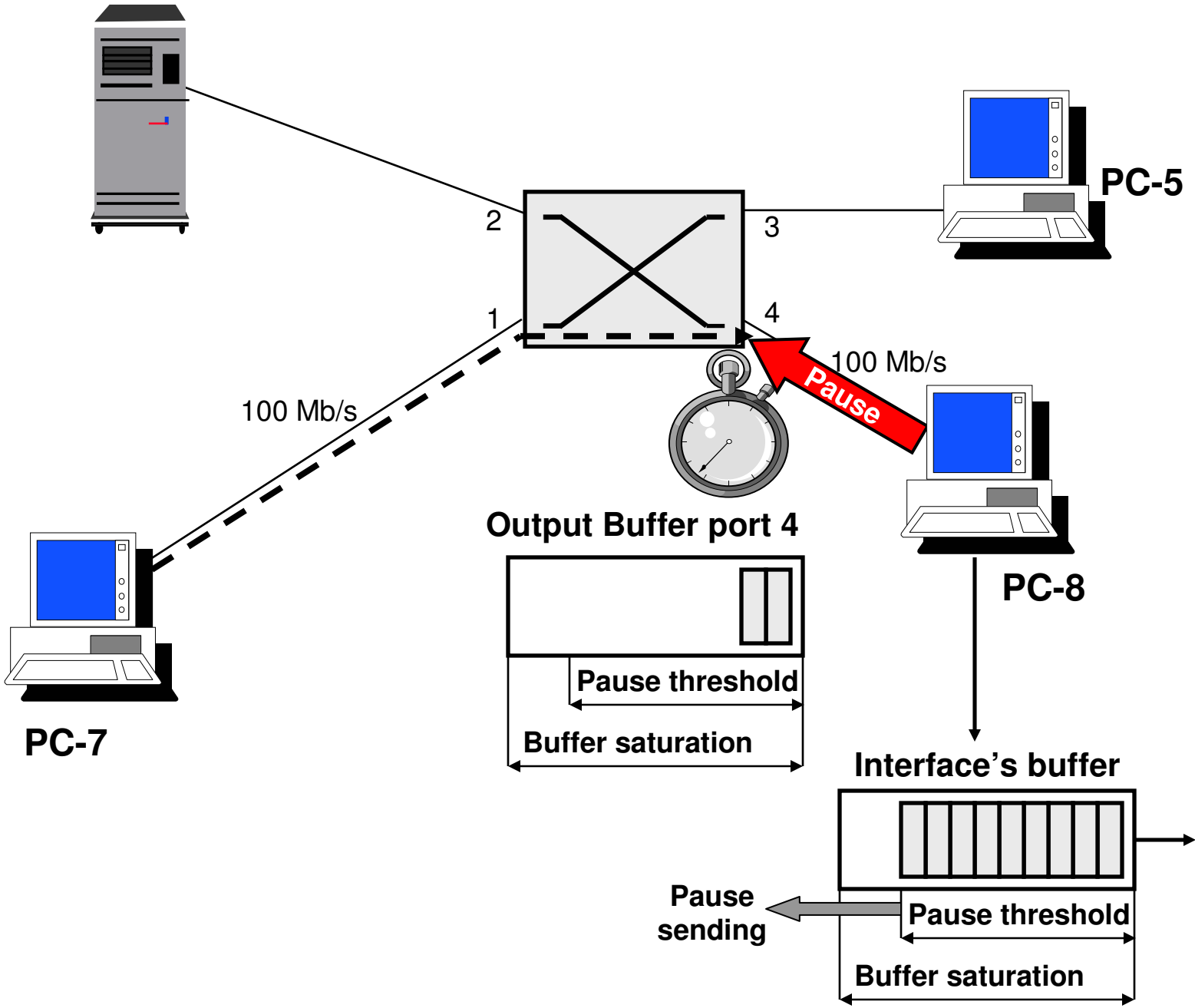


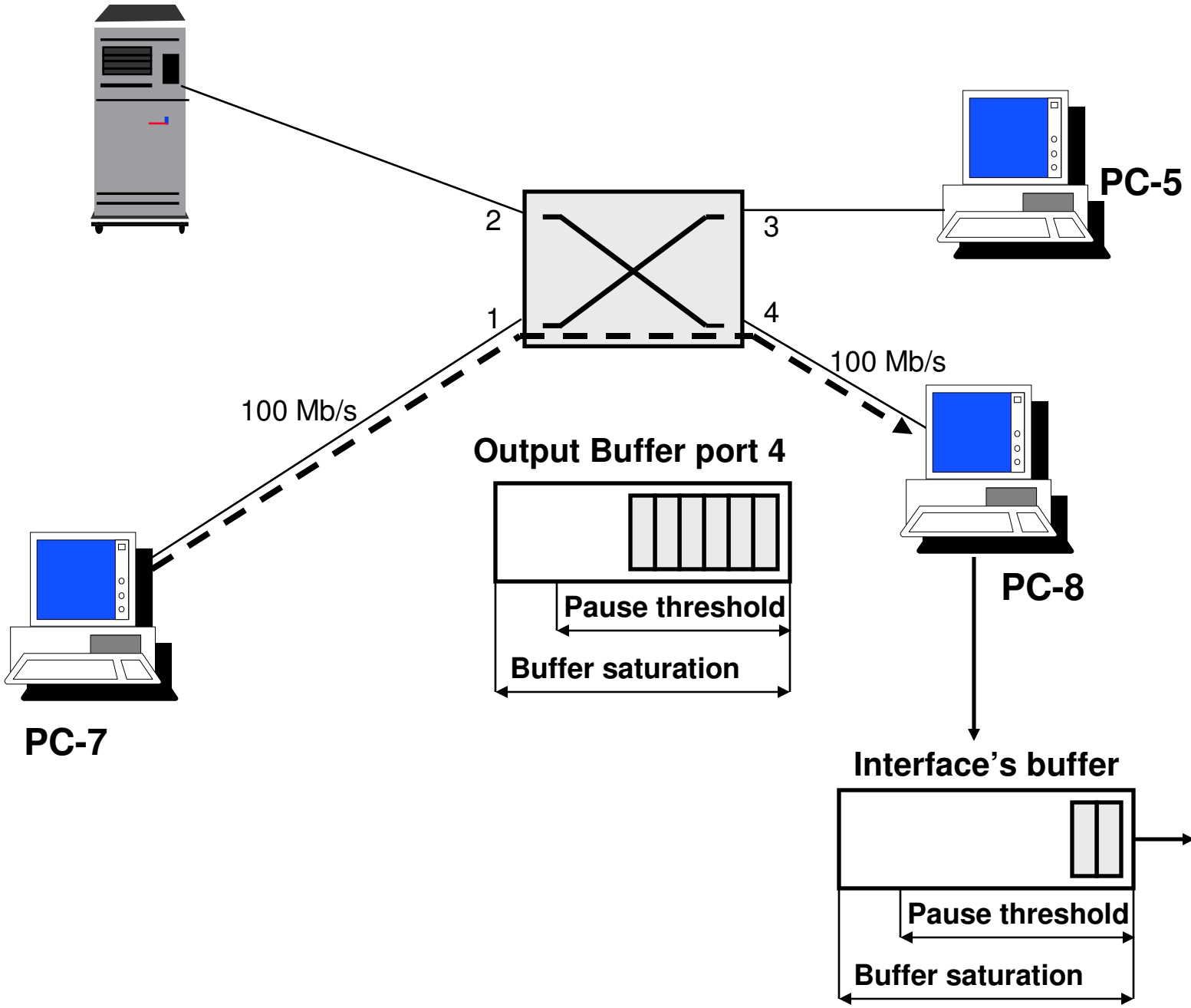
Symmetric flow control

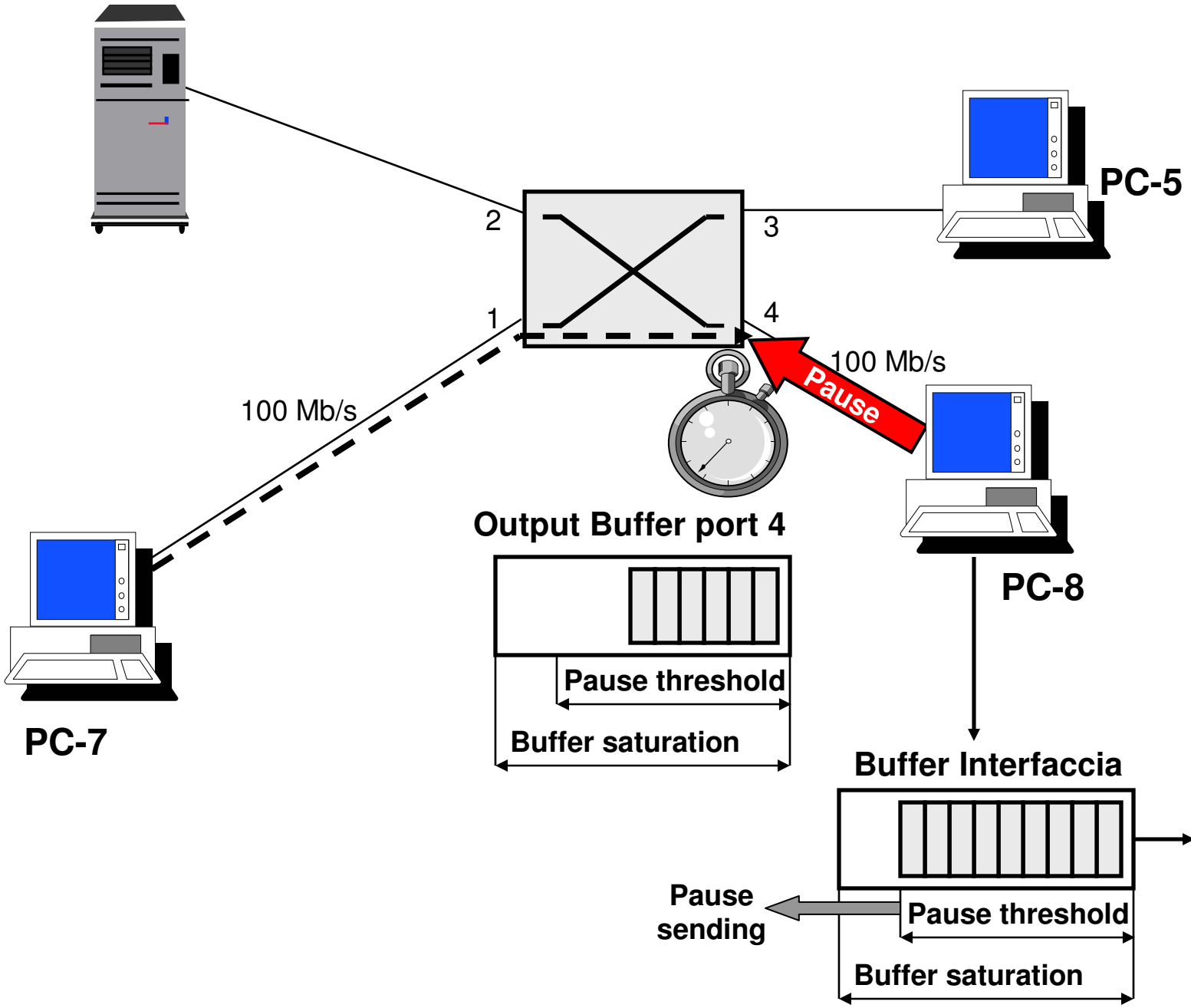


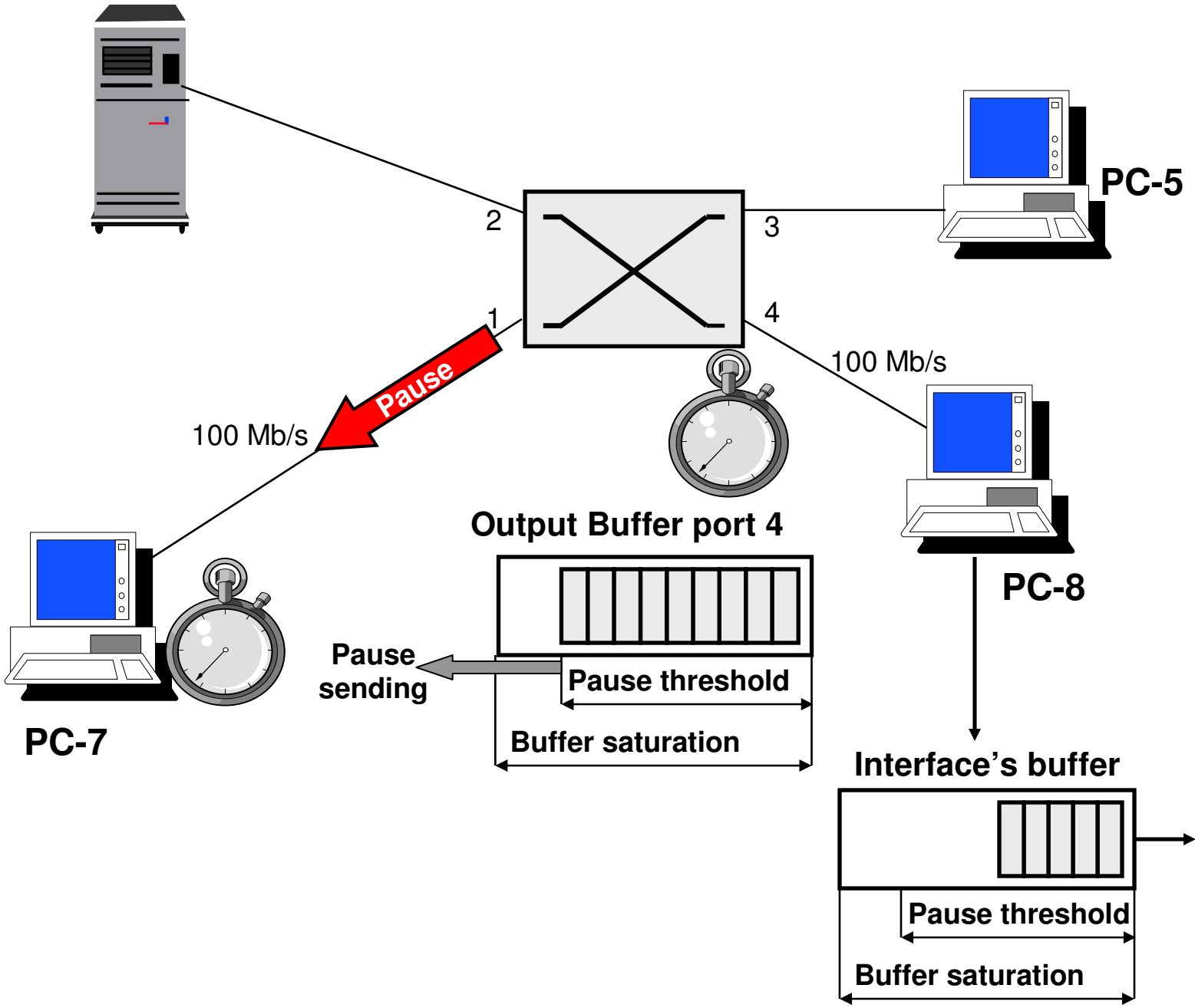


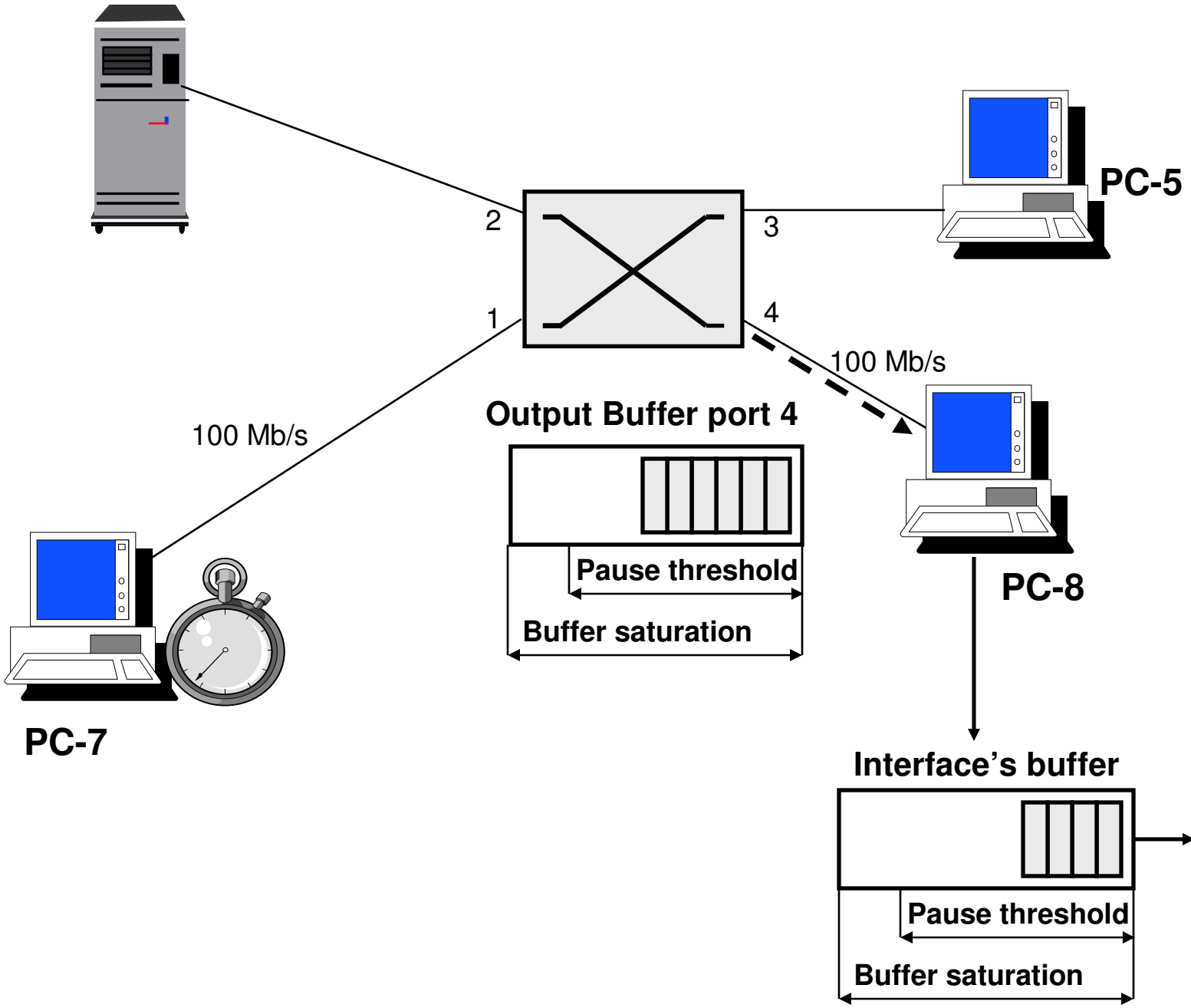












Sym. or Both Pause

Sym. or Both Pause

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Sym. or Both Pause

Fast station

Symmetric flow control

Both Pause

Both Pause

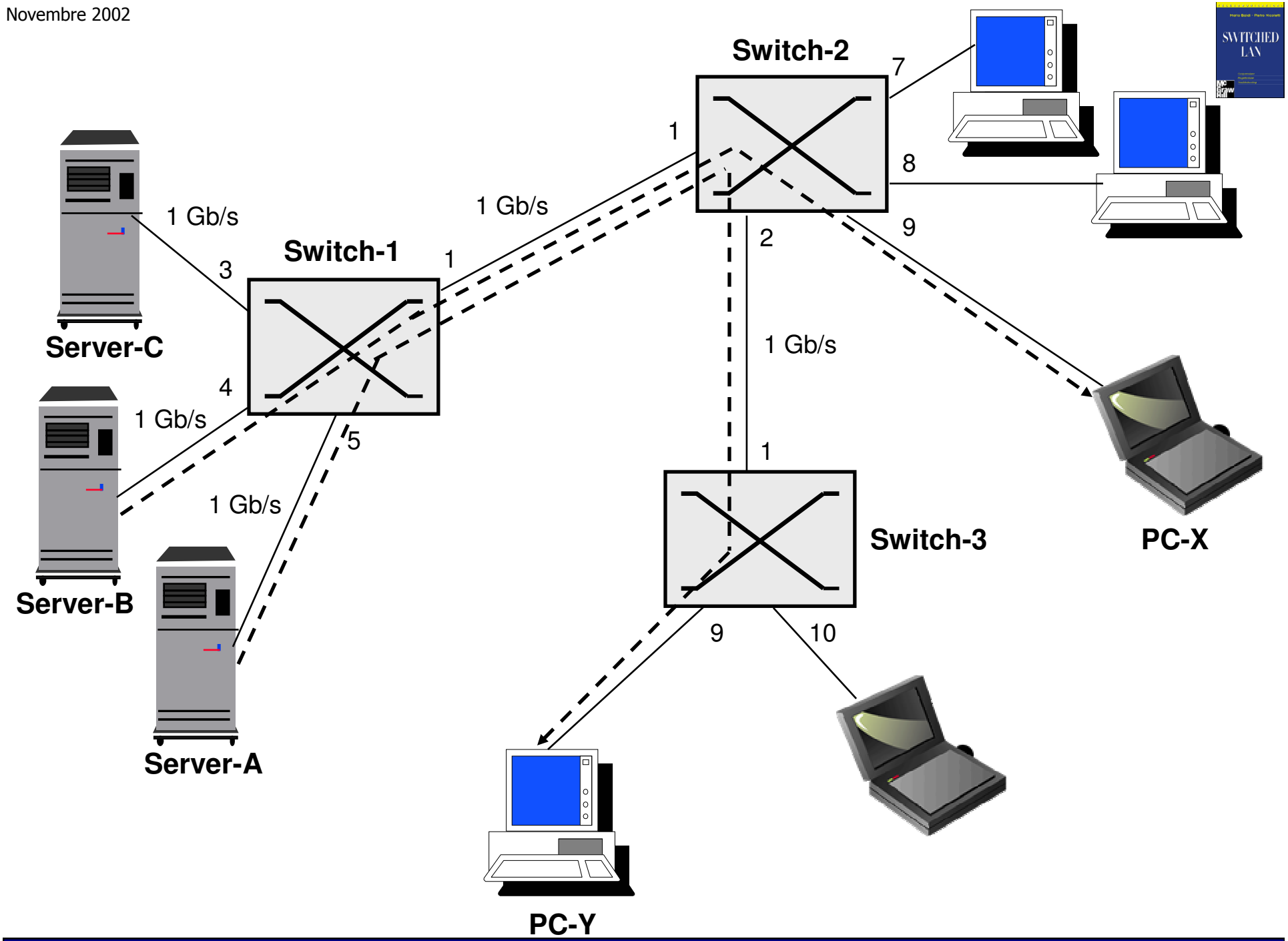
Asymmetric flow control

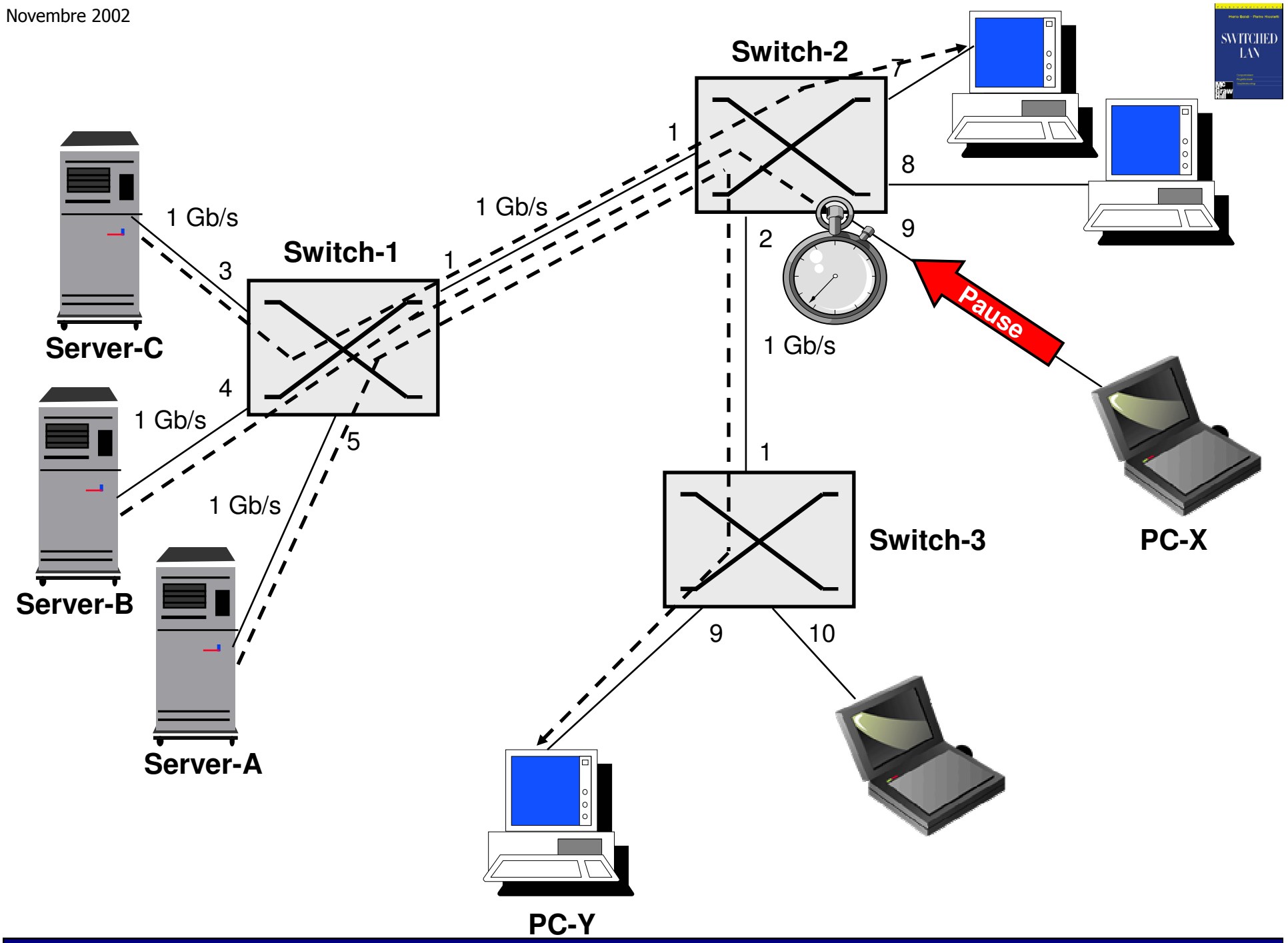
Asym. Pause

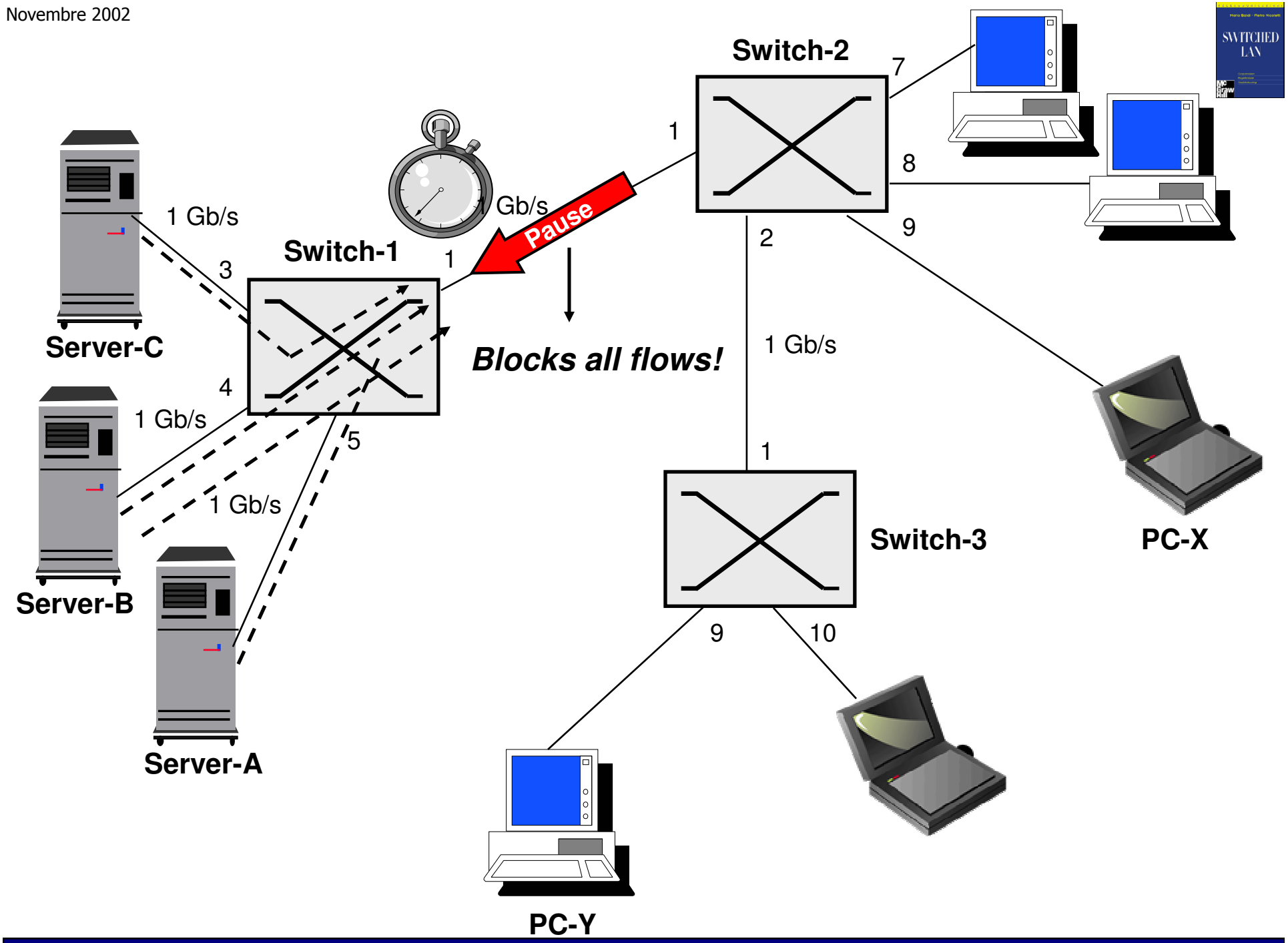
Asym. Pause

Slow station

Slow station

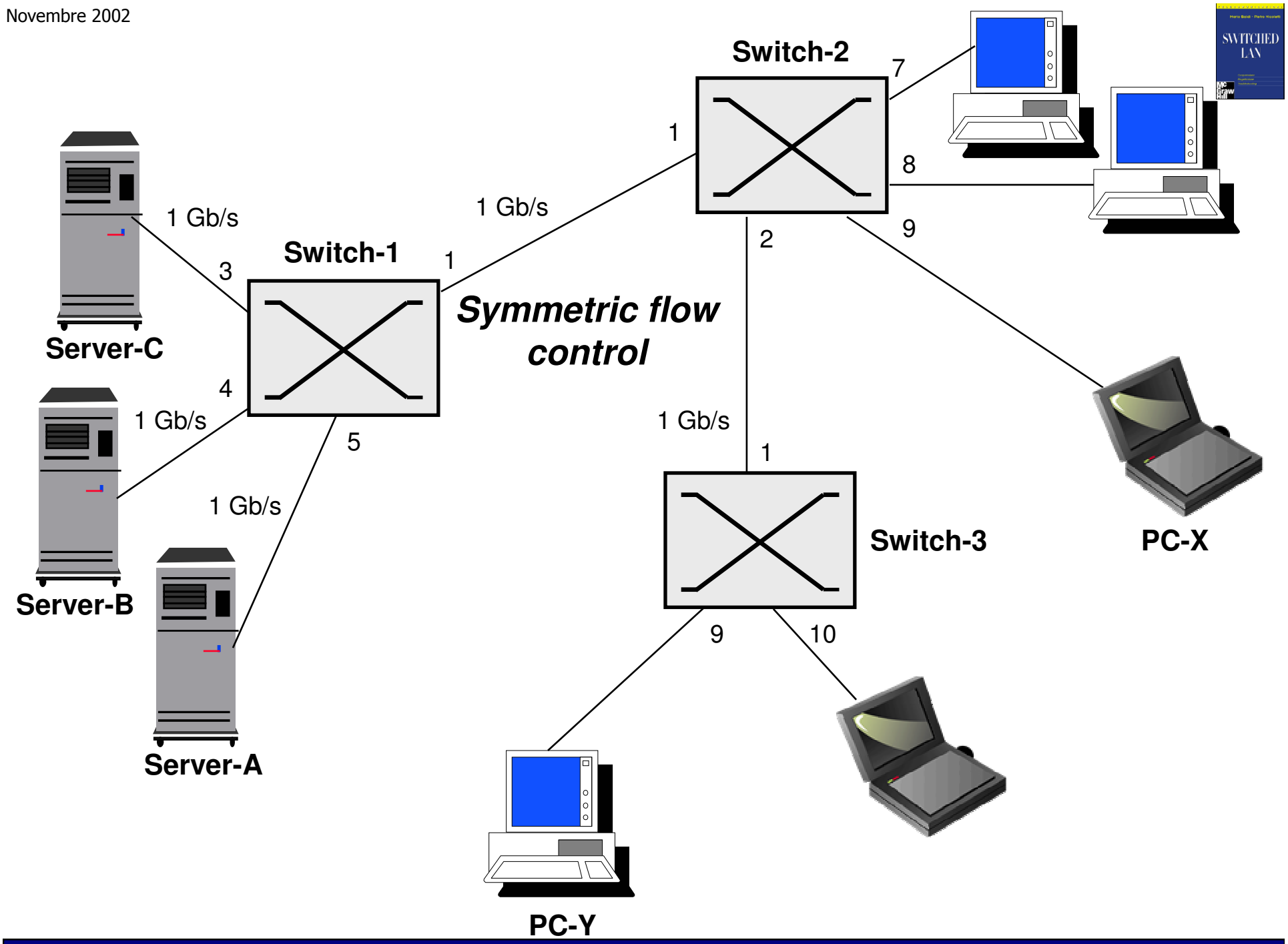


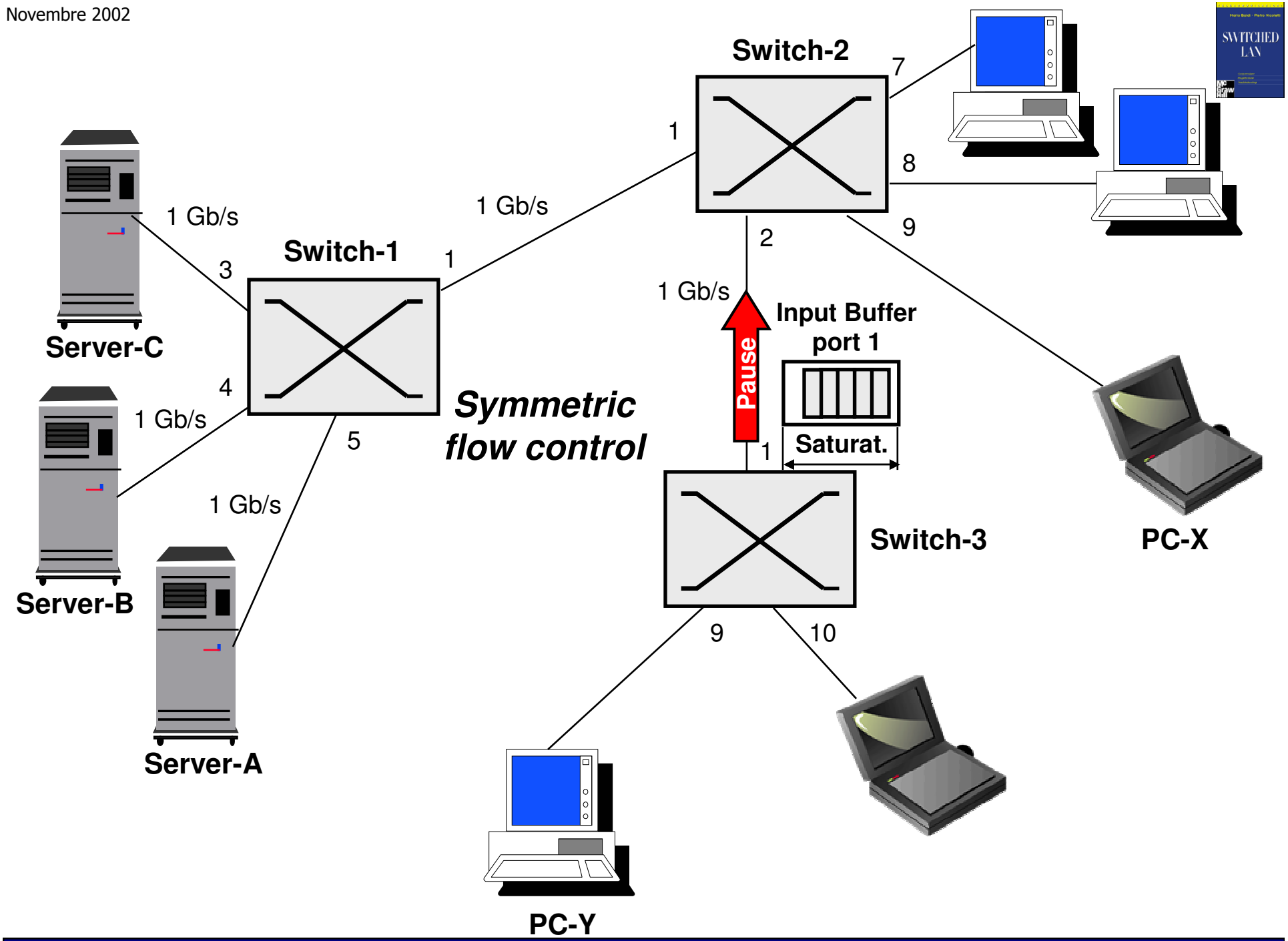


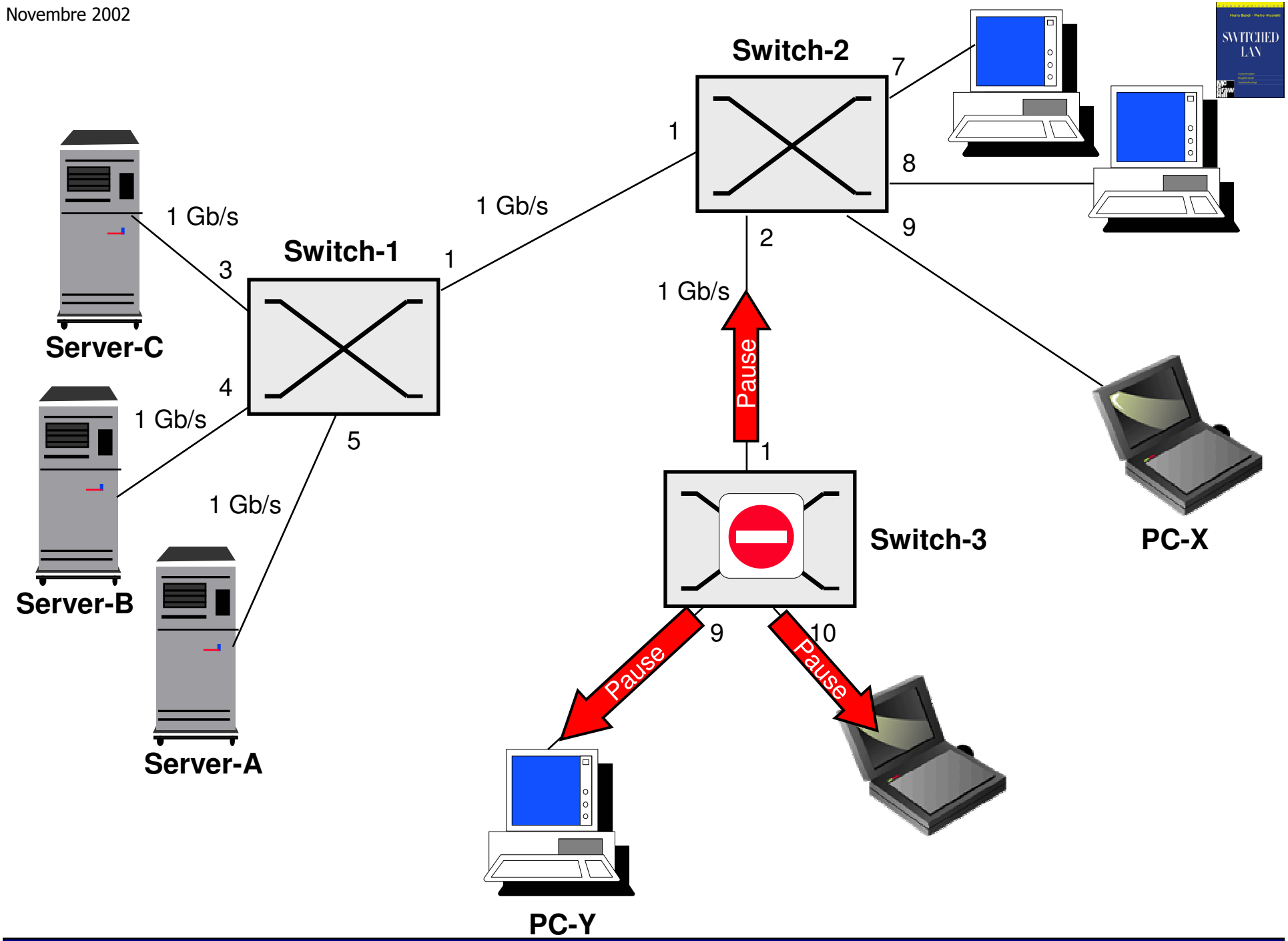


Flow control on switch with input buffer

- If an input buffer met is saturation because of input port congestion, it send a Pause packet in the concerned port
  - If switching matrix is blocking
  - If exist contention on output ports
    - No output buffer
    - Output buffer are full
- If switching matrix is congested, the event unleash the sending of Pause packet on all ports
  - Pause packet sending occurs only on switch with blocking matrix







Realistical approach on switch with output buffer

- Asymmetric flow control is enabled only on switch-station connections
  - make up temporary congestions on input buffers of station's network interfaces
  - not an ideal solution, but can be a good deal in certain traffic condition