Technion

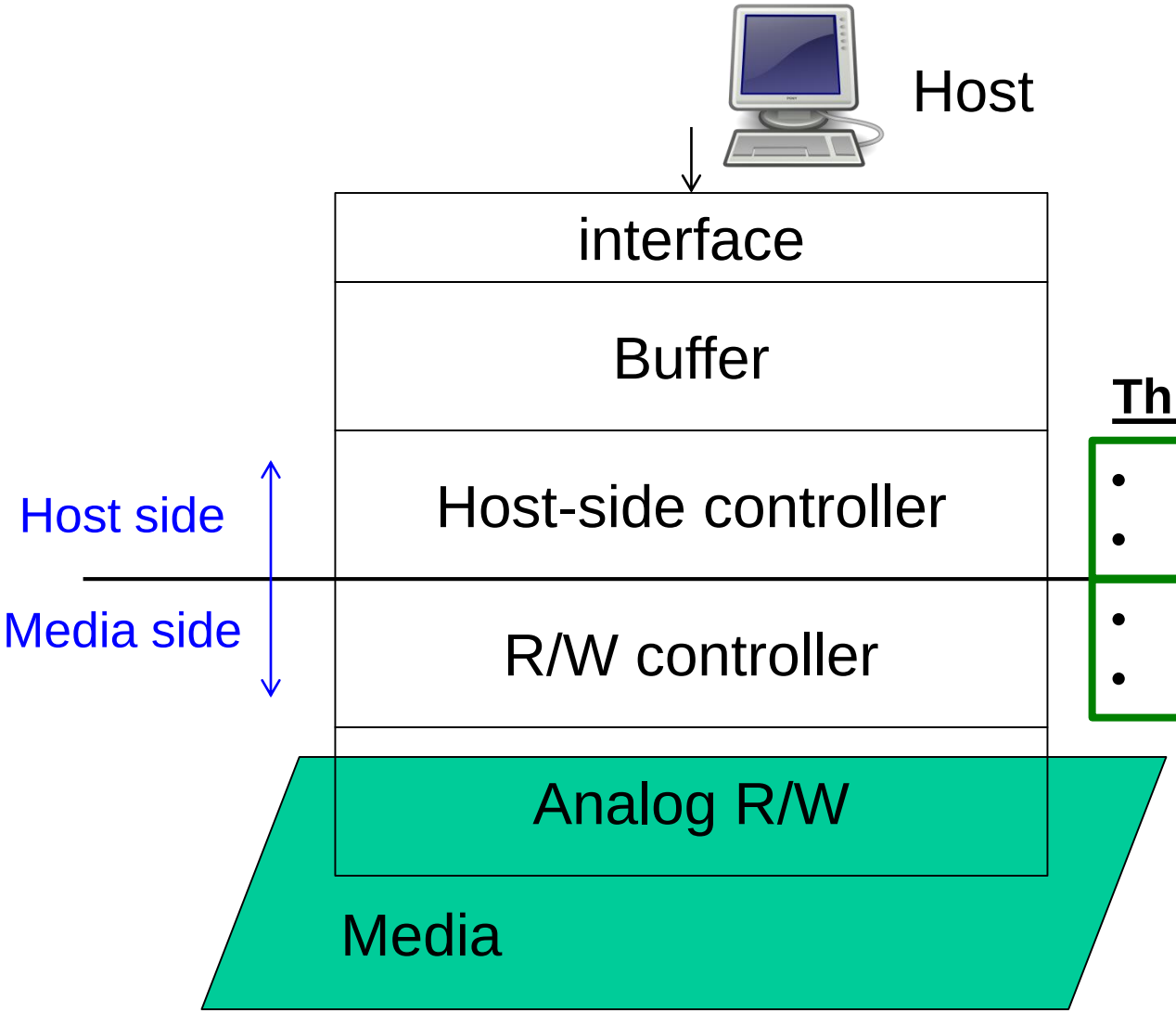
Electronics
Computers
Communications

Information in Storage Devices

049063 – EE Department, Technion

# LECTURE 1: INTRODUCTION

# Structure of Storage Devices




**This course:**

- Placement
- Access Optimization
- Representation
- Coding

Other problems:

- Signal proc/detection
- VLSI/circuits
- Materials eng.
- Physics, chemistry
- Mechanics etc.

# 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/in$^2$], [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

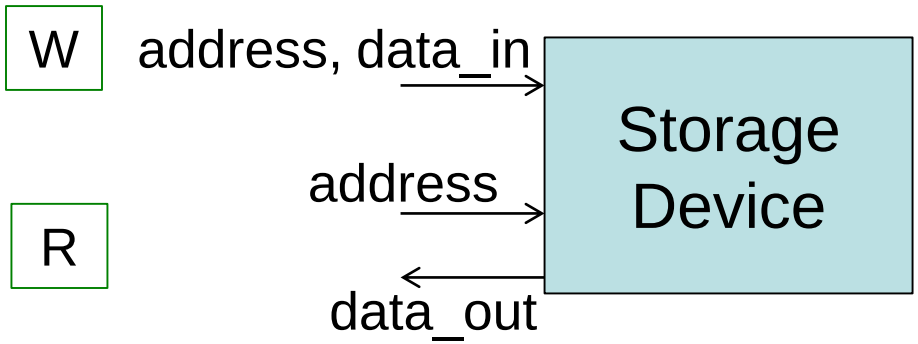
3. Solid-State Drive
   - silicon-based cells in 2D/3D matrix

4. RAID – redundant array of independent disks
   - array of disks, consolidated by controller

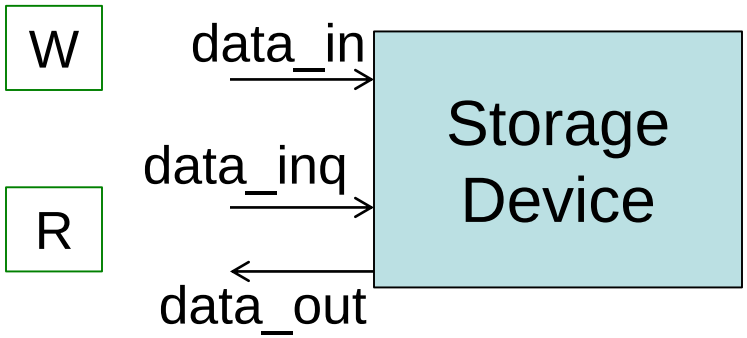
5. Distributed Storage
   - multi-node/multi-site storage system

# How does the device know which data I want?

Addresses!

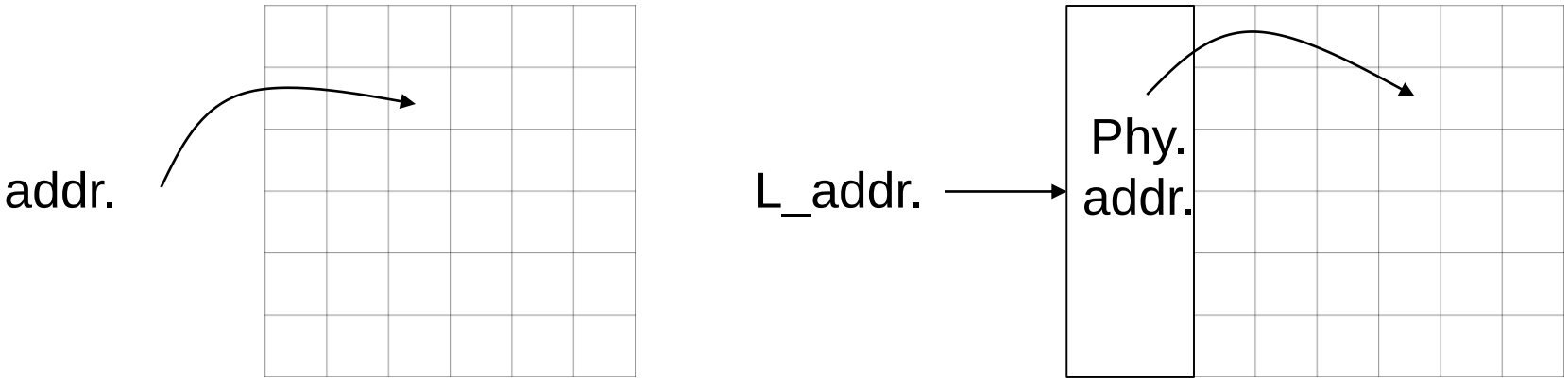



Location addressed




Content addressed

# Location-Addressed Storage




Direct addressing

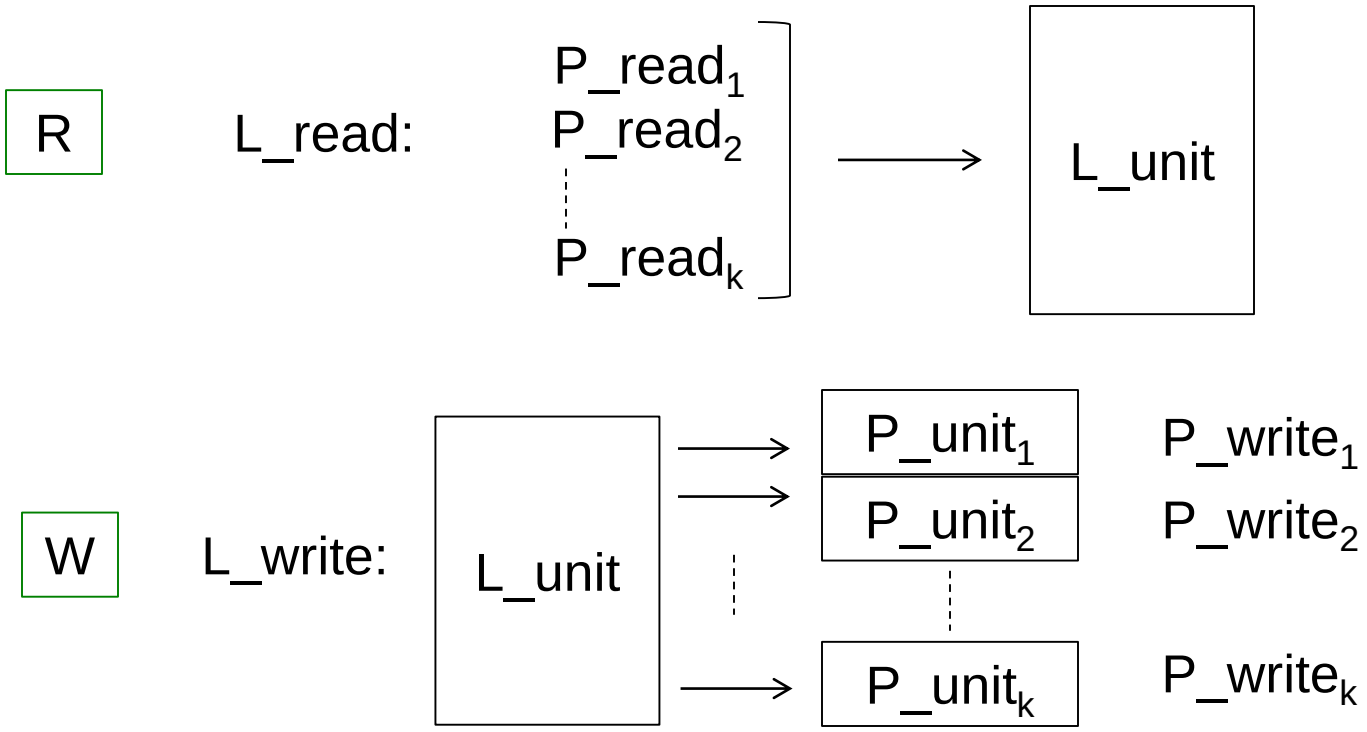
Indirect addressing

Memory ⟷ Storage Device

# Storage Units

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

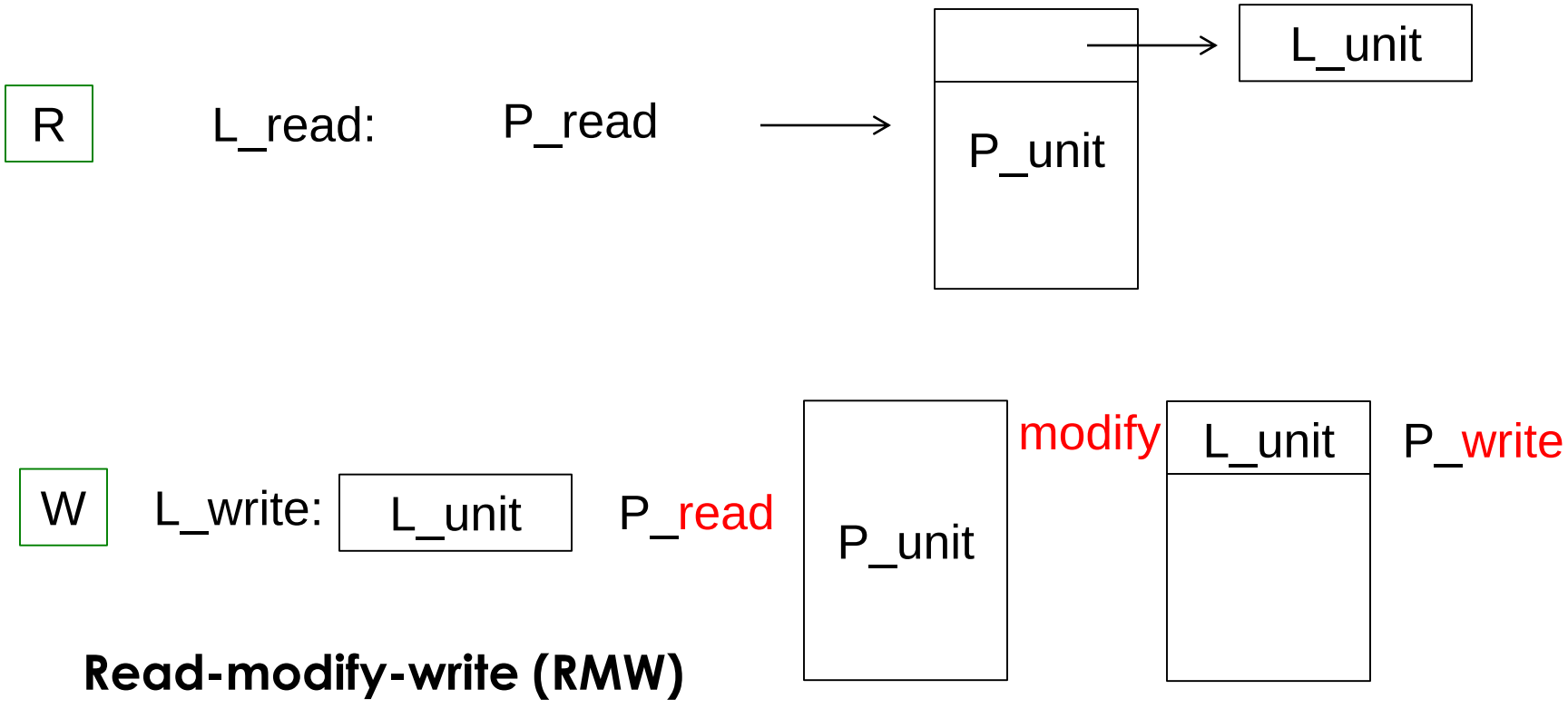
Case 1: Logical>Physical



# 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

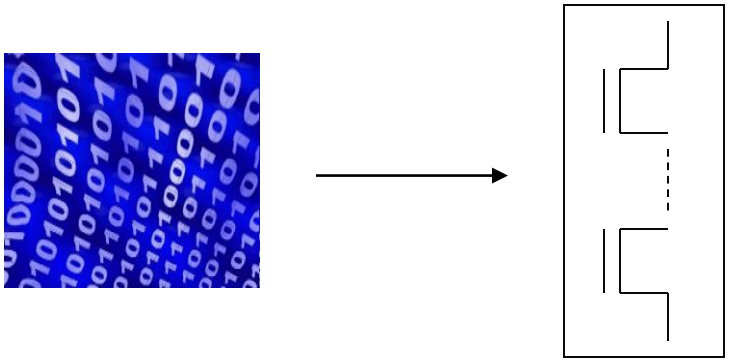



**Read-modify-write (RMW)**

# Data Storage = Representation + Placement

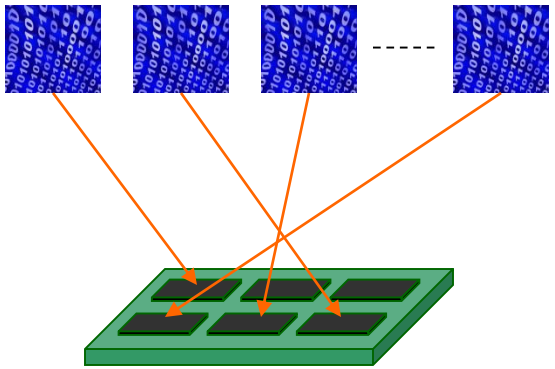
## Data Representation

- User bits ↔ Multilevel cells
- Error-correcting codes
- Multi-write codes
- Compression

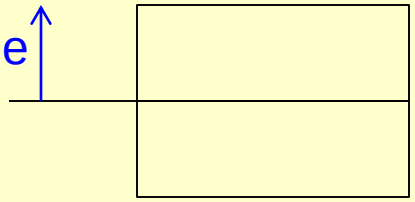


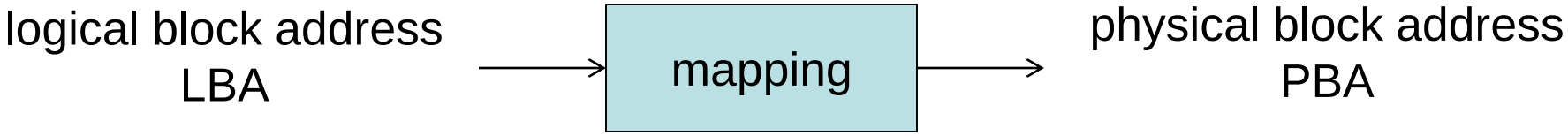
## Data Placement

- Logical pages ↔ Physical pages
- Flash Translation Layer
- Access optimization

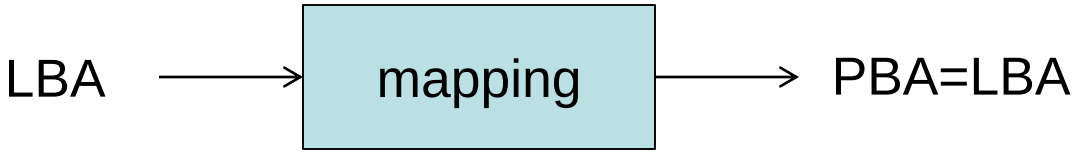


# 1. Data Placement

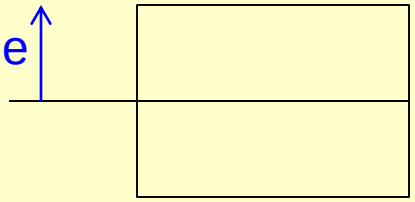


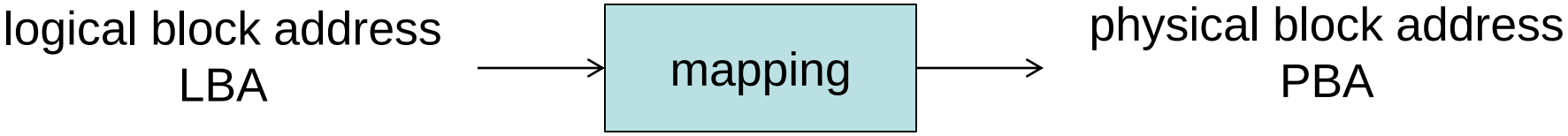




Example: trivial mapping

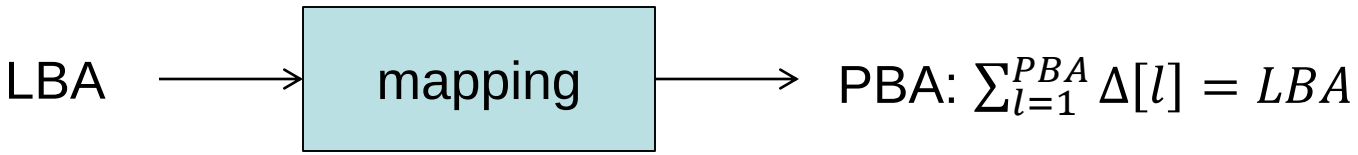


# 1. Data Placement



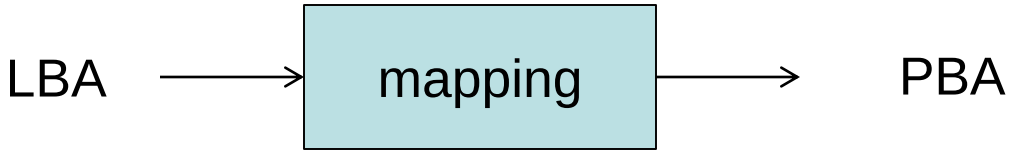

Example: defects



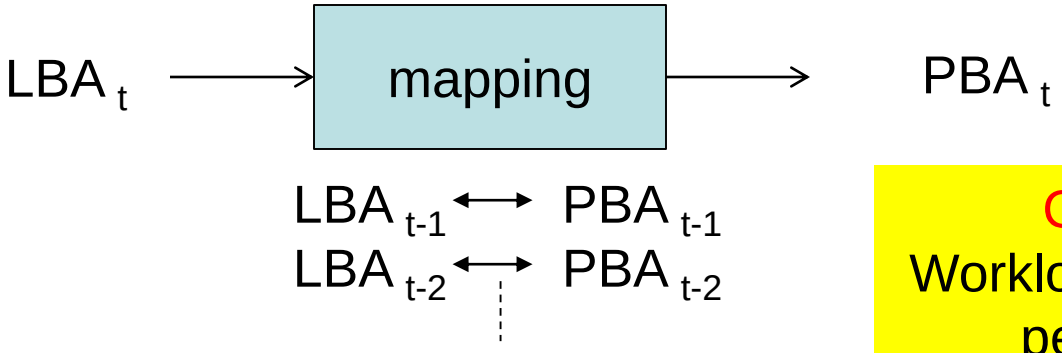

$$\Delta[l] = \begin{cases} 0 & \text{if } PBA_l \text{ defective} \\ 1 & \text{otherwise} \end{cases}$$

# Static vs. Dynamic Placement

Static placement (memoryless):

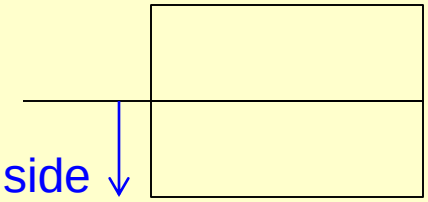


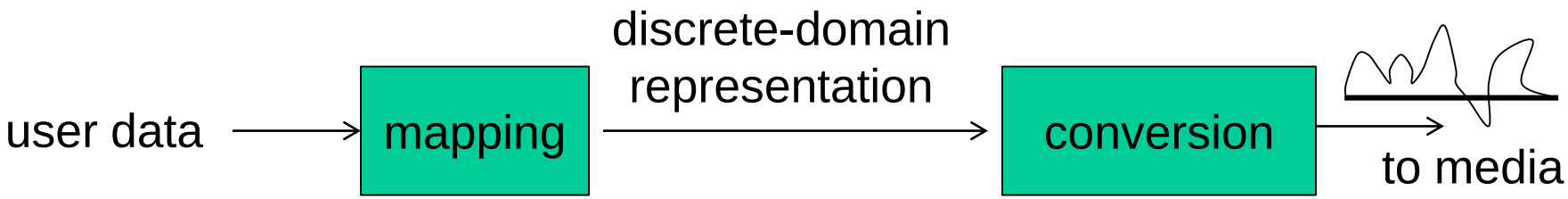

Dynamic placement (workload dependent):



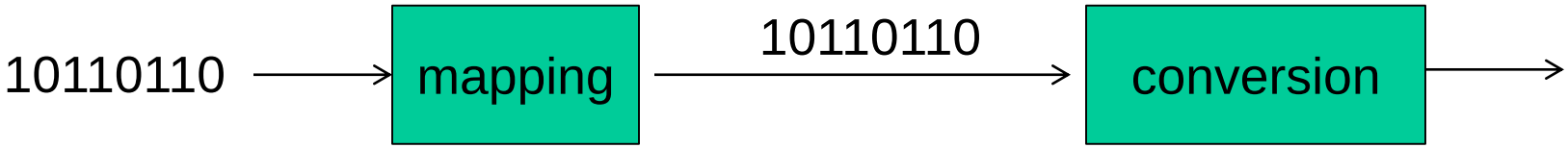

CAUTION:
Workload –dependent performance

# 2. Data Representation

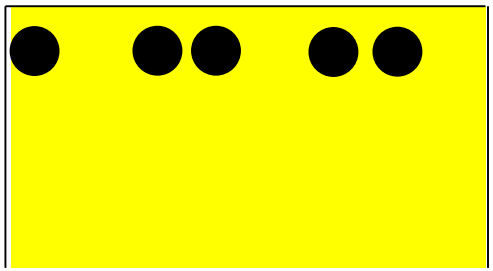


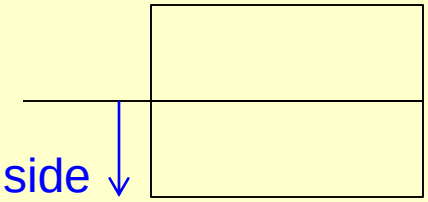

Example: trivial mapping

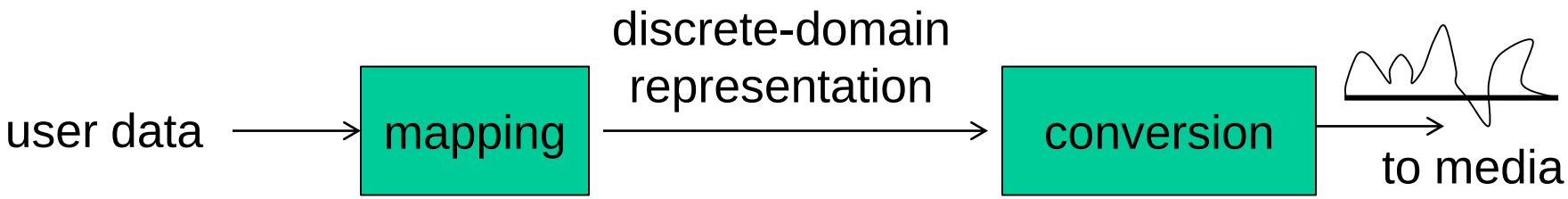



media:
punch tape

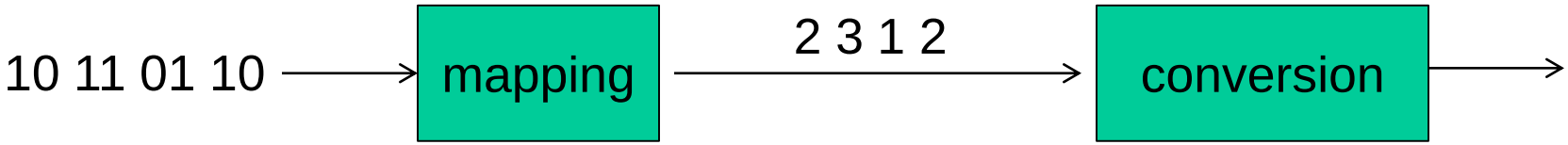


# 2. Data Representation

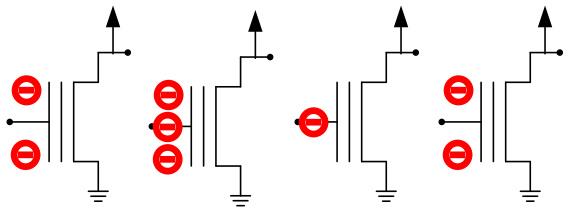


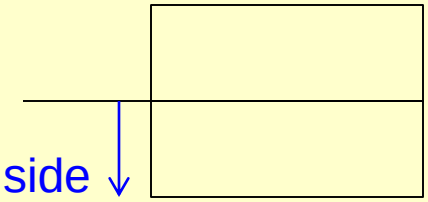

Example: multi-level flash

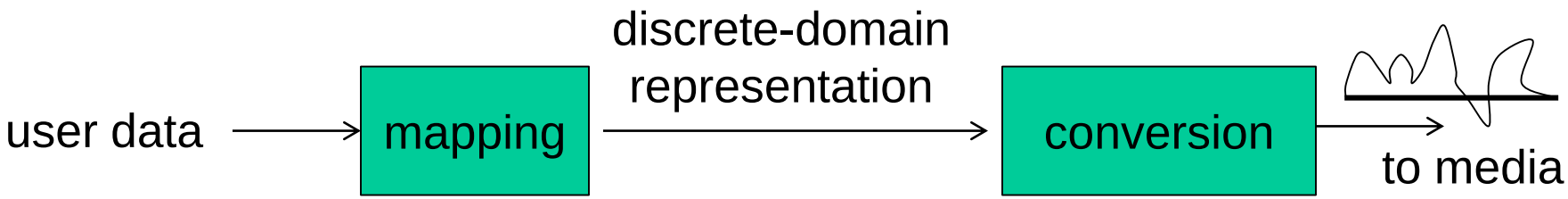



media:
4-level flash

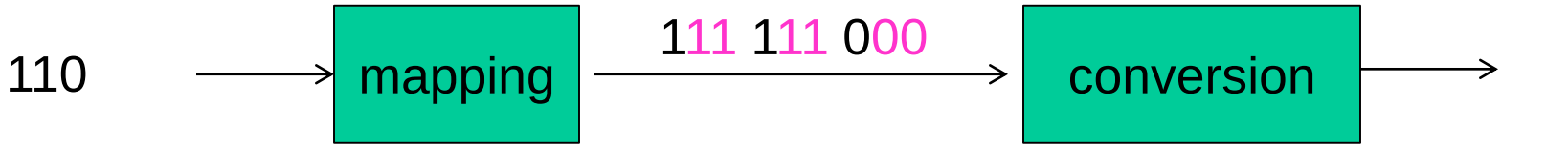


# 2. Data Representation

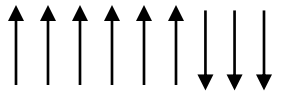


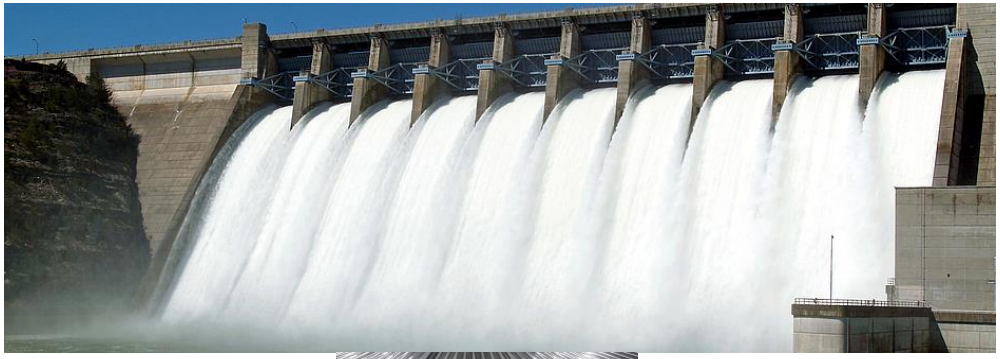

Example: error-correcting codes




media:
magnetic
recording



# A new game: Big Data



W

big_data_in

Storage Device

R

wisdom_out

# Wisdom storage

- Machine learning (trained model)
  - Need to know the question in advance
- Lossless compression (fully invertible)
  - Retain all wisdoms
- Differential wisdom (knowledgeable reader)
  - Deduplication
  - Compression with side information