Information Retrieval

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CS F469, Information Retrieval
Lecture No. 4

Recap of Lecture 3

- Character encodings
- Document unit
- Tokenization
- Normalization
- Stemming and Lemmatization

Today's Lecture

- Faster merging of posting lists
- Positional postings and phrase queries
- Collocations

Recap: Posting List Intersection

Eg. query: **word 1** AND **word 3**

Word 1 →

Doc 1	Doc 20	Doc 34	Doc 90	**...**

intersection

Word 3 →

Doc 3	Doc 40	Doc 44	Doc 55	Doc 90

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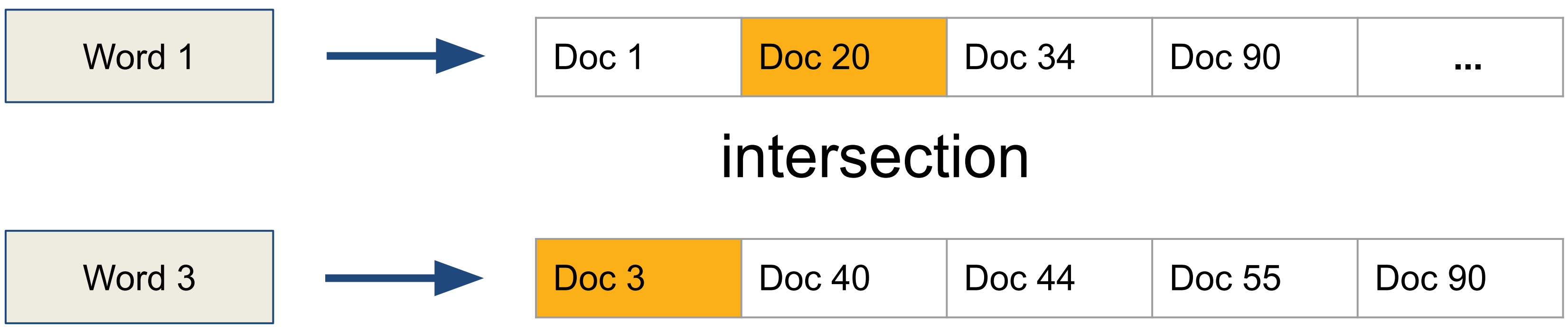

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intersection

Word 3 → | Doc 3 | Doc 40 | Doc 44 | Doc 55 | Doc 90 | NIL |

Result → | Doc 90 |

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Word 3 →

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=

Result → Doc 90

The algorithm will perform $O(|L_1| + |L_2|)$ operations.

Skip Pointers in Posting Lists

Faster Posting List Intersection via Skip Pointers

Brutus →

2	4	8	16	19	23	28	43	…

Caesar →

1	2	3	5	8	41	51	60	71	…

Example from Figure 2.9, Introduction to IR, C.D. Manning, P. Raghavan and H. Schütze.

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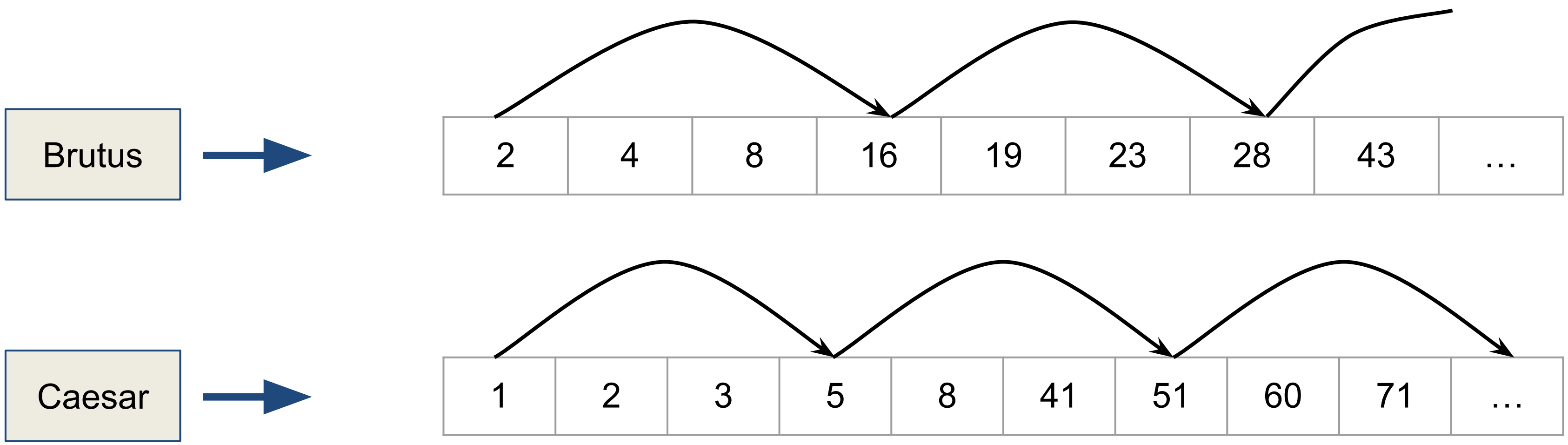

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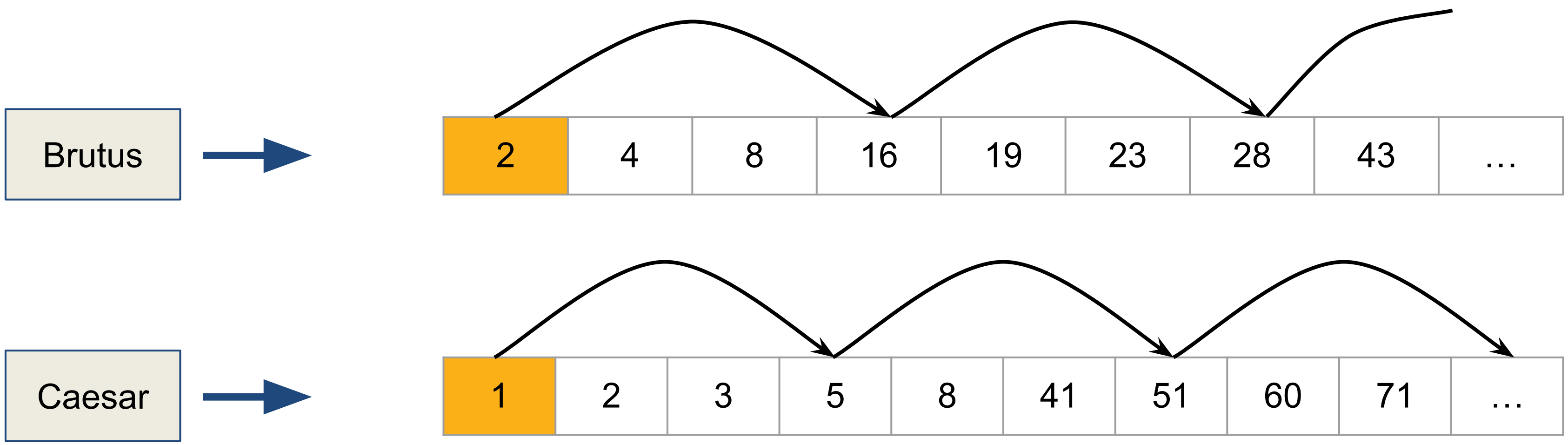

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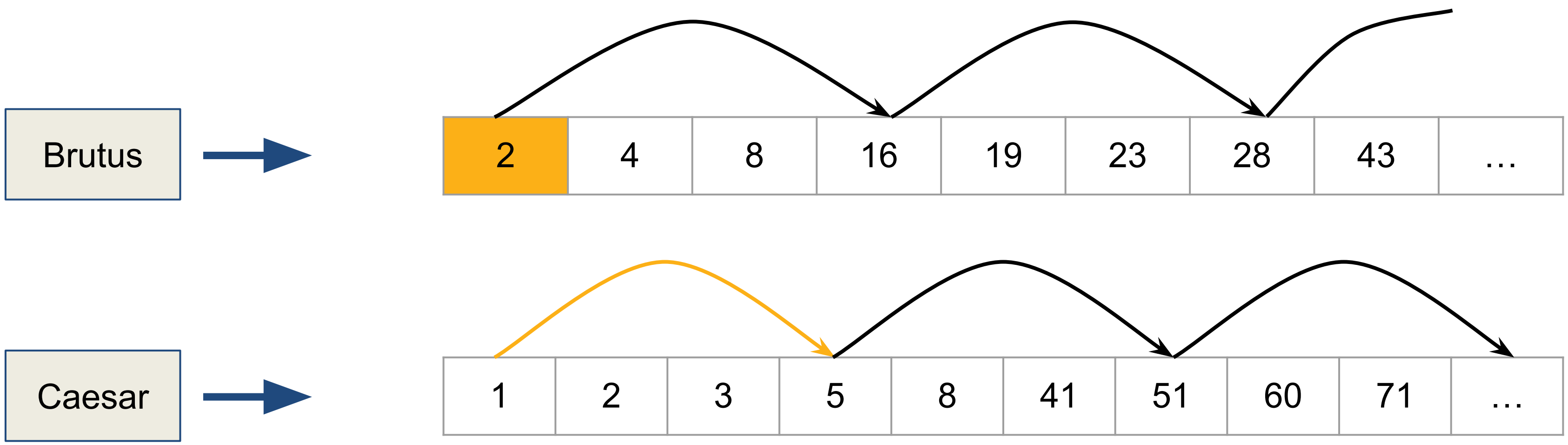

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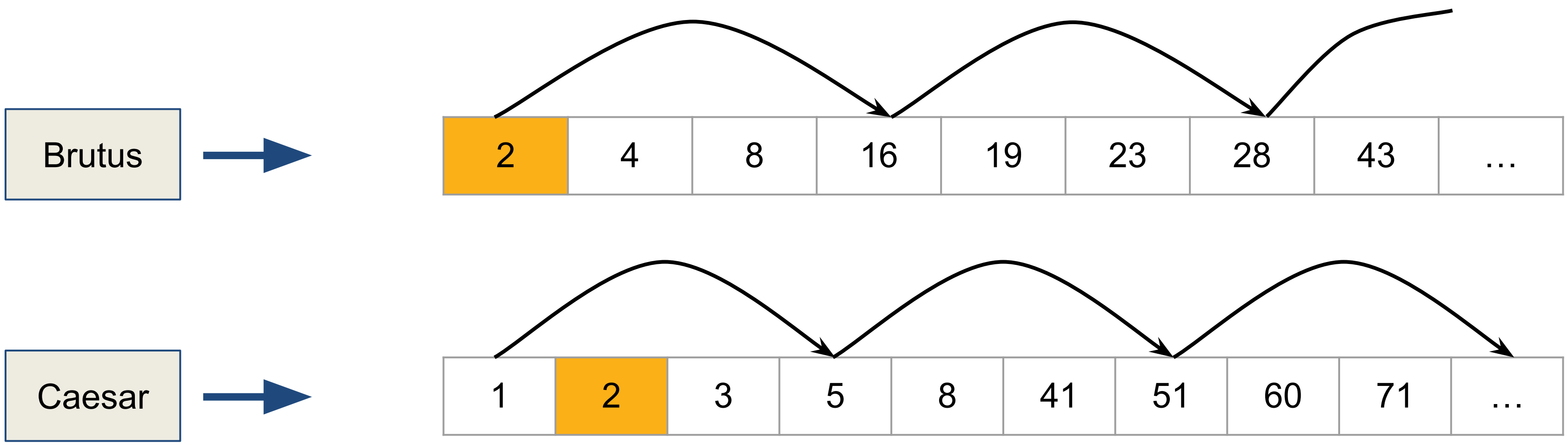

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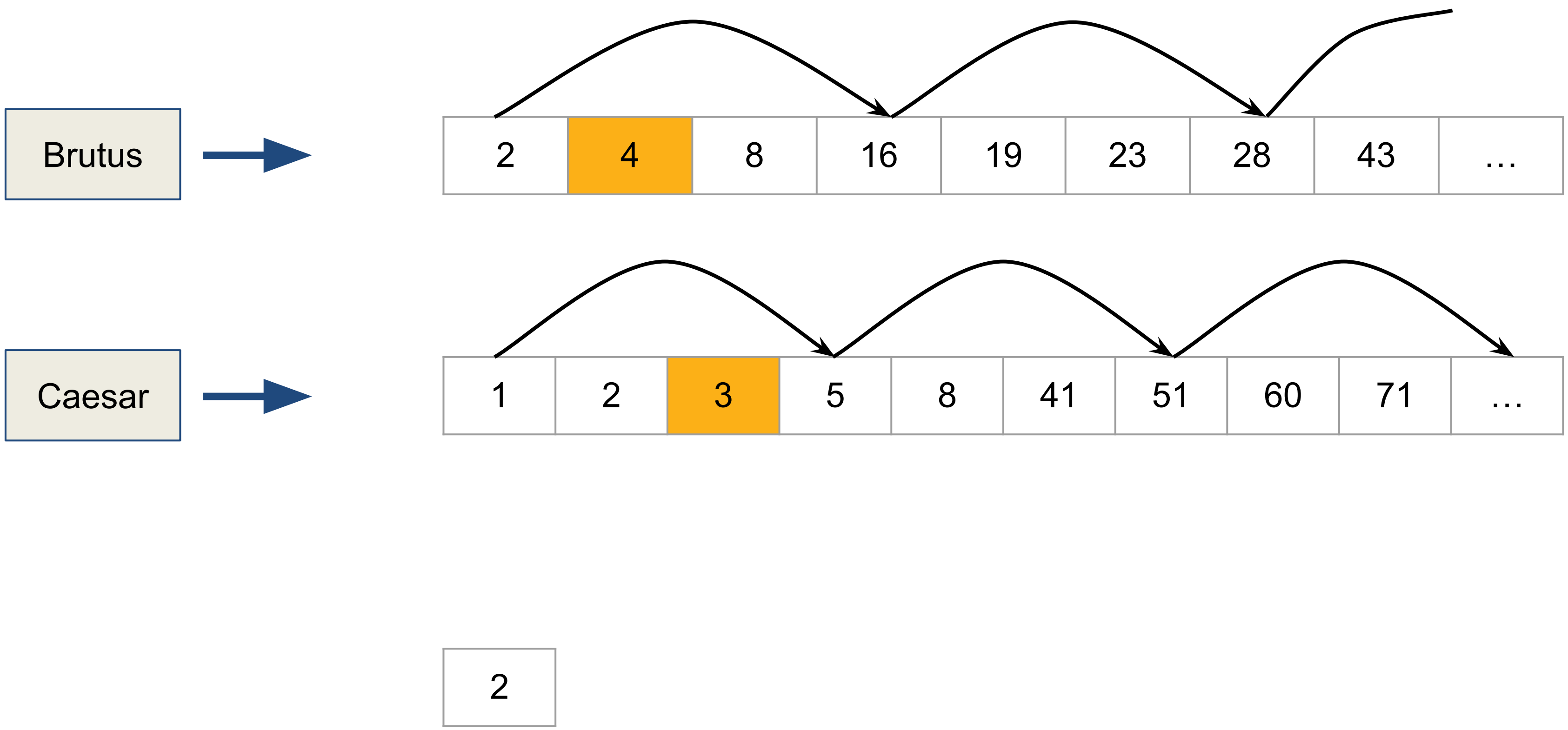

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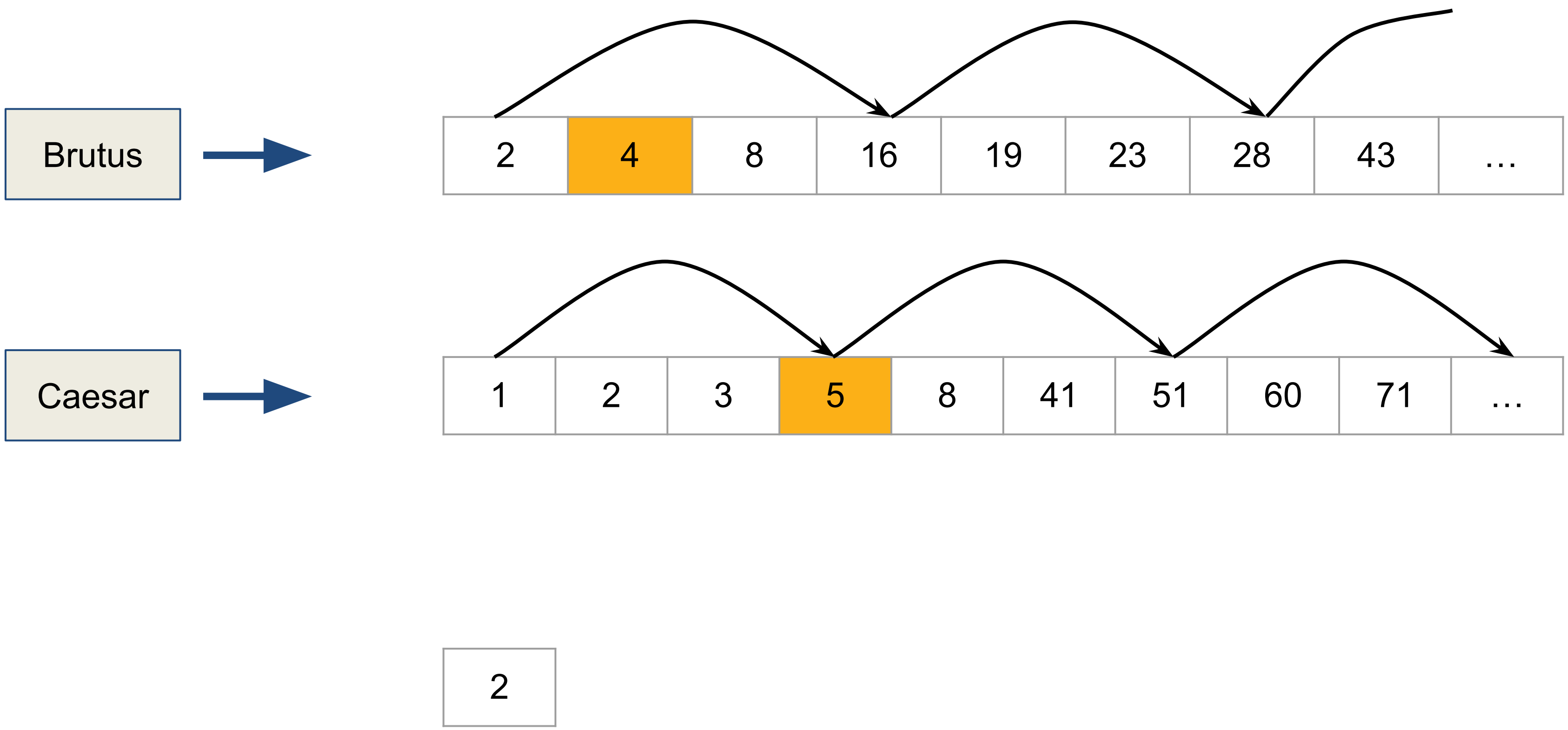

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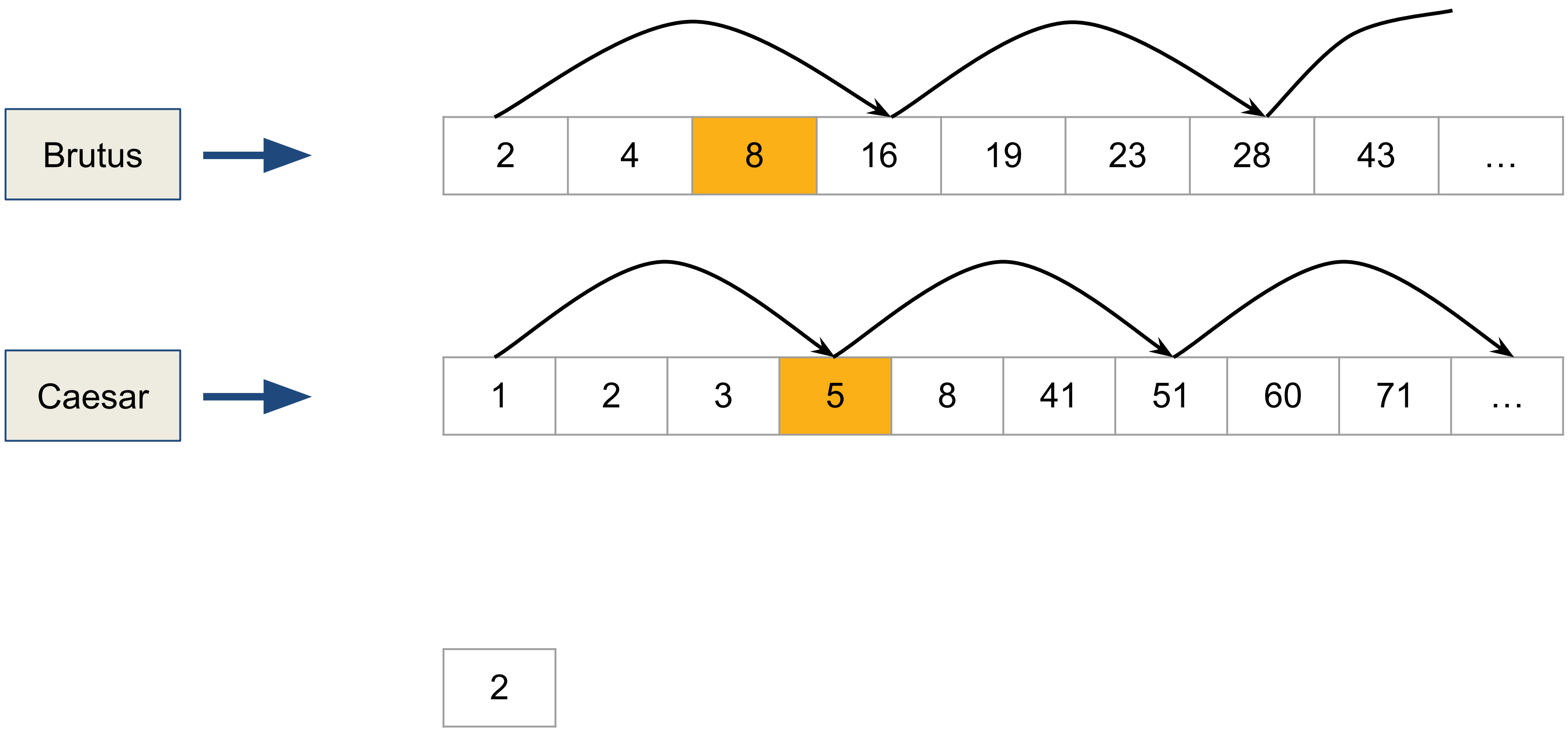

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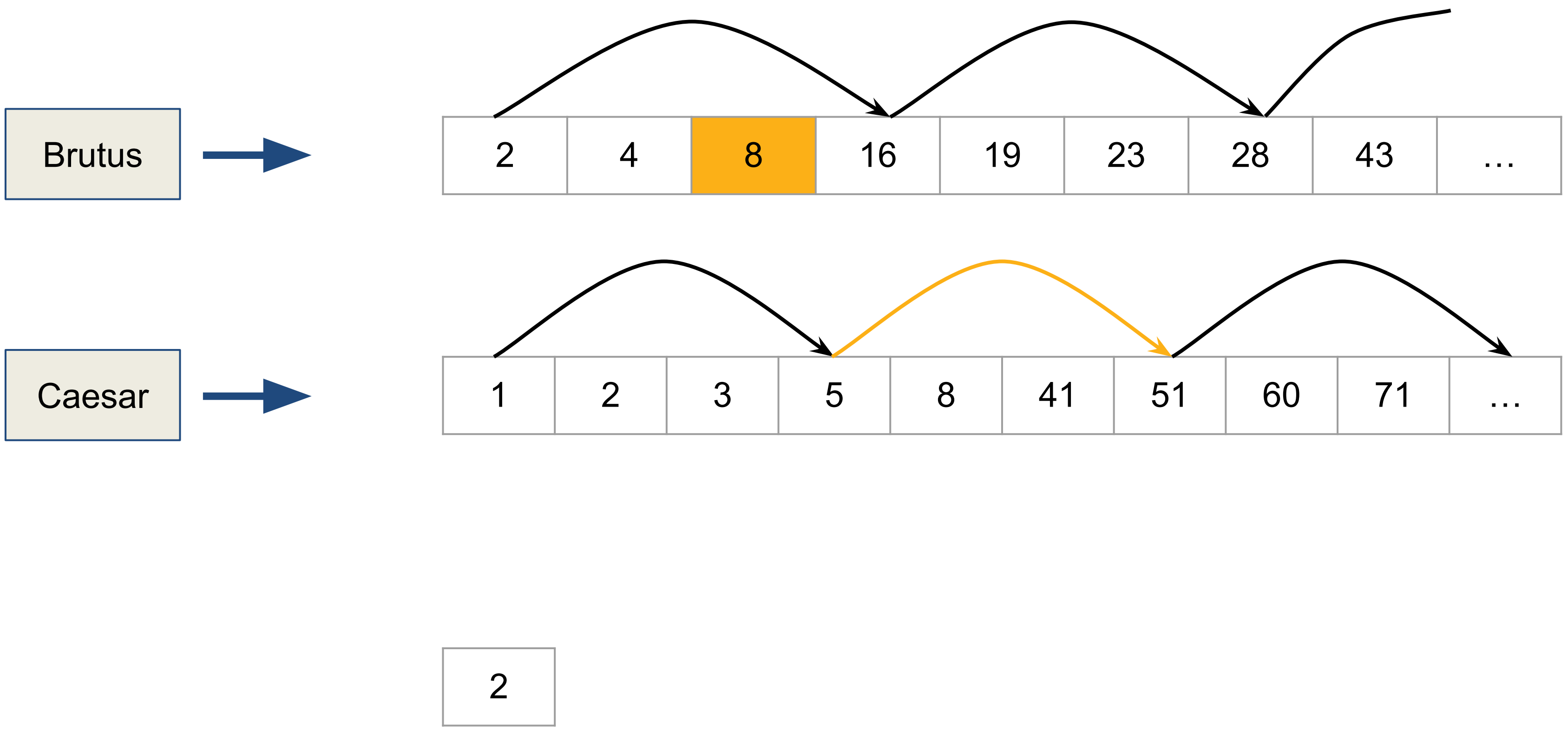

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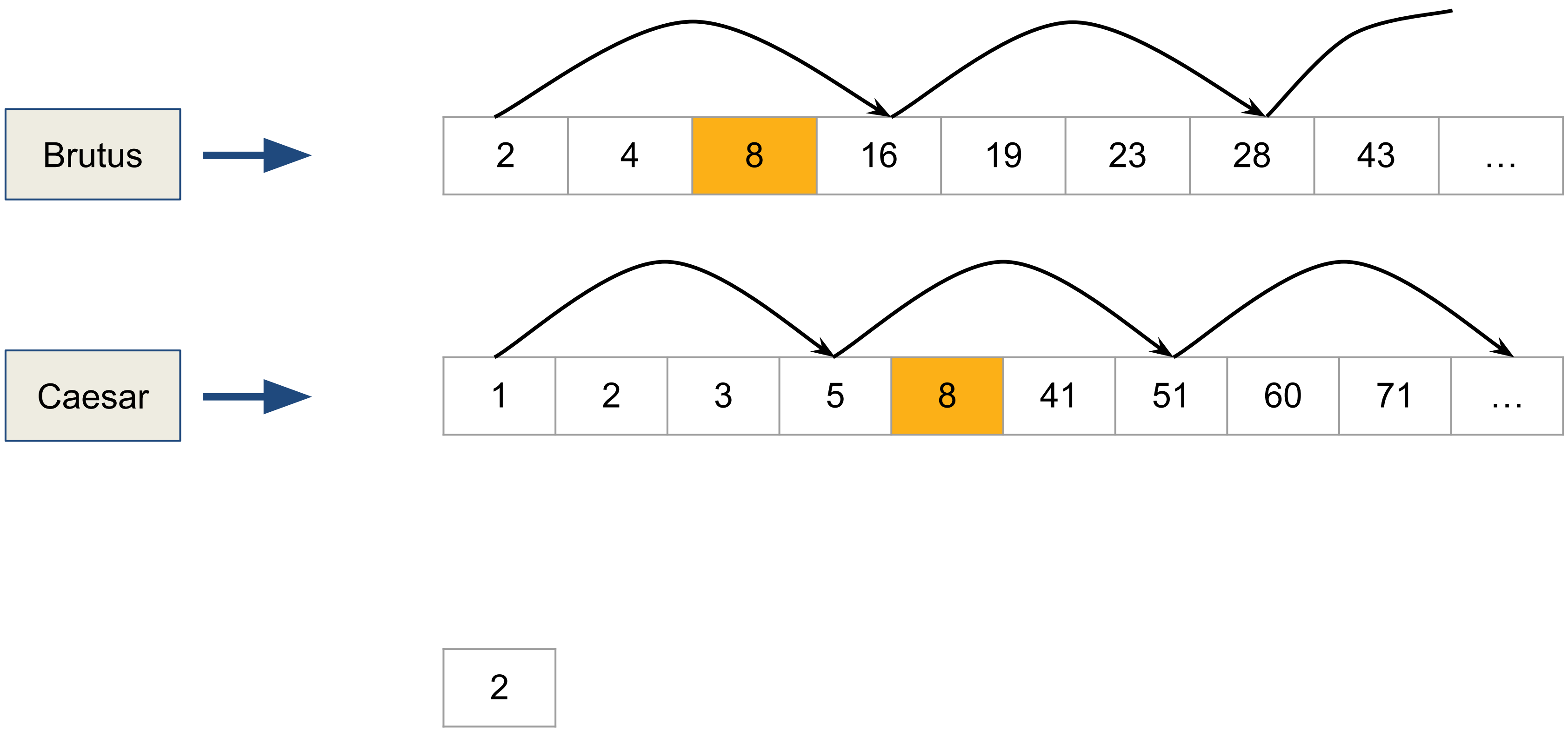

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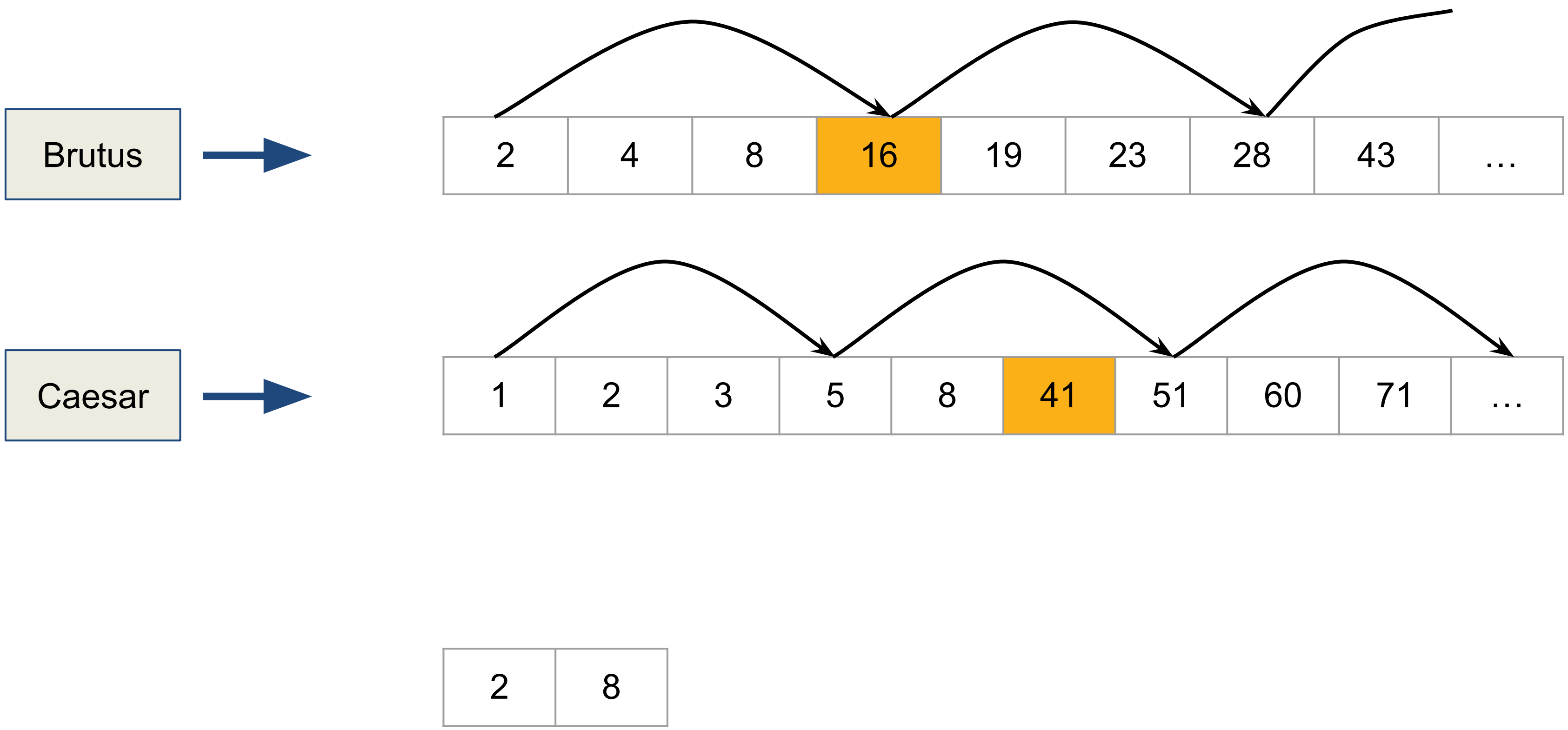

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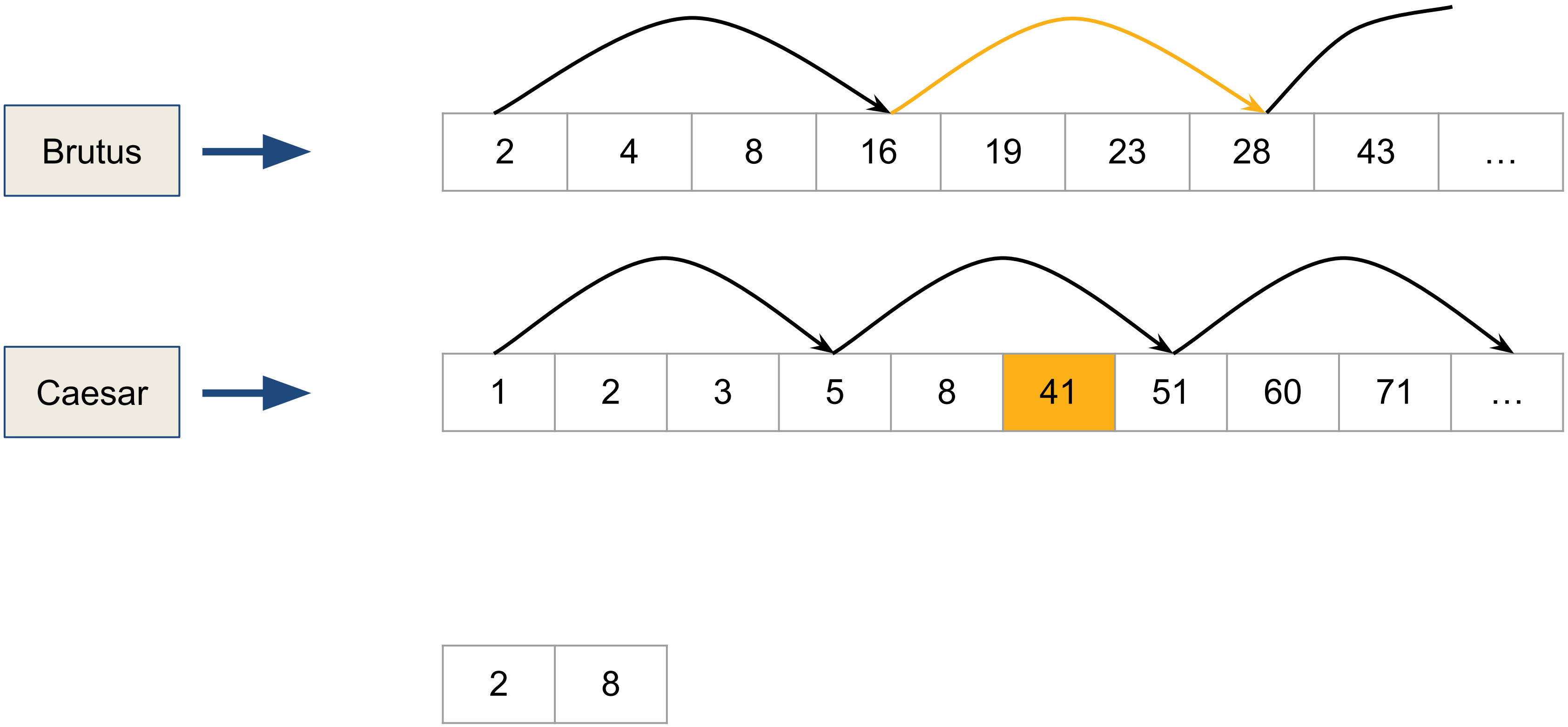

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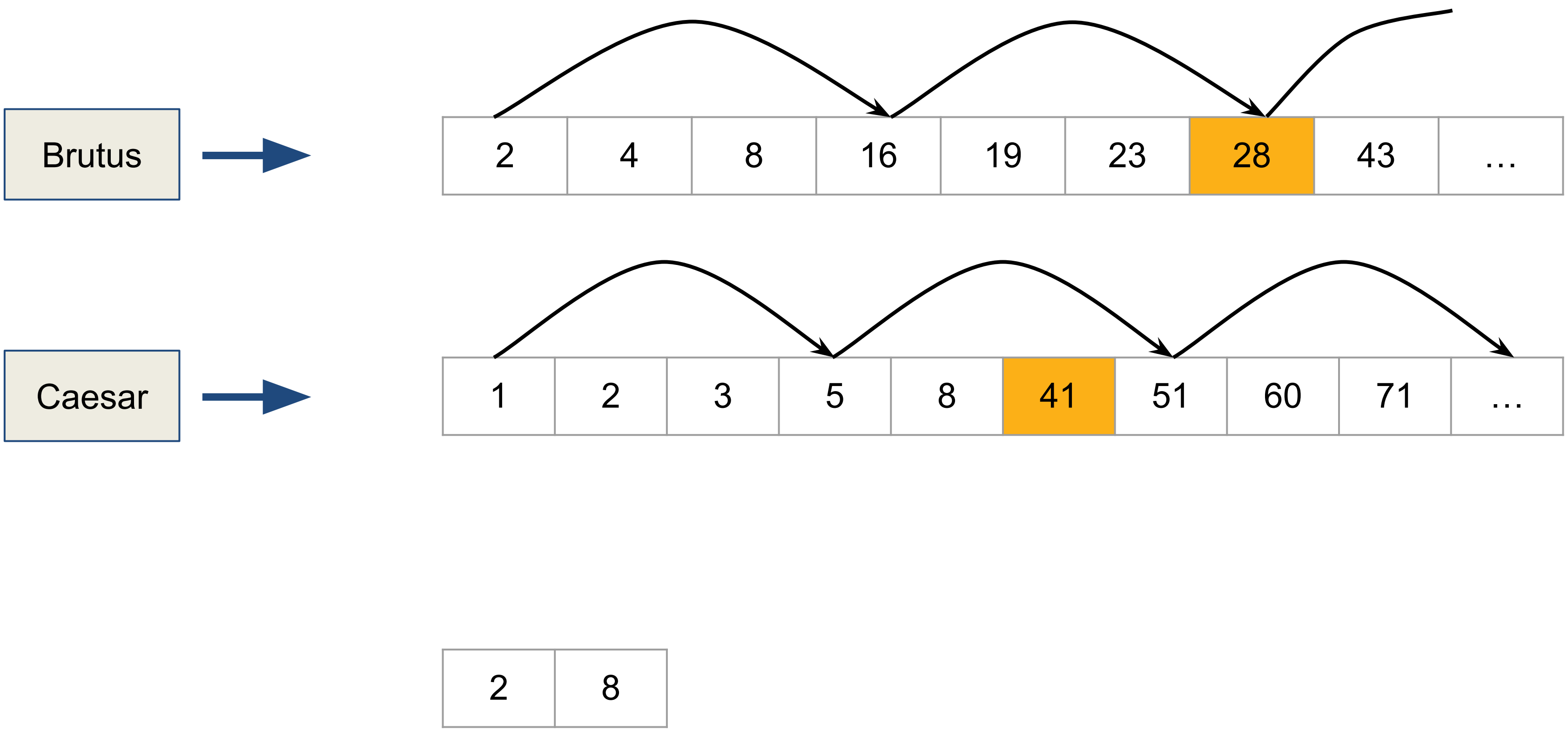

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Algorithm

```
INTERSECTWITHSKIPS(p1, p2)
answer ← ⟨ ⟩
while p1 ≠ NIL and p2 ≠ NIL
do if docID(p1) = docID(p2)
     then ADD(answer, docID(p1))
          p1 ← next(p1)
          p2 ← next(p2)
     else if docID(p1) < docID(p2)
            then if hasSkip(p1) and (docID(skip(p1)) ≤ docID(p2))
                   then while hasSkip(p1) and (docID(skip(p1)) ≤ docID(p2))
                          do p1 ← skip(p1)
                   else p1 ← next(p1)
            else if hasSkip(p2) and (docID(skip(p2)) ≤ docID(p1))
                   then while hasSkip(p2) and (docID(skip(p2)) ≤ docID(p1))
                          do p2 ← skip(p2)
                   else p2 ← next(p2)
return answer
```

Figure 2.10, Introduction to IR, C.D. Manning, P. Raghavan and H. Schütze.

Where to place skip pointers?

- Tradeoff
  - **Too many skip pointers** → Shorter skip span

    Skip pointers will be used more and also number of comparisons related to skip pointers will be high.

  - **Too few skip pointers** → Longer skip span

    Few successful long skips, however most cases will be like linear scan.

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- A simple heuristics that work well in practice: For posting list of size P, use sqrt(P) evenly spaced skip pointers.[1]

[1]Moffat, Alistair, and Justin Zobel. "Self-indexing inverted files for fast text retrieval." *ACM Transactions on Information Systems (TOIS)* 14.4 (1996): 349-379.

Limitations

- Harder to maintain skip pointers if the index is changing frequently because of updates in the documents.
- The posting list size is larger, as these additional pointers need to be stored.
- In modern systems, the I/O cost of loading bigger posting list can be much larger than the benefits gained for quicker in-memory merges.

Questions

- Will skip pointers be useful for queries of the form **x** OR **y**?

- Does skip pointer-based intersection algorithm uses an order of magnitude fewer operations on its worst-case when compared with the normal merge algorithm worst-case?

Positional Postings and Phrase Queries

Phrase Queries

- Several group of words are phrases, i.e., group of words standing together as a conceptual unit. For example, **Stanford University**, **New Delhi**, **New York**.
- We would like that the IR systems, do not consider them as words connected by AND operator.

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Example Query: "Stanford University"
Example Document: "The inventor Stanford Ovshinsky never went to university."

- Shall we consider the above document relevant for the example query?

- **Biword indexes**
- **Positional postings**

Biword indexes

- Consider every pair of consecutive terms in a document as a phrase.

For example, the text Friends, Romans, Countrymen would generate the biwords:

friends romans
romans countrymen

- Two word phrasal queries can be easily answered.

Processing longer phrases in Biword indexes

- Longer phrases can be processed by breaking them down.
- For example: “stanford university palo alto” phrase can be decomposed as:

“stanford university” AND “university palo” AND “palo alto”

- Does the documents retrieved by the above decomposed query always contains the original phrase?

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- Does the documents retrieved by the above decomposed query always contains the original phrase? **NO**

Extended Biword index

- Phrases of form: “the abolition of slavery”, “renegotiation of the constitution”.
- Here nouns and noun phrases which describe important concepts are separated from each other by various function words.
- In such cases, use Part-Of-Speech tagging.

renegotiation	of	the	constitution
N	X	X	N

- Now any string of term form NX*N can be considered as a biword.

Extended Biword index

Example:

The query,

cost overruns on a power plant

is parsed into

“cost overruns” AND “overruns power” AND “power plant”

Limitations of Biword Indexes

- How can we retrieve documents for single term query using biword indexes?
- Index size blow up due to large vocabulary of biwords.
- Is effective for phrases of more that two words, however, does not always return correct answers.

Positional postings

Positional Indexes

- While indexing a term, also store the position where the term appeared in the document.

Positional Indexes

to, 993427:

(1, 6: (7, 18, 33, 72, 86, 231);

2, 5: (1, 17, 74, 222, 255);

4, 5: (8, 16, 190, 429, 433);

5, 2: (363, 367);

7, 3: (13, 23, 191); …)

be, 178239:

(1, 2: (17, 25);

4, 5: (17, 191, 291, 430, 434);

5, 3: (14, 19, 101); …)

Example from Figure 2.11, Introduction to IR, C.D. Manning, P. Raghavan and H. Schütze.

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Proximity Search

- Positional indexes can be used for proximity searches.
- Example: house /4 brick
  Find all documents that contain house and brick within four words of each other.

  Relevant phrases could be:

      red brick house
      red house of brick
      house made of red brick

Combination schemes

- Usually biword indexing and positional indexing can be combined.
- There are several biwords that are extremely frequent. For example, New York, Narendra Modi, Donald Trump.
- **Combination scheme:** Index frequent biwords and other phrases using positional indexes.
- The most speedup will be when the two words are common but the desired phrase is rare. Example: “The Who”.

Collocations

- In corpus linguistics, a **collocation** is a series of words or terms that co-occur more often than would be expected by chance.

Example: Red Wine, New York, strong tea, powerful computer, heavy rail.
vs Yellow Wine, Latest York, powerful tea, strong computer, thick rain.

How to Find Collocations?

- Bigram Frequency based methods.
- Bigram frequency + POS tag frequency.

Advantages:

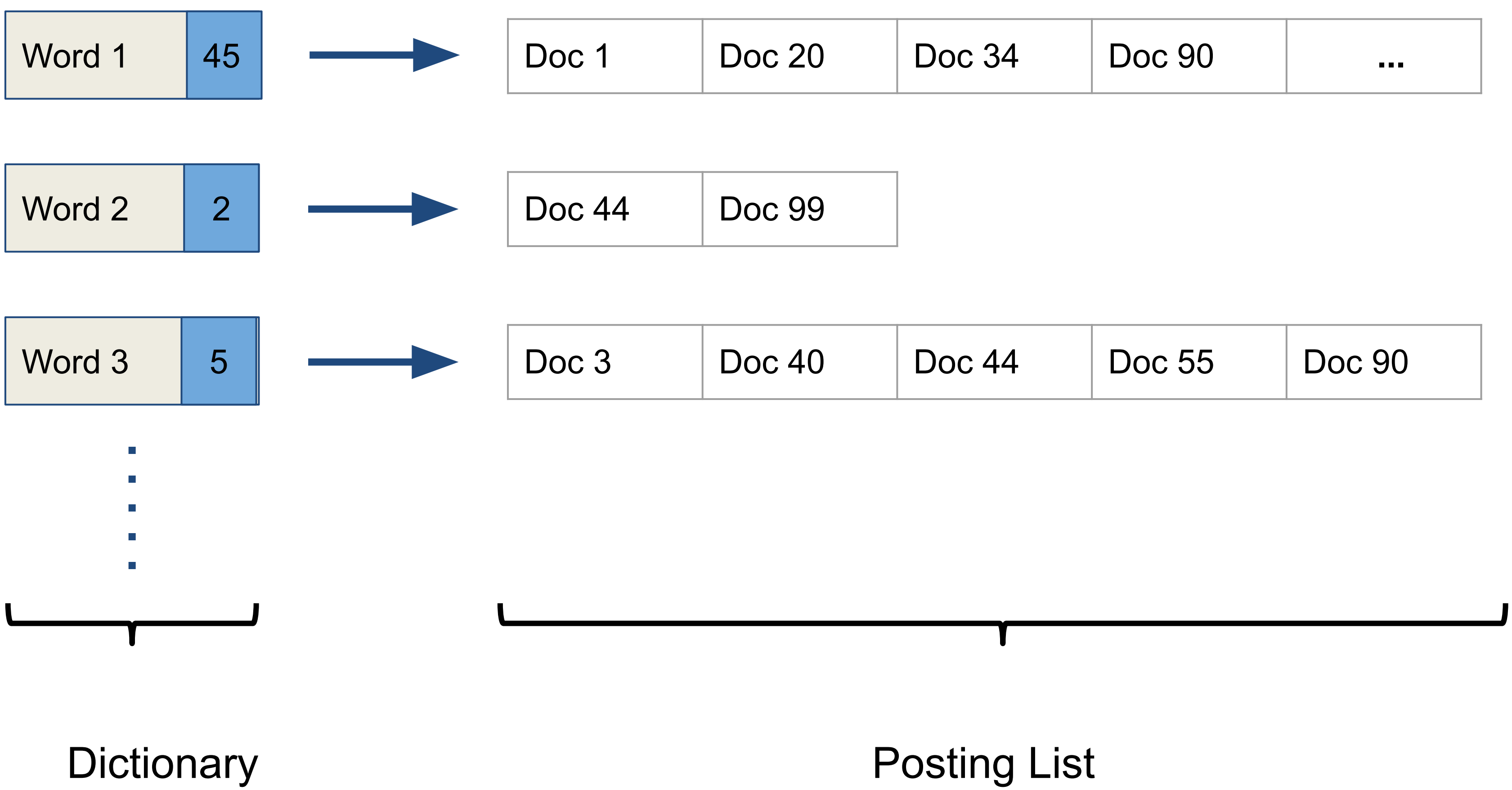
- Simple methods

Disadvantages:

- High frequency can sometimes be random, without any specific meanings.
- Works only for fixed length phrases but not for:
  - She <u>knocked</u> on his <u>door</u>.
  - They <u>knocked</u> at the <u>door</u>.

Dictionaries, Tolerant Retrieval

Dictionary data structures for inverted index



What could be underlying implementation?

- How to store a dictionary in memory efficient way?
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- Hash tables
- Trees

Reference

https://nlp.stanford.edu/IR-book/

Chapter 2

Thank You!