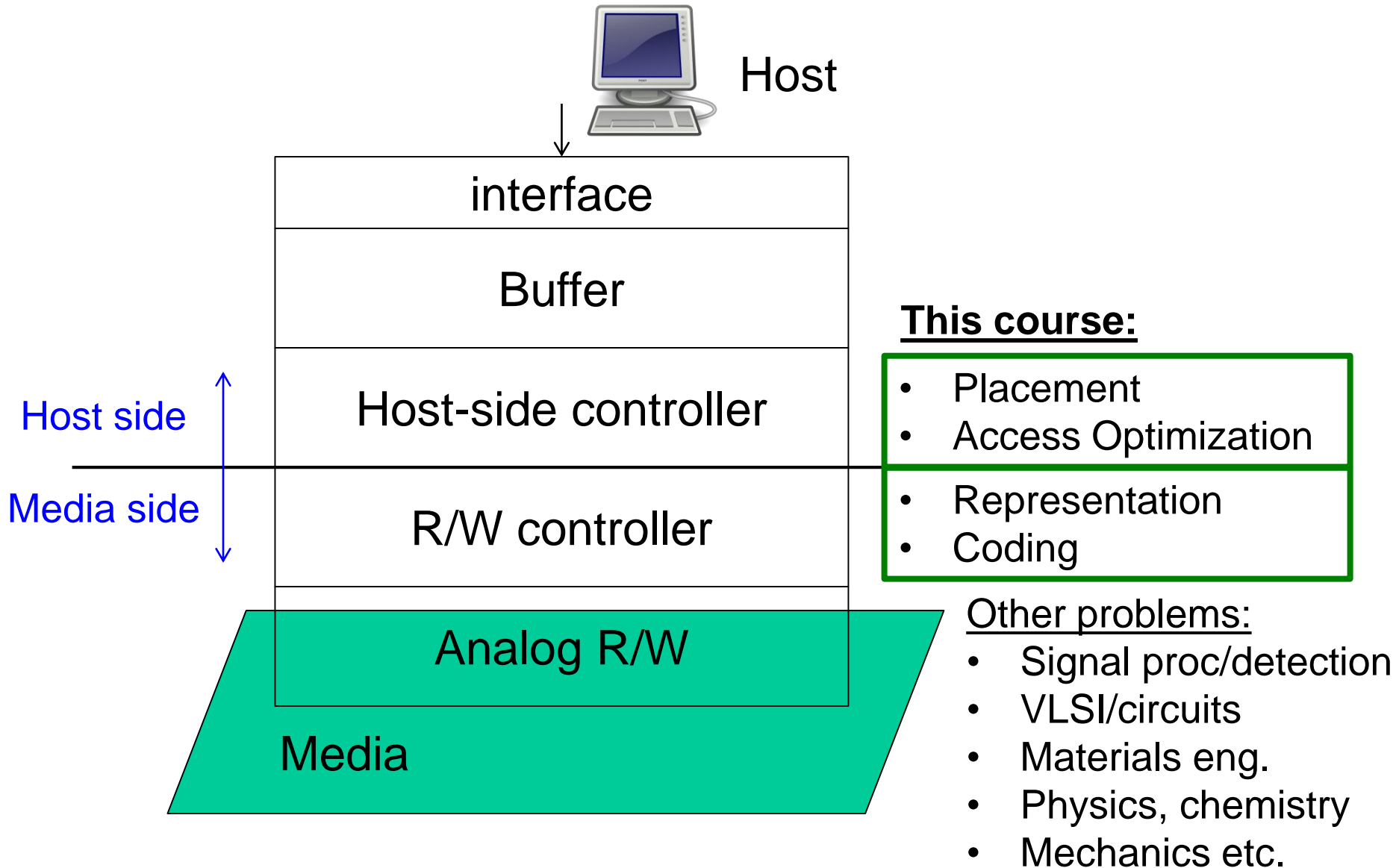


Information in Storage Devices
049063 – EE Department, Technion

LECTURE 1: INTRODUCTION

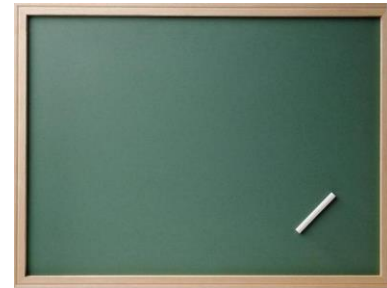
Structure of Storage Devices



Storage Features

What do we expect from our storage device?

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.



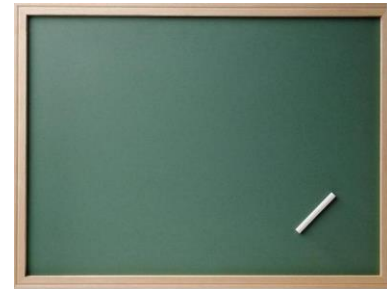
Storage Features

What do we expect from our storage device?

1. Density [bits/in²], [bits/\$]
2. Access speed [IO/sec], [MB/sec]
 - e.g 4KB Read IOPS
3. Reliability
 - MTBF [hours] – mean time between failures
 - MTTDL [hours] – mean time to data loss
4. Retention [years] (powered down)
5. Endurance [write cycles], [prog-erase cycles]
6. Fixed cost [\$]

Type of Storage Devices

- 1.
- 2.
- 3.
- 4.
- 5.



Type of Storage Devices

1. Hard-Disk Drive

- revolving disks, magnetic media



2. Tape

- spinning tape reels, magnetic media



3. Solid-State Drive

- silicon-based cells in 2D/3D matrix



4. RAID – redundant array of independent disks

- array of disks, consolidated by controller

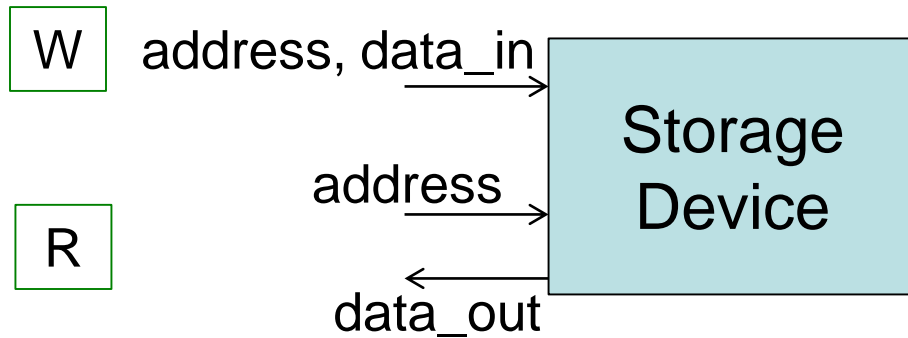


5. Distributed Storage

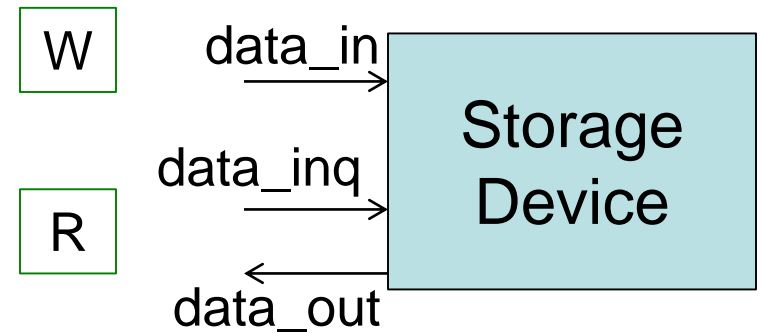
- multi-node/multi-site storage system

How does the device know which data I want?

Addresses!

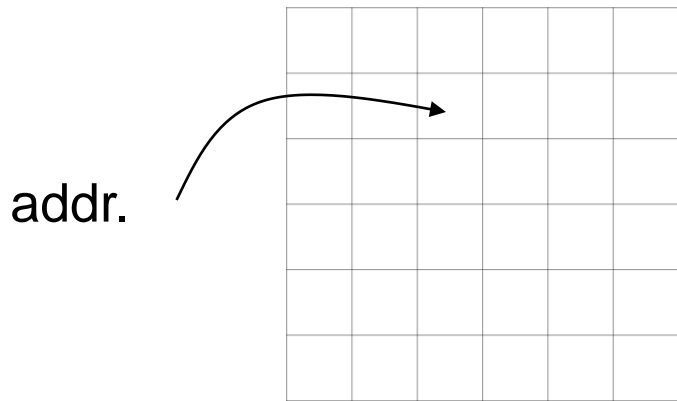


Location
addressed



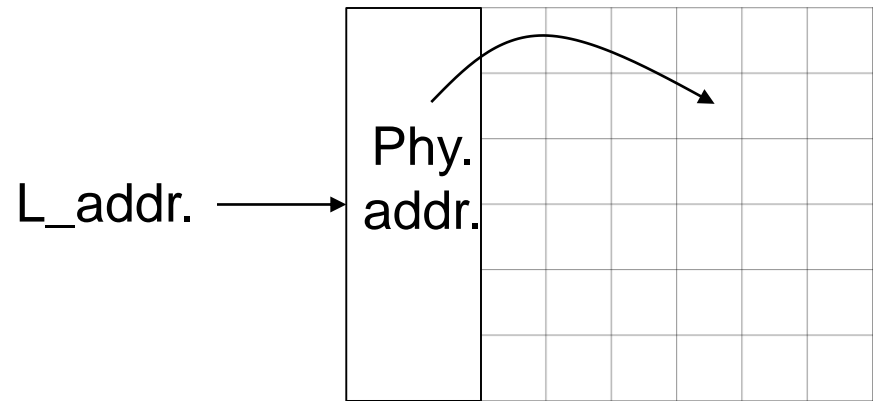
Content
addressed

Location-Addressed Storage



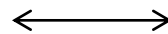
Direct
addressing

Memory



Indirect
addressing

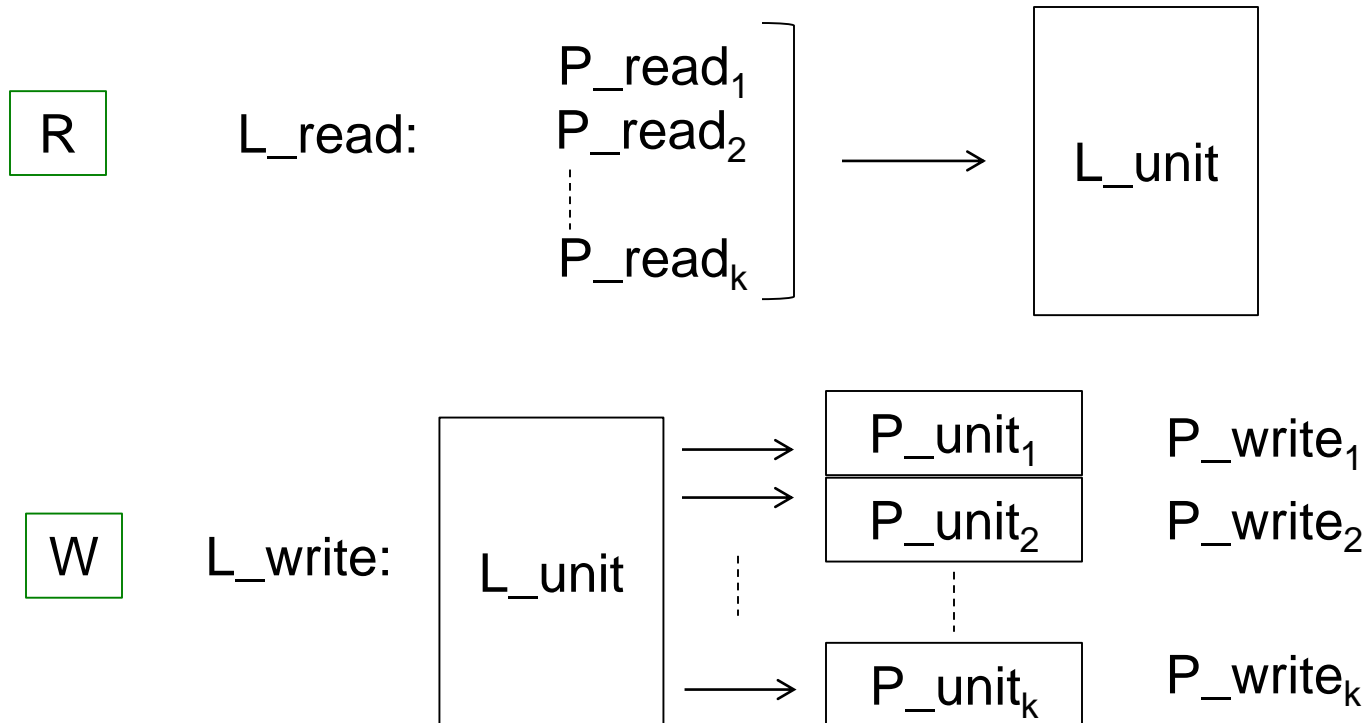
Storage Device



Storage Units

1. Logical Unit (host-side, e.g. file-system block)
2. Physical Unit (e.g. HDD sector, flash page)

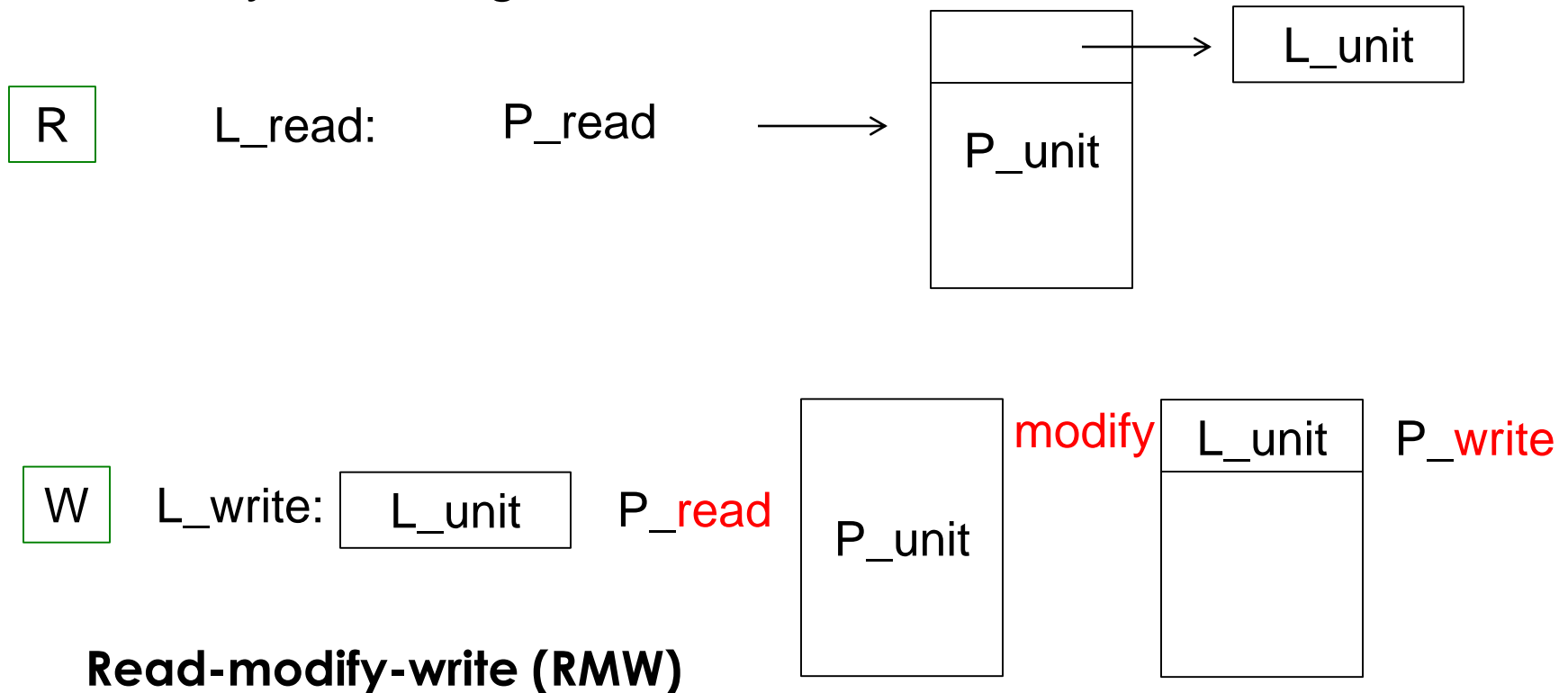
Case 1: Logical > Physical



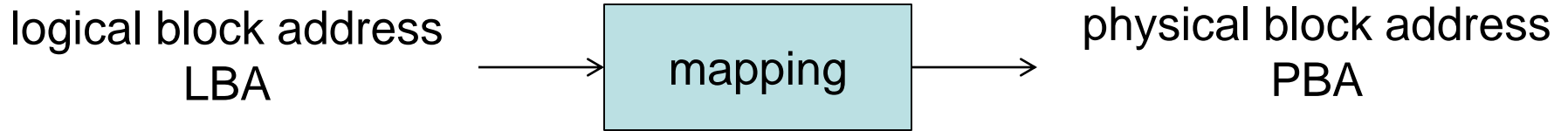
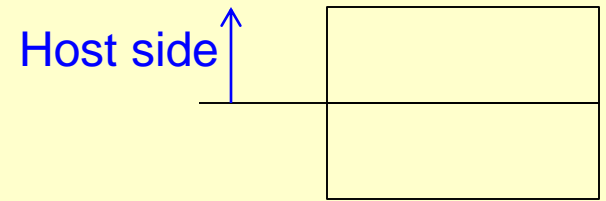
Storage Units

1. Logical Unit (host-side, e.g. file-system block)
2. Physical Unit (e.g. HDD sector, flash page)

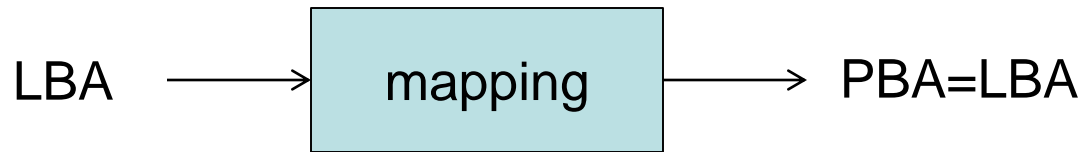
Case 2: Physical > Logical



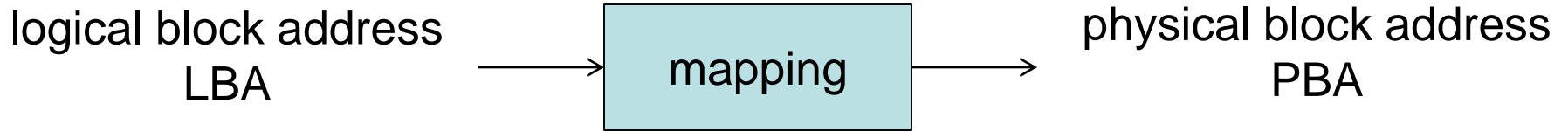
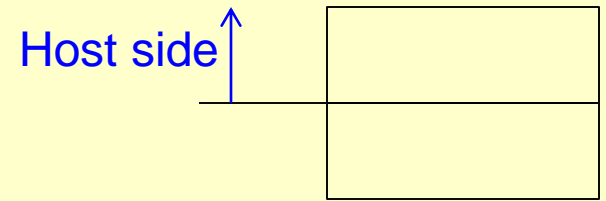
1. Data Placement



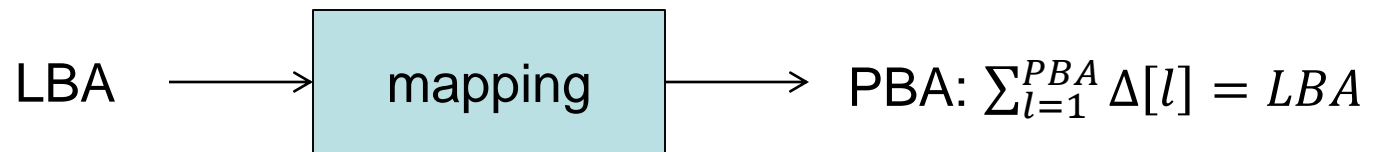
Example: trivial mapping



1. Data Placement



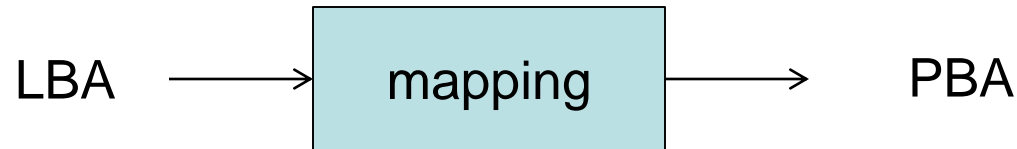
Example: defects



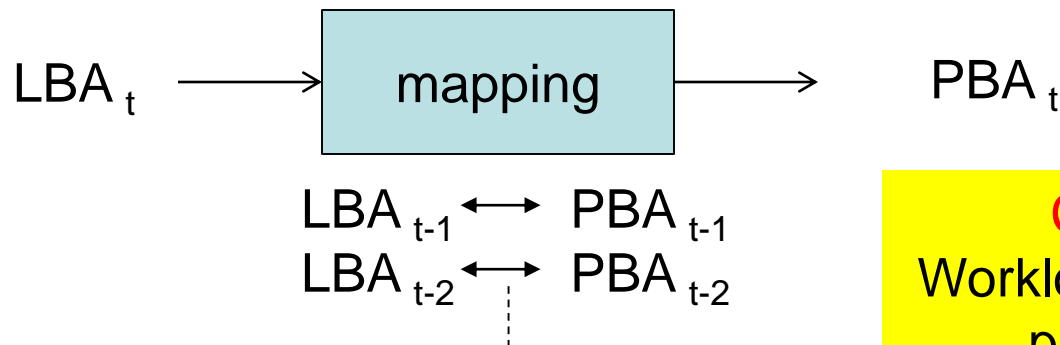
$$\Delta[l] = \begin{cases} 0 & \text{if } PBA_l \text{ defective} \\ 1 & \text{otherwise} \end{cases}$$

Static vs. Dynamic Placement

Static placement (memoryless):



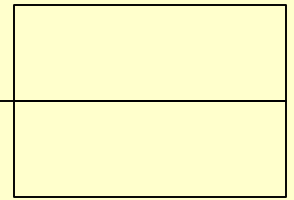
Dynamic placement (workload dependent):



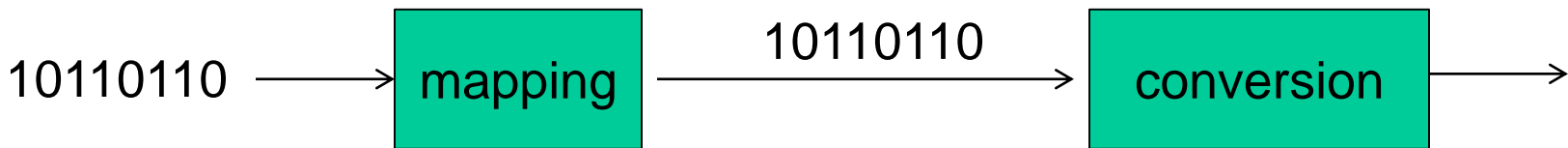
CAUTION:
Workload –dependent
performance

2. Data Representation

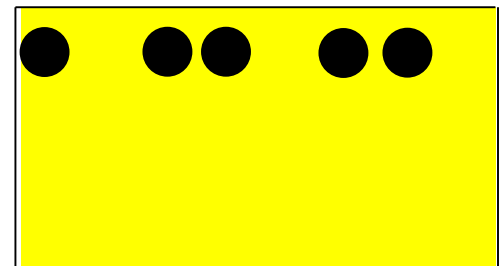
Media side



Example: trivial mapping

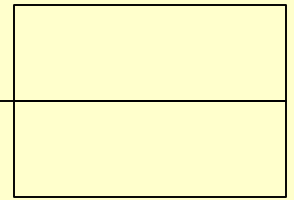


media:
punch tape

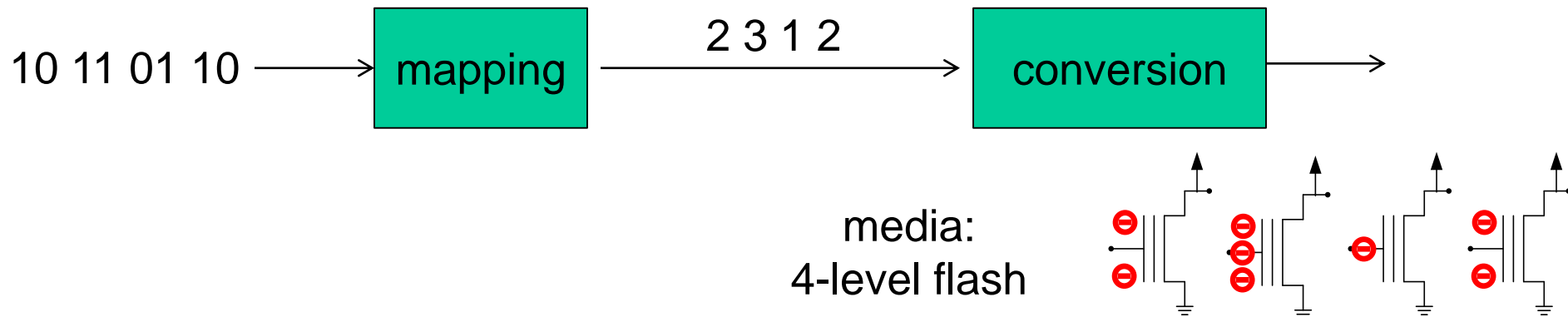


2. Data Representation

Media side ↓

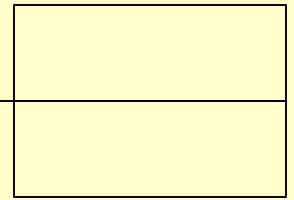


Example: multi-level flash

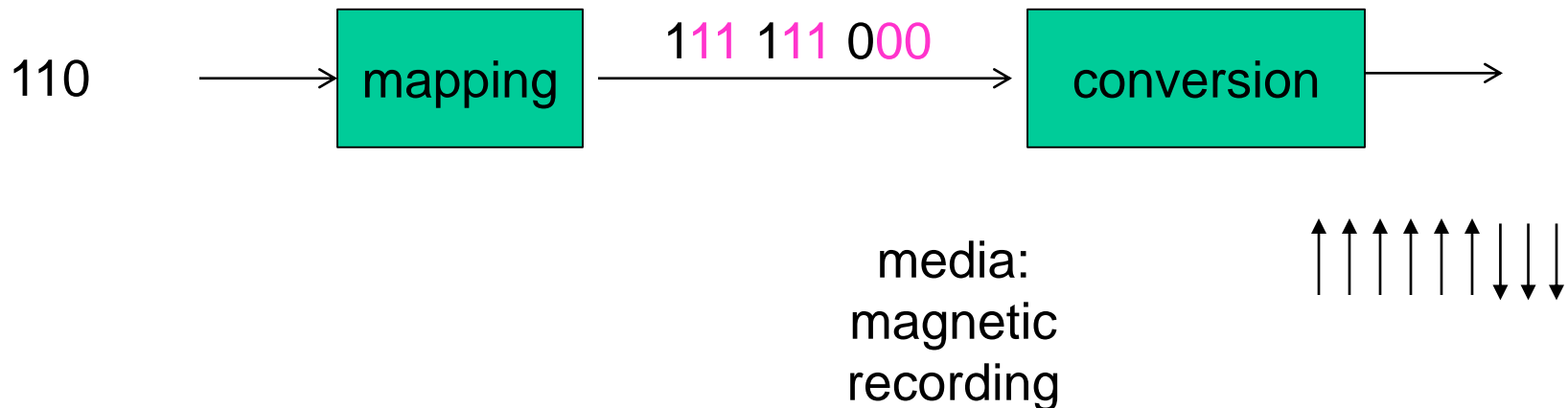


2. Data Representation

Media side

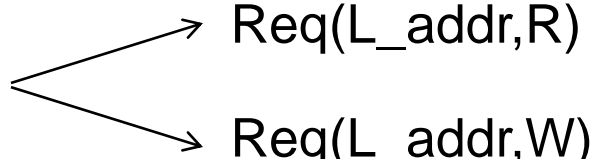


Example: error-correcting codes

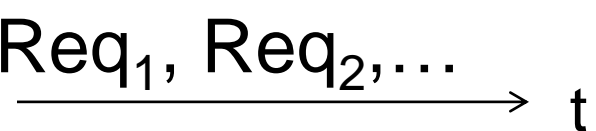


Random vs. Restricted Access

Define:

Access request $\text{Req}(L_addr, rw)$  $\begin{cases} \text{Req}(L_addr, R) \\ \text{Req}(L_addr, W) \end{cases}$

Definition:

A device is called **random access** if any sequence of requests $\text{Req}_1, \text{Req}_2, \dots$  \xrightarrow{t}

is allowed, and all such sequences exhibit a similar response behavior.

Examples of Non-Random Access

- Read/Write ordering
 - HDD R/W switch time
- Seek time
 - Tape
- Constrained writing
 - Shingled recording

