ENGR 102 PROGRAMMING PRACTICE

WEEK 12

Searching & Ranking

Setting Up Database

Four dictionaries:

- **urllist** is the list of URLs that have been indexed.
  {url: outgoing_link_count}
- **wordlocation** is a list of the locations of words in the documents.
  {word: {url: [loc1, loc2, ..., locN]}}
- **link** stores two URL IDs, indicating a link from one page to another.
  {tourl: {fromUrl: None}}
- **linkwords** store words that are included in a link.
  {word: [(urlFrom1, urlTo1), ..., (urlFromN, urlToN)]}

Recording links

```
# Add a link between two pages
def addlinkref(self, urlFrom, urlTo, linkText):
    fromUrl = smart_str(urlFrom)
    toUrl = smart_str(urlTo)

    if fromUrl == toUrl: return False

    self.link.setdefault(toUrl, {})
    self.link[toUrl][fromUrl] = None

    words = self.separatewords(linkText)
    for word in words:
        word = smart_str(word)

        if word in ignorewords: continue

        self.linkwords.setdefault(word, [])
        self.linkwords[word].append((fromUrl, toUrl))

    return True
```

Crawling pages

```
import mysearchengine
pagelist = ['http://sehir.edu.tr']
dbtables = {'urllist': 'urllist.db',
            'wordlocation': 'wordlocation.db',
            'link': 'link.db',
            'linkwords': 'linkwords.db'}
crawler = mysearchengine.crawler(dbtables)
crawler.createindextables()
crawler.crawl(pagelist)
```

Search Engine

- 1. Crawl to collect documents.
- 2. Index to improve search.
- **3. Query for a select set of documents.**

Querying

```
def getmatchingpages(self,q):
    results = {}
    # Split the words by spaces
    words = [smart_str(word).lower for word in q.split()]
    if words[0] not in self.wordlocation:
        return results, words

    url_set = set(self.wordlocation[words[0]].keys())

    for word in words[1:]:
        if word not in self.wordlocation:
            return results, words
        url_set = url_set.intersection(self.wordlocation[word].keys())

    for url in url_set:
        results[url] = []
        for word in words:
            results[url].append(self.wordlocation[word][url])

    return results, words
```

Querying

- We've managed to retrieve pages that match the queries.
- **Problem**: In a large set of pages, you would be stuck sifting through *a lot of irrelevant content* for any mention of each of the query terms in order to find the pages that are **really related to your search.**

Ranking

```
import mysearchengine
pagelist = ['http://sehir.edu.tr']
dbtables = {'urllist': 'urllist.db',
            'wordlocation': 'wordlocation.db',
            'link': 'link.db',
            'linkwords': 'linkwords.db'}
searcher = mysearchengine.searcher(dbtables)
# no ranking:
searcher.query('career')
# with ranking:
searcher.query('career', searcher.ALL)
```

Ranking

- Content-based Ranking
- Inbound-link Ranking

Ranking measures

Content-based

- **Word frequency:** the number of times the words in the query appear in the document can help determine how relevant the document is.
- **Document location:** the main subject of a document will probably appear near the beginning of the document.
- **Word distance:** if there are multiple words in the query, they should appear close together in the document.

Word Frequency

- The word frequency metric scores a page based on how many times the words in the query appear on that page.
- Search for "python"

  - a page about *Python (or pythons) with many mentions of the word python.*

  vs.

  - *a page about a musician that has a pet python.*

Word Frequency

```
def frequencyscore(self, results):
    counts = {}
    for url in results:
        score = 1
        for wordlocations in results[url]:
            score *= len(wordlocations)
        counts[url] = score
    return self.normalizescores(counts, smallIsBetter=False)
```

Normalization

- In order to compare the results from different scoring methods, we need a way to normalize them.
- The normalization function: each score is scaled according to how close it is to the best result, which will always have a score of 1.

```
normalizescores(scores, smallIsBetter=False)
```

Score Computation

```
def getscoredlist(self, results, words, ranking):
    totalscores = dict([(url, 0) for url in results])

    # This is where you'll put the scoring functions
    weights = []

    # word frequency scoring
    if (ranking & self.FREQ) != 0:
       weights.append((1.0, self.frequencyscore(results)))

    if (ranking & self.LOC) != 0:
       weights.append((1.0, self.locationscore(results)))

    if (ranking & self.LINK) != 0:
       weights.append((1.0, self.inboundlinkscore(results)))

    for (weight, scores) in weights:
        for url in totalscores:
            totalscores[url] += weight*scores.get(url, 0)

    return totalscores
```

Ranking
word frequency - based

change the weights line in getscoredlist to this:

```
weights=[(1.0, self.frequencyscore(results))]
```

```
import mysearchengine

pagelist = ['http://sehir.edu.tr/en']

dbtables = {'urllist': 'urllist.db',
            'wordlocation': 'wordlocation.db',
            'link': 'link.db',
            'linkwords': 'linkwords.db'}

searcher = mysearchengine.searcher(dbtables)

searcher.query('career')
```

Document Location

- Search term's location in the page.
- If a page is relevant to the search term, it will appear closer to the top of the page
  - perhaps even in the title.
- Score results higher if the query term appears early in the document.
- wordlocation **table:**
  - the locations of the words were recorded.

Document Location

```
def locationscore(self, results):
    locations=dict([(url, 1000000) for url in results])
    for url in results:
        score = 0
        for wordlocations in results[url]:
            score += min(wordlocations)
        locations[url] = score
    return self.normalizescores(locations, smallIsBetter=True)
```

Ranking

word location - based

change the weights line in getscoredlist to this:

```
weights=[(1.0, self.locationscore(results))]
```

```
import mysearchengine

pagelist = ['http://sehir.edu.tr']

dbtables = {'urllist': 'urllist.db',
            'wordlocation': 'wordlocation.db',
            'link': 'link.db',
            'linkwords': 'linkwords.db'}

searcher = mysearchengine.searcher(dbtables)

searcher.query('career')
```

Word Distance

- When a query contains multiple words, seek results in which the words in the query are close to each other in the page.
  - i.e., seek pages that conceptually relates search words.

Ranking

word distance - based

Left as a take-home exercise!

Link information

- Used scoring metrics based on the content of the page.
- How about information that others have provided about the page?
  - who linked to the page?
  - what they said about it?

Pages created by spammers are less likely to be linked than pages with real content.

Link information

link stores two URL IDs, indicating a link from one page to another.

{toUrl: {fromUrl: None}}

linkwords store words that are included in a link.

{word: [(urlFrom1, urlTo1), ..., (urlFromN, urlToN)]}

- The **link** table has the URLs for the source and target of every link that it has encountered.
- The **linkwords** table connects the words with the links.

Simple Count

- Count inbound links to each page and use the total number of links as a metric for the page.
- The scoring function based on this count:

```
def inboundlinkscore(self, results):
    inboundcount=dict([(url, len(self.link[url]))
                       for url in results if url in self.link])
    return self.normalizescores(inboundcount)
```

Simple Count

- Using this metric by itself will simply return all the pages containing the search terms,

  "*ranked solely on how many inbound links they have.*"

- We need to combine the inbound-links metric with one of the content/relevance metrics we saw earlier.

```
weights =  [(1.0, self.frequencyscore(results)),
            (1.0, self.locationscore(results)),
            (1.0, self.inboundlinkscore(results))]
```

What if?

- Someone can easily set up several sites pointing to a page whose score they want to increase.

What about …?

- What about result pages that have attracted the attention of very **popular** sites?
- How to make *links from popular pages worth more* in calculating rankings?

PageRank

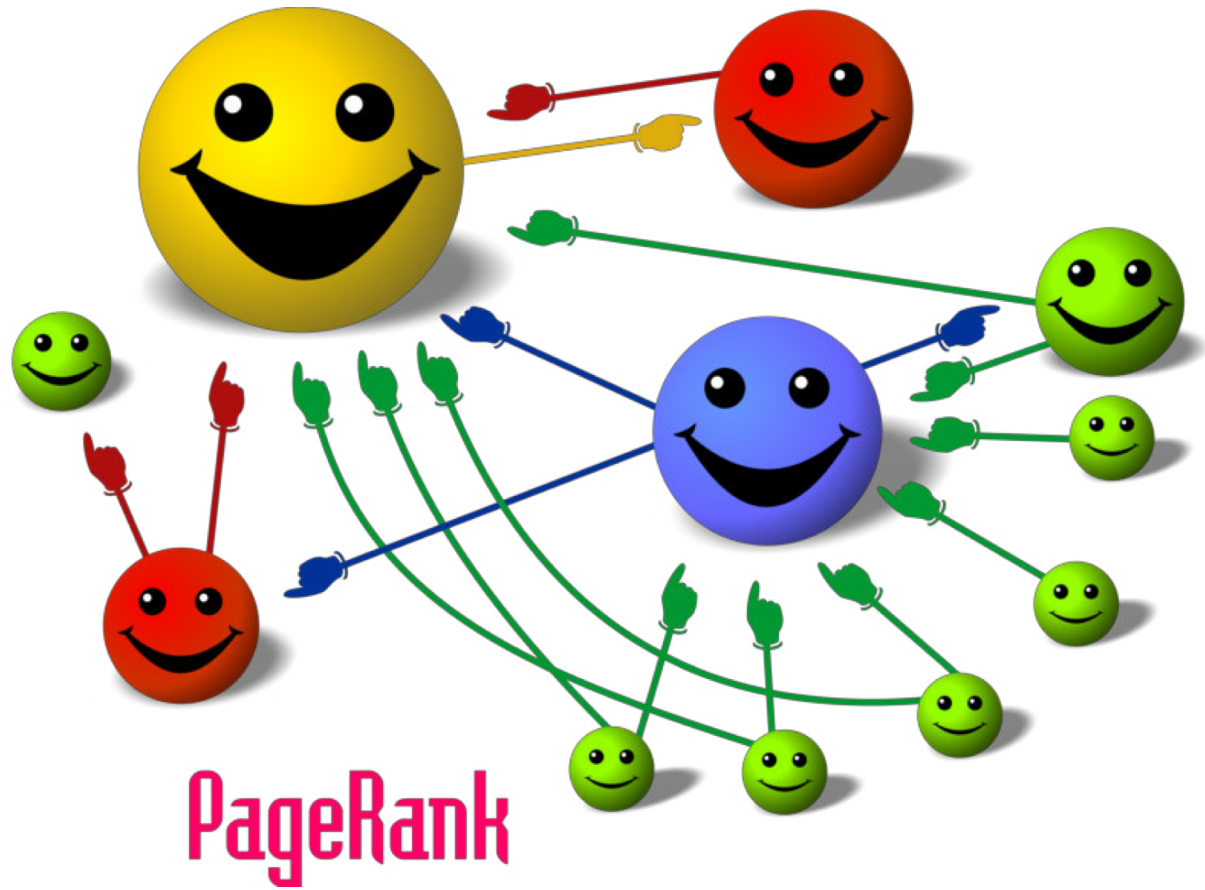
PageRank

- **Page**Rank (named after Larry **Page**) calculates the probability that someone randomly clicking on links will arrive at a certain page.
- The more inbound links the page has from other popular pages, the more likely it is that someone will end up there purely by chance.

PageRank

- Basic principle of PageRank.

The size of each face is proportional to the total size of the other faces which are pointing to it.



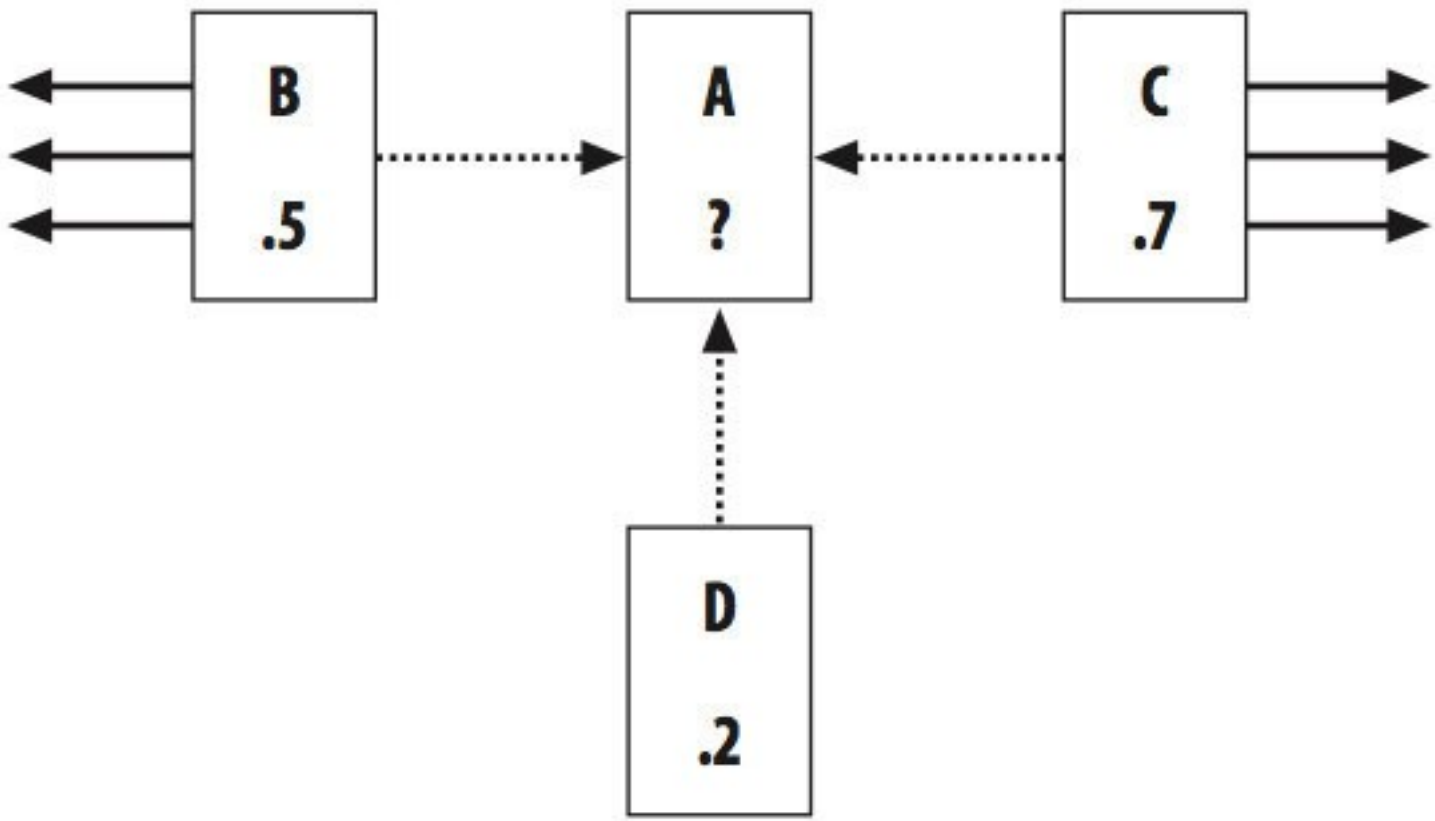
Source: http://en.wikipedia.org/wiki/PageRank

PageRank

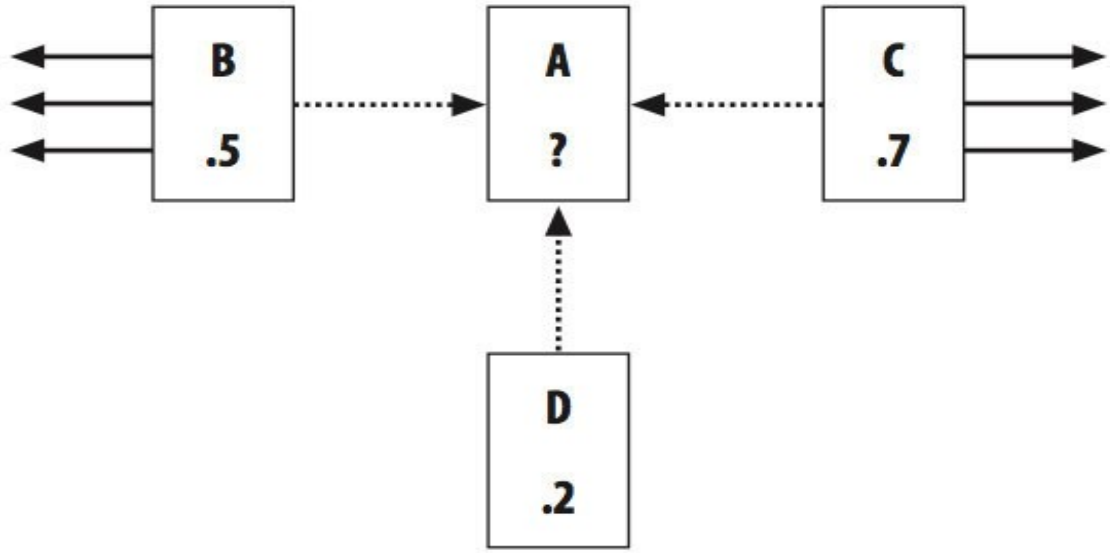
- If the user keeps clicking forever, they'll eventually reach every page, but most people stop surfing after a while.
- To capture this, PageRank also uses a damping factor of 0.85, indicating that

there is an 85% chance that a user will continue clicking on links at each page.

PageRank



PageRank



PR(A) = 0.15 + 0.85 *
(PR(B)/links(B) + PR(C)/links(C) + PR(D)/links(D))

= 0.15 + 0.85 * (0.5/4 + 0.7/4 + 0.2/1)
= 0.15 + 0.85 * (0.125 + 0.175 + 0.2)
= 0.15 + 0.85 * 0.5
= 0.575

There is a small catch!

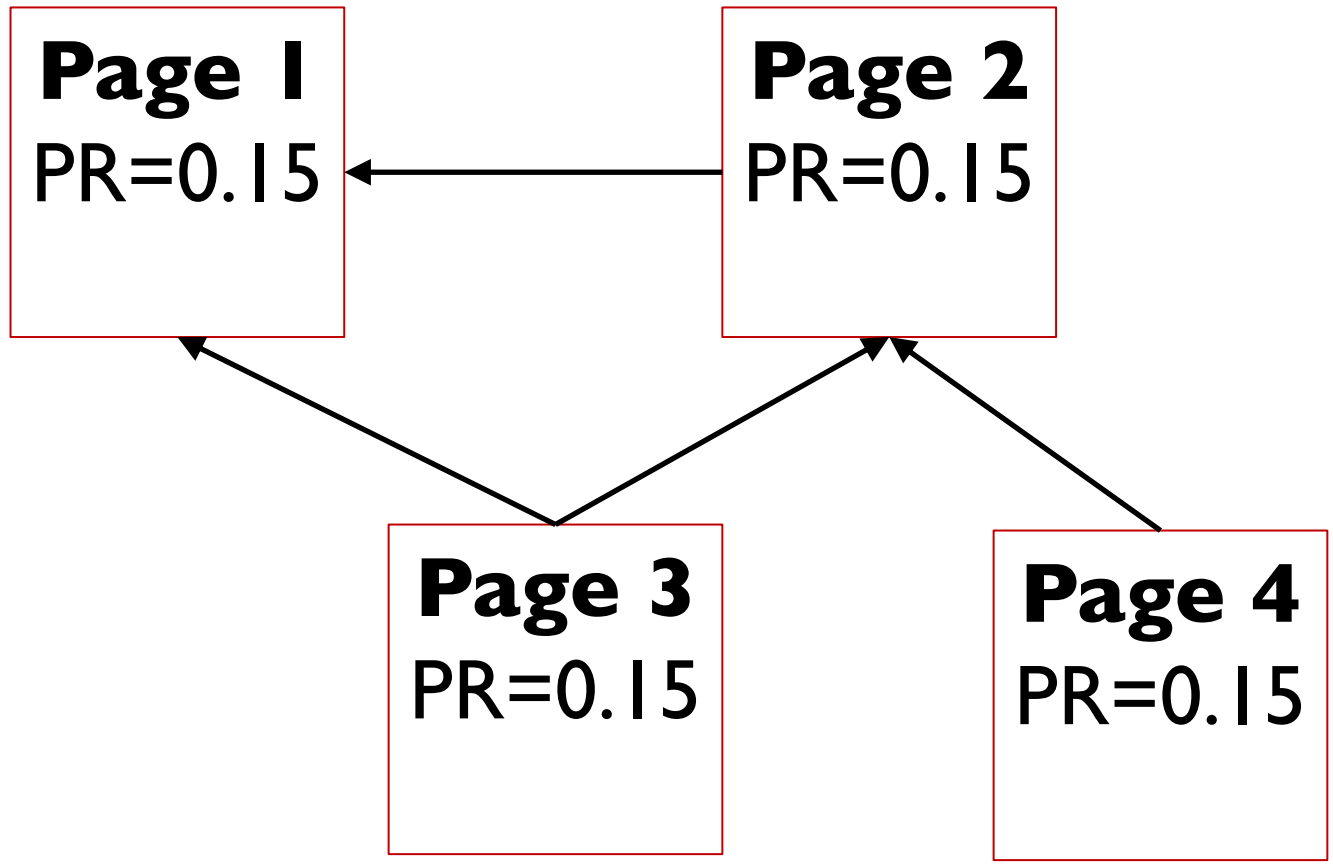
- All the pages linking to A already had PageRanks.
- You can't calculate a page's score until you know the scores of all the pages that link this page!
    - And, you can't calculate their scores without doing the same for all the pages that link to them.
- How is it possible to calculate PageRanks for a whole set of pages that don't already have PageRanks?

AND YET THE QUESTION REMAINED:
"WHO CAME FIRST?"

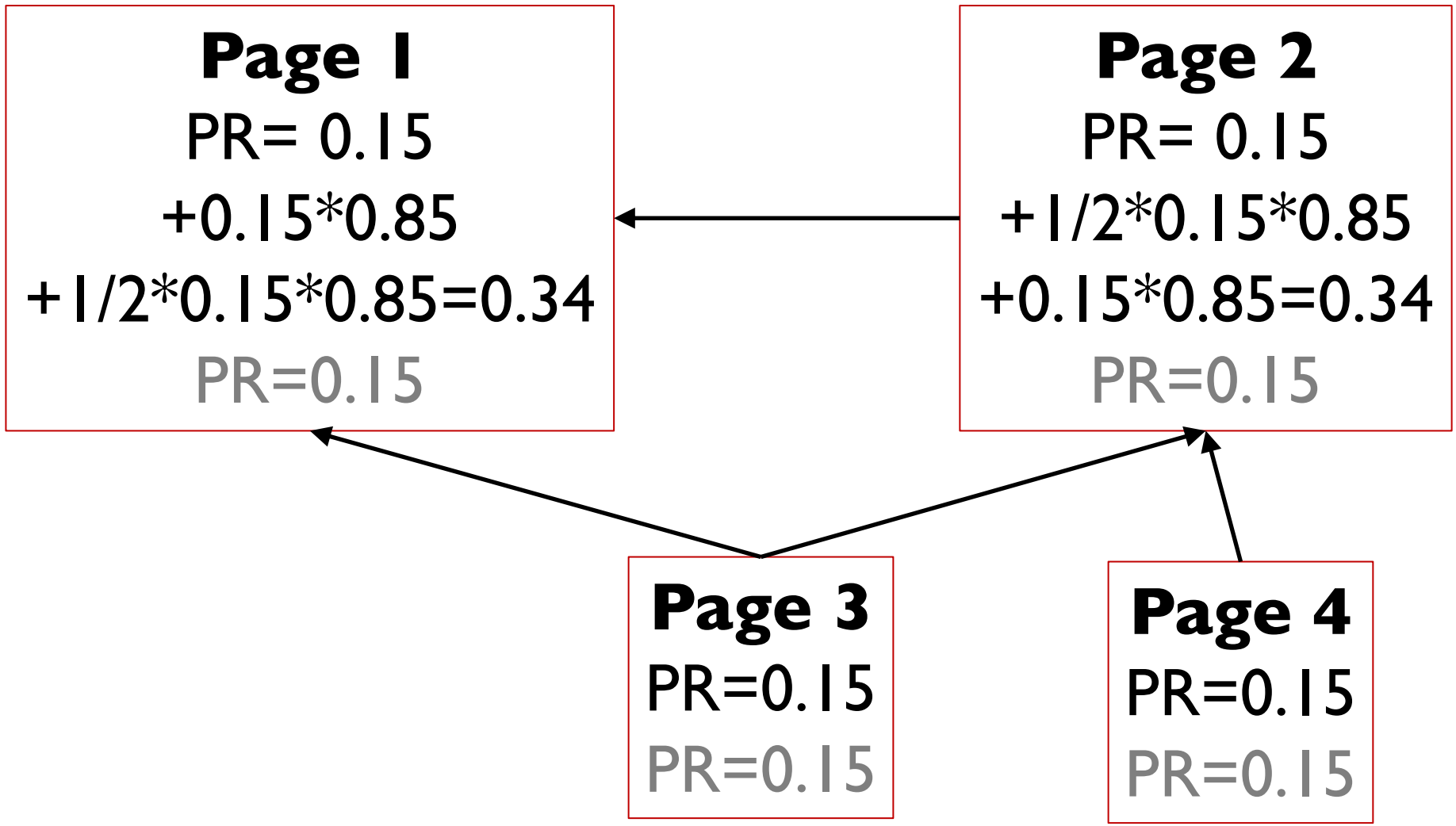
PageRank

- The solution is to set all the PageRanks to an initial arbitrary value
  - (*the code will use 1.0, but the actual value doesn't make any difference*).
- Repeat the calculation over several iterations.
- After each iteration, the PageRank for each page gets closer to its true PageRank value.
- The number of iterations needed varies with the number of pages.

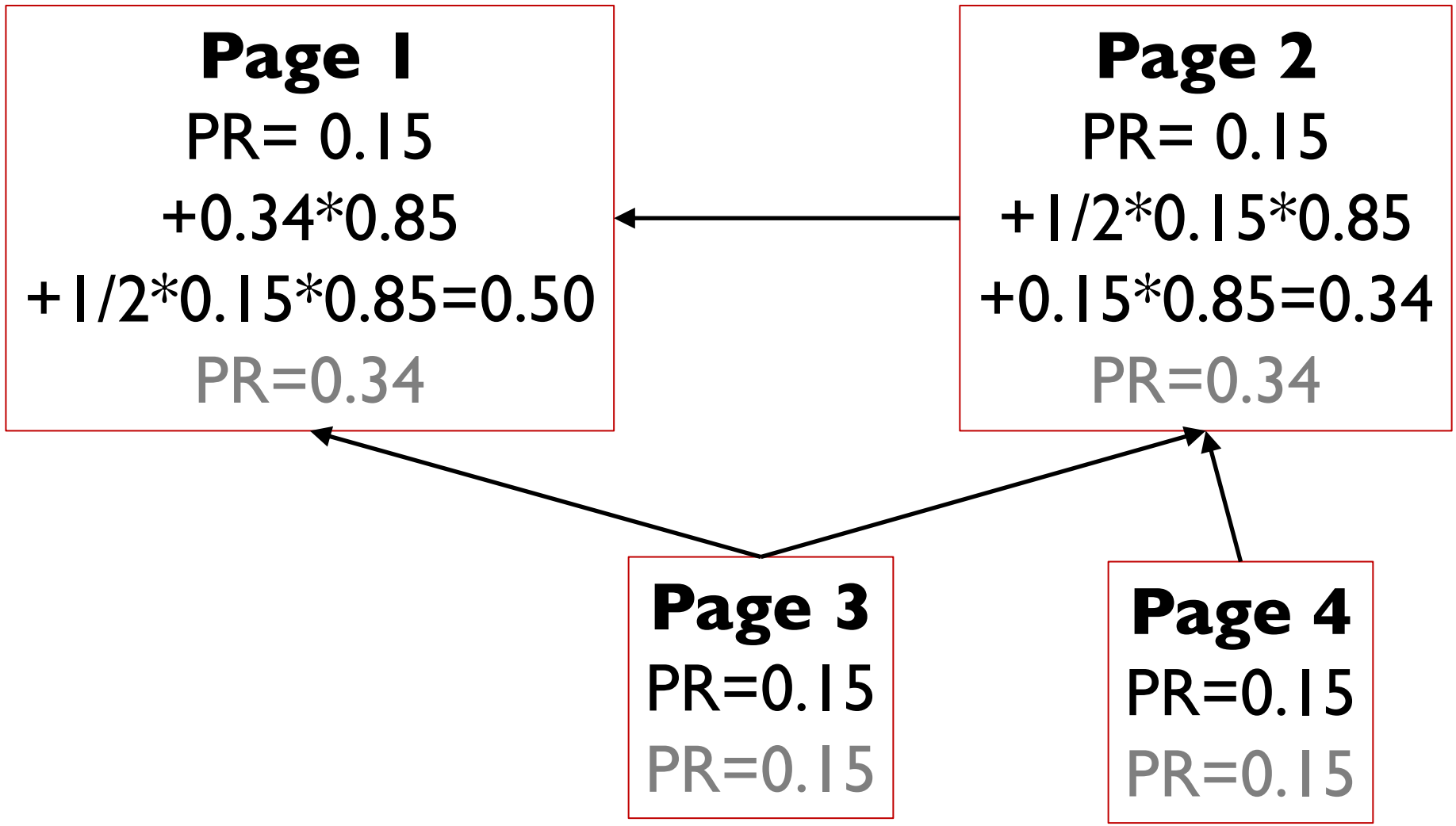
Iteration 0



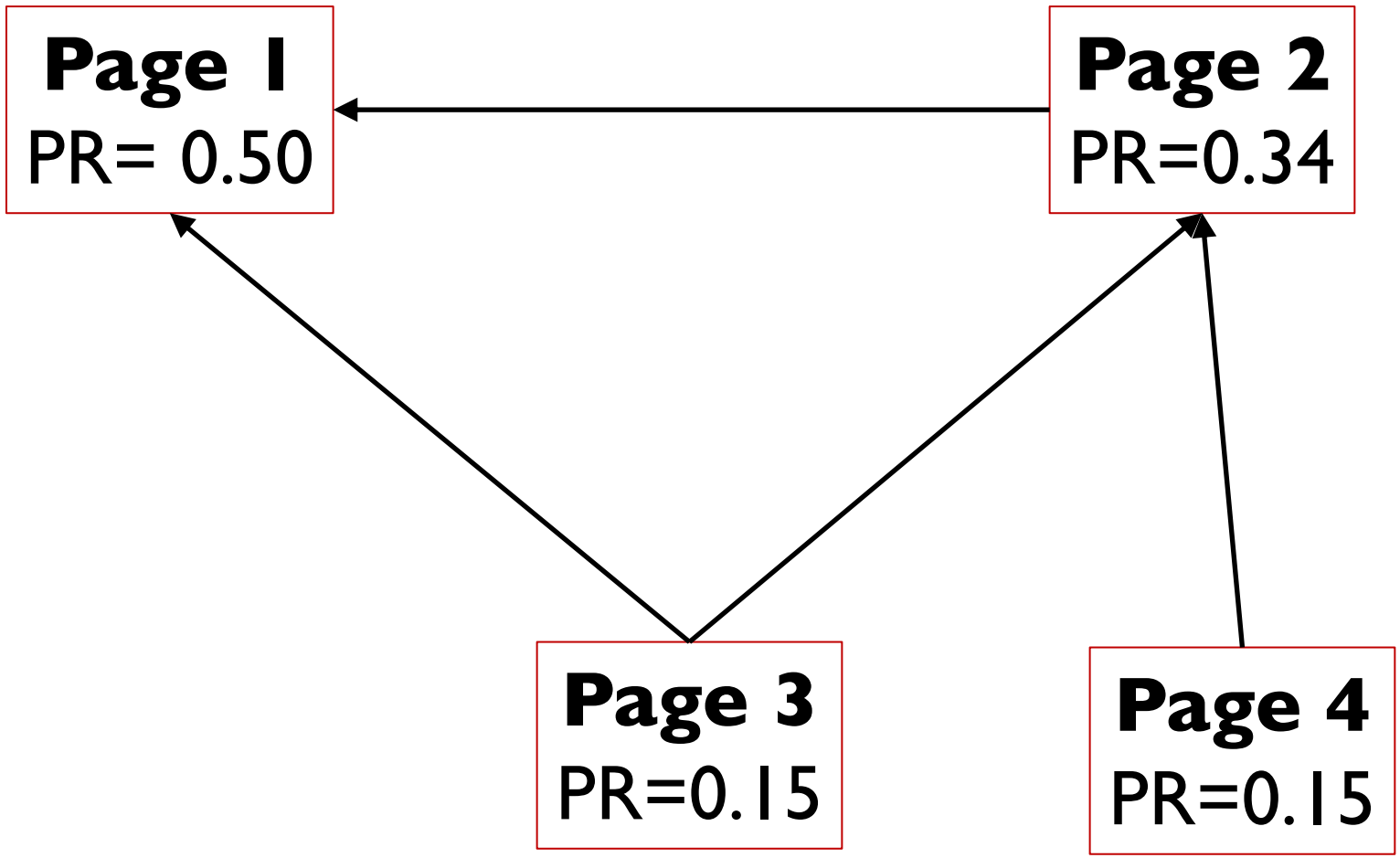
Iteration 1


Page 1
PR= 0.15
+0.15*0.85
+1/2*0.15*0.85=0.34
PR=0.15
Page 2
PR= 0.15
+1/2*0.15*0.85
+0.15*0.85=0.34
PR=0.15
Page 3
PR=0.15
PR=0.15
Page 4
PR=0.15
PR=0.15

Iteration 2


Page 1
PR= 0.15
+0.34*0.85
+1/2*0.15*0.85=0.50
PR=0.34
Page 2
PR= 0.15
+1/2*0.15*0.85
+0.15*0.85=0.34
PR=0.34
Page 3
PR=0.15
PR=0.15
Page 4
PR=0.15
PR=0.15

Iteration 3+



PageRank computation

```
def calculatepagerank(self,iterations=20):
    self.pagerank = shelve.open(self.dbtables['pagerank'],
                                writeback=True, flag='n')

    # initialize every url with a page rank of 1
    for url in self.urllist:
        self.pagerank[url] = 1.0

    for i in range(iterations):
        print "Iteration %d" % (i)
        for url in self.urllist:
            pr = 0.15
            # Loop through all the pages that link to this one
            if url in self.link:
              for linker in self.link[url]:
                  linkingpr = self.pagerank[linker]

                  # Get the total number of links from the linker
                  linkingcount = self.urllist[linker]
                  pr += 0.85*(linkingpr/linkingcount)

            self.pagerank[url] = pr
```

PageRank computation

```
import mysearchengine

crawler=searchengine.crawler(dbtables)

crawler.calculatepagerank()
```

Score Combination

```
weights =  [(1.0, self.locationscore(rows)),
            (1.0, self.frequencyscore(rows)),
            (1.0, self.pagerankscore(rows))]
```