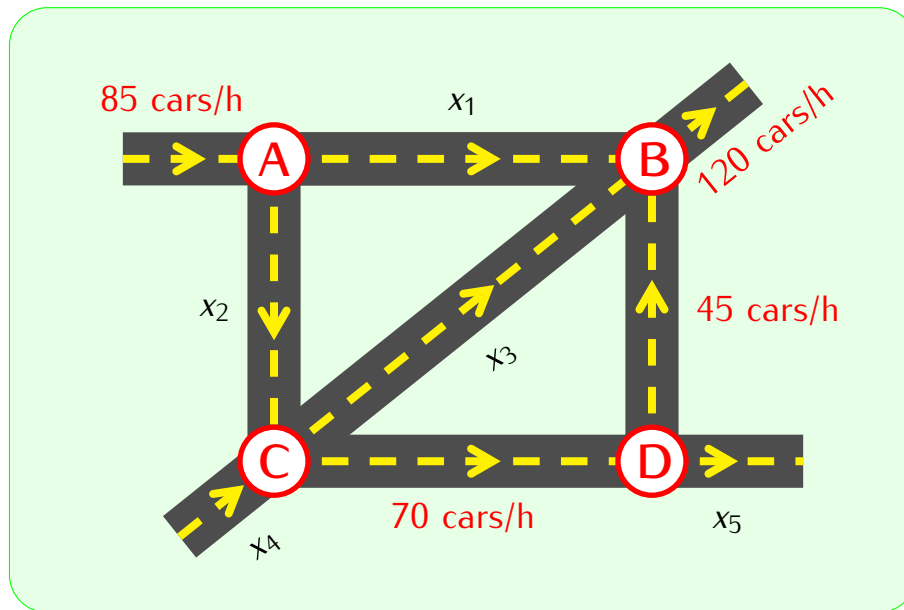


## Computations of traffic flow



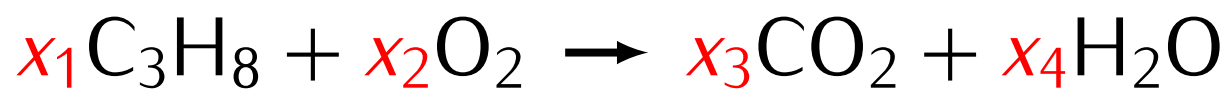
**Problem.** Find the flow rate of cars on each segment of streets.

**Note:**

- flow into an intersection = flow out of that intersection
- total flow in = total flow out

## Balancing chemical equations

Burning propane:

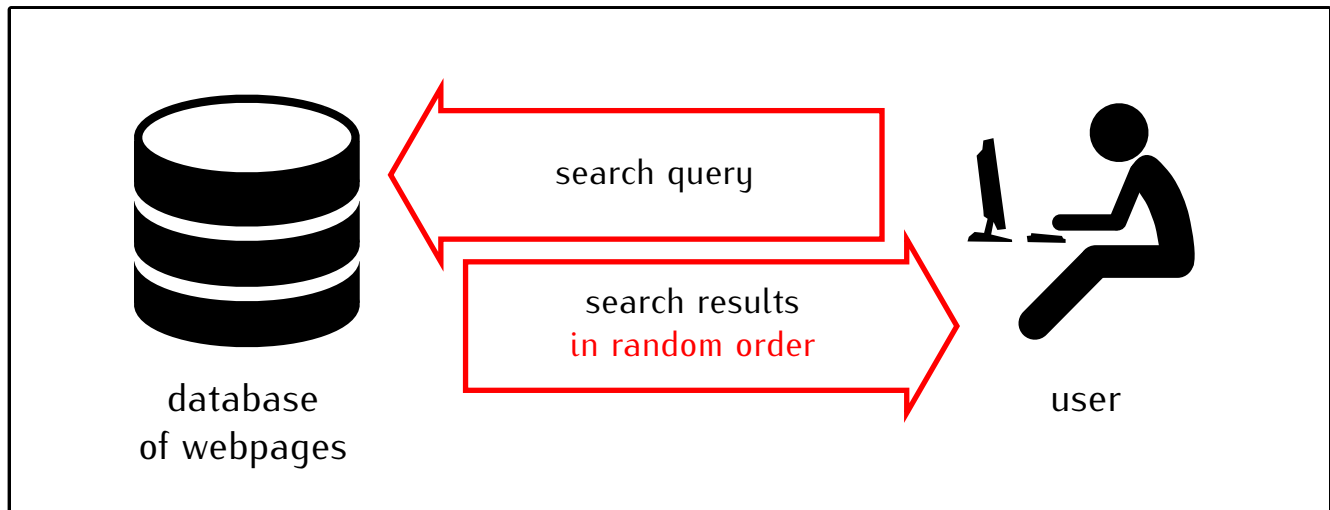


Note:

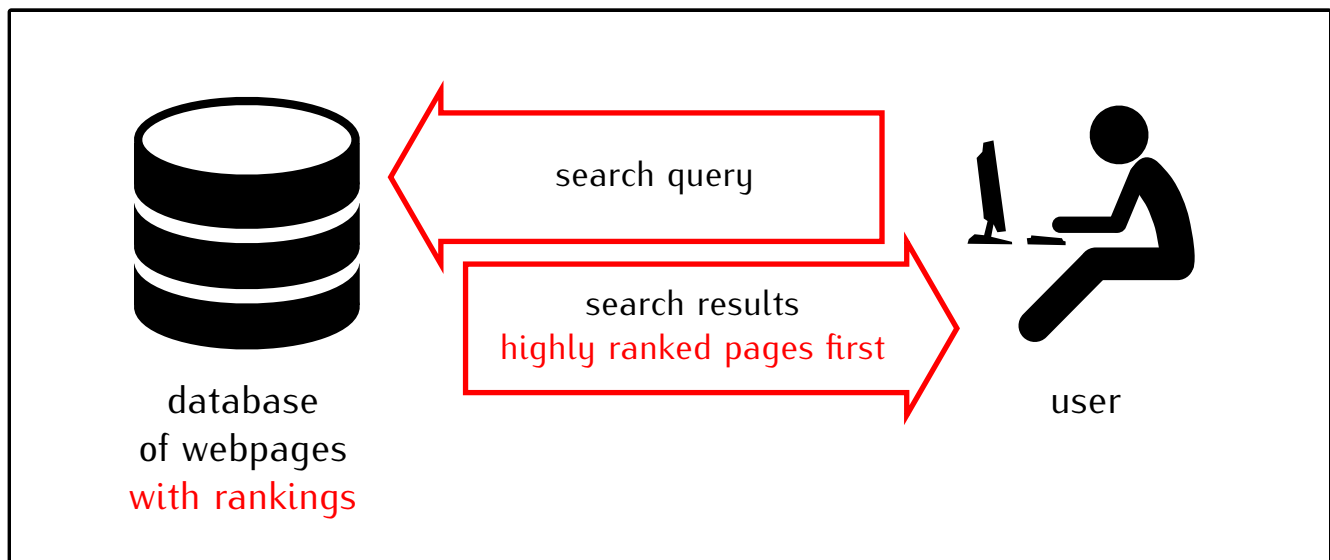
- The numbers  $x_1, x_2, x_3, x_4$  are positive integers.
- The number of atoms of each element on the left side is the same as the number of atoms of that element on the right side.

## Google PageRank

Early search engines:



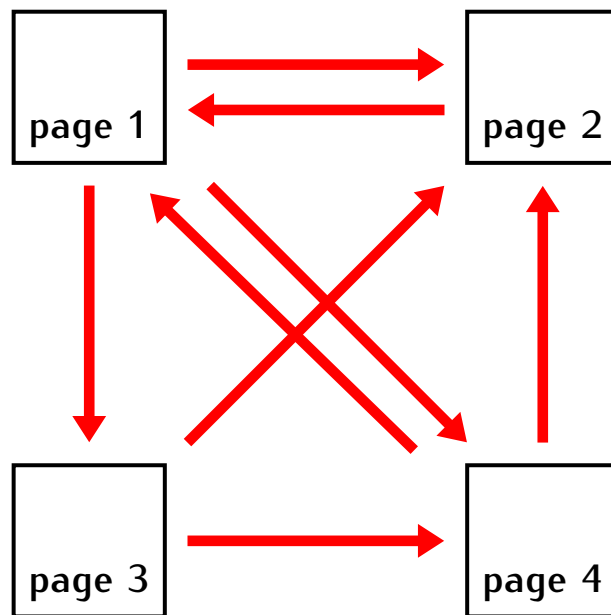
Google search engine:



## How to rank webpages?

Very simple ranking:

$$\text{ranking of a page} = \left( \begin{array}{c} \text{number of links} \\ \text{pointing to that page} \end{array} \right)$$



*Network of web pages.*

**Problem.** This is very easy to manipulate.

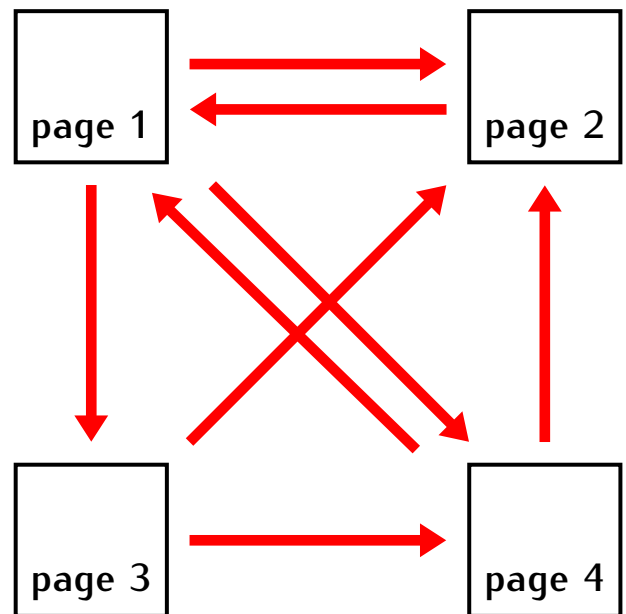
## How to rank webpages?

**Google PageRank:** Links from highly ranked pages are worth more than links from lower ranked pages.

If:

- the rank of a page is  $x$
- the page has  $n$  links to other pages

then each link from that page is worth  $x/n$ .



Next: From systems of linear equations to vector equations.

$$\begin{cases} x_1 + 2x_2 = 4 \\ 2x_1 + 7x_2 = 9 \\ 4x_1 + x_2 = 0 \end{cases} \quad \Rightarrow \quad x_1 \begin{bmatrix} 1 \\ 2 \\ 4 \end{bmatrix} + x_2 \begin{bmatrix} 2 \\ 7 \\ 1 \end{bmatrix} = \begin{bmatrix} 4 \\ 9 \\ 0 \end{bmatrix}$$

**Why vectors and vector equations are useful:**

- They show up in many applications (velocity vectors, force vectors etc.)
- They give a better geometric picture of systems of linear equations.