Design and Analysis
of Algorithms I

Data Structures

Hash Tables and Applications

Hash Table: Supported Operations

Purpose : maintain a (possibly evolving) set of stuff.
(transactions, people + associated data, IP addresses, etc.)

Insert : add new record

Delete : delete existing record

Lookup : check for a particular record
(a “dictionary”)

Using a “key”

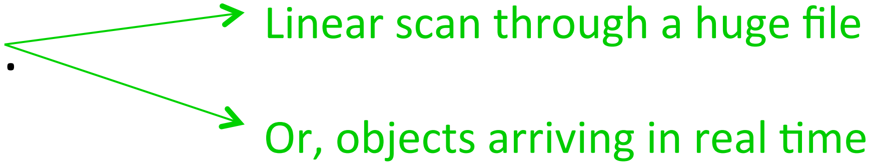
AMAZING GUARANTEE

All operations in O(1) time ! *

* 1. properly implemented 2. non-pathological data

Application: De-Duplication

Given : a “stream” of objects.



Linear scan through a huge file

Or, objects arriving in real time

Goal : remove duplicates (i.e., keep track of unique objects)

-e.g., report unique visitors to web site

- avoid duplicates in search results

Solution : when new object x arrives

- lookup x in hash table H
- if not found, Insert x into H

Application: The 2-SUM Problem

Input : unsorted array A of n integers. Target sum t.

Goal : determine whether or not there are two numbers x,y in A with

x + y = t

Naïve Solution : $\theta(n^2)$ time via exhaustive search

Better : 1.) sort A ($\theta(n\log n)$ time)

2.) for each x in A, look for t-x in A via binary search

$\theta(n\log n)$

$\theta(n)$ $time$

Amazing : 1.) insert elements of A into hash table H

2.) for each x in A, Lookup t-x

$\theta(n)$ $time$

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Further Immediate Applications

- Historical application : symbol tables in compilers

- Blocking network traffic

- Search algorithms (e.g., game tree exploration)

    - Use hash table to avoid exploring any configuration (e.g., arrangement of chess pieces) more than once

- etc.