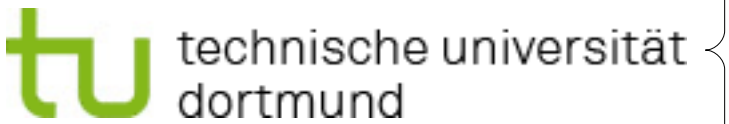
16th International Symposium on Experimental Algorithms

Compression with the tudocomp framework



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Kunihiko Sadakane

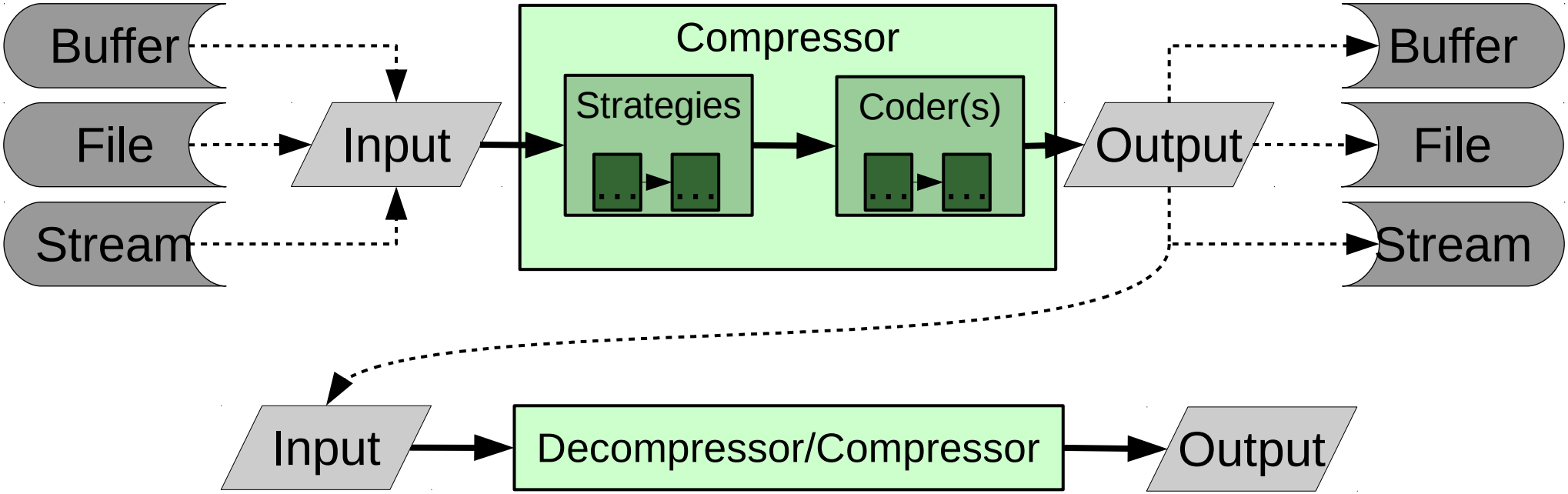
Version: Jun 25, 2017

The tudocomp framework

tudocomp

A C++ framework
for engineering new
text compression algorithms

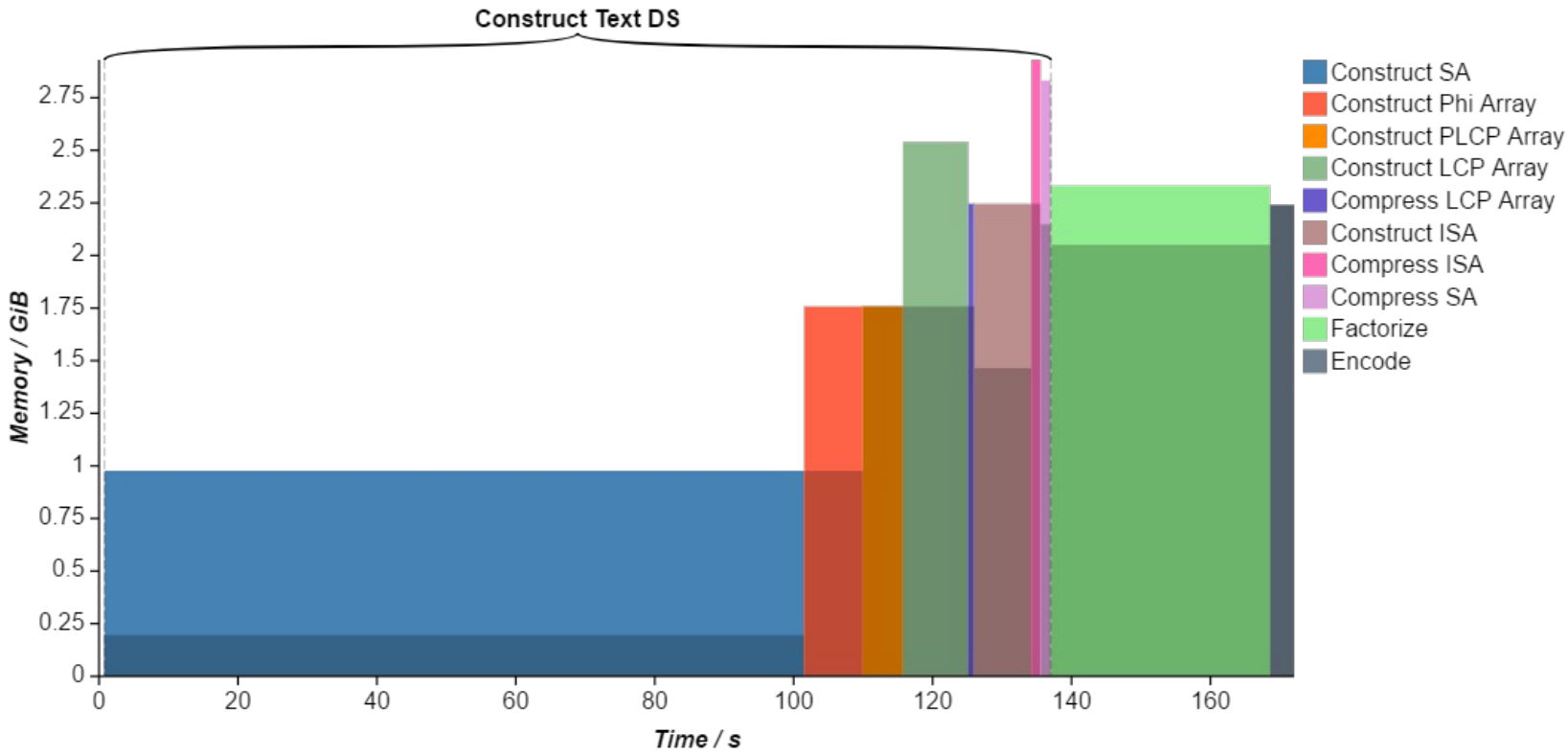
tudocomp – Modularity



tudocomp – Statistics

Time and memory allocation measurement

- Execution partitioned into *phases*
- Logging to JSON dataset, chart visualization



tudocomp – Components

Compressors

- LZ77
- LZ78
- LZW
- **lcpcomp (new)**

Lempel-Ziv family

- BWT+MTF+RLE
- Re-Pair
- *Longest-First**
- *ESP**

grammar compressors

Integer Coders

- Elias γ and δ
- vByte
- Rice

Statistical Coders

- Huffman
- Arithmetic

* in development (theses)

tudocomp – Command-Line

Algorithm selection via the command-line

```
./tdc -a 'lzw(coder = ascii, lz78trie = ternary)' -g 'fib(4)' --usestdout
```

tudocomp – Benchmarking

- Automatic download of benchmark text collections (including Pizza & Chili corpus)
- Tool to compare multiple compressors on the same input

Compressor	C Time	C Memory	C Rate	D Time	D Memory	chk
lcpcomp	103.1s	3.2GiB	2.8505%	36.6s	7.6GiB	OK
lz77	98.5s	2.9GiB	4.0530%	4.3s	230.6MiB	OK
bwt+mtf+rle	83.6s	1.7GiB	6.8688%	22.6s	1.4GiB	OK
huffman	2.7s	230.5MiB	28.1072%	5.9s	30.6MiB	OK
lzw	14.3s	480.9MiB	23.4411%	5.5s	452.6MiB	OK
lz78	13.6s	480.8MiB	29.1033%	10.3s	142.9MiB	OK
gzip -9	107.6s	6.6MiB	26.2159%	1.0s	6.6MiB	OK
bzip2 -9	13.8s	15.4MiB	25.2368%	5.6s	11.7MiB	OK
lzma -9	138.6s	691.7MiB	1.9047%	337.3ms	82.7MiB	OK

tudocomp – API

String Generators

- Random (uniform) strings
- Thue-Morse sequences
- Fibonacci words

Succinct Data

- Bit-Compact integer vectors
- Bitwise I/O streaming

Text Data Structures

- Suffix array: divsufsort
- LCP array
  - Kasai / Φ algorithm
  - PLCP array

tudocomp – Website

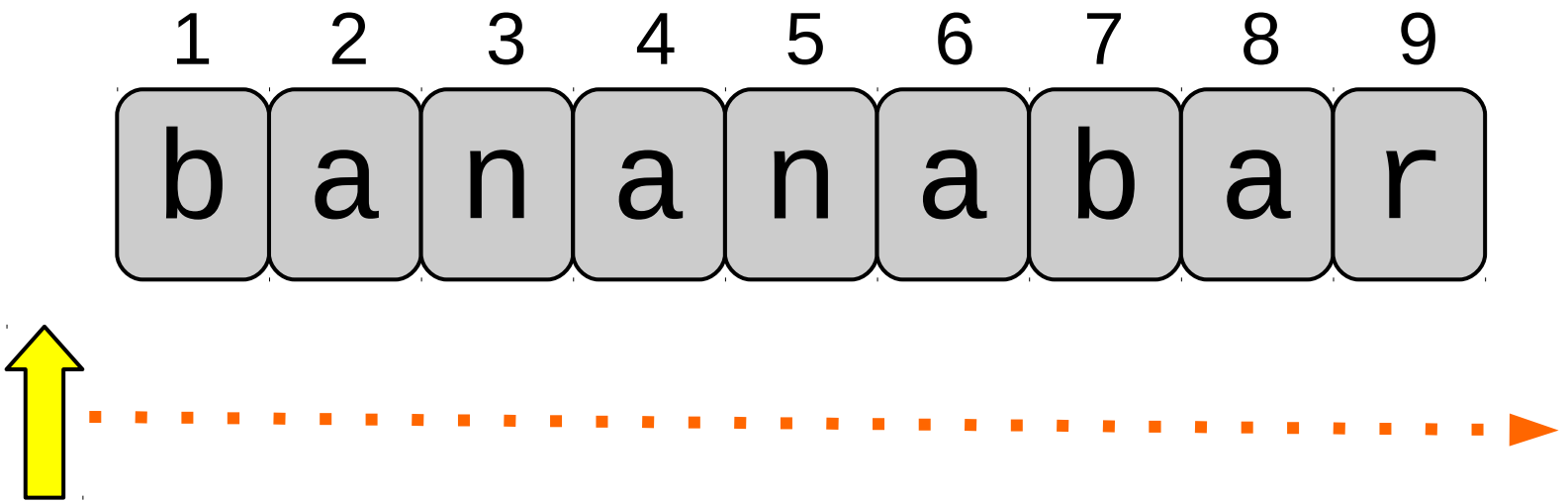
http://tudocomp.org

tudocomp - Application

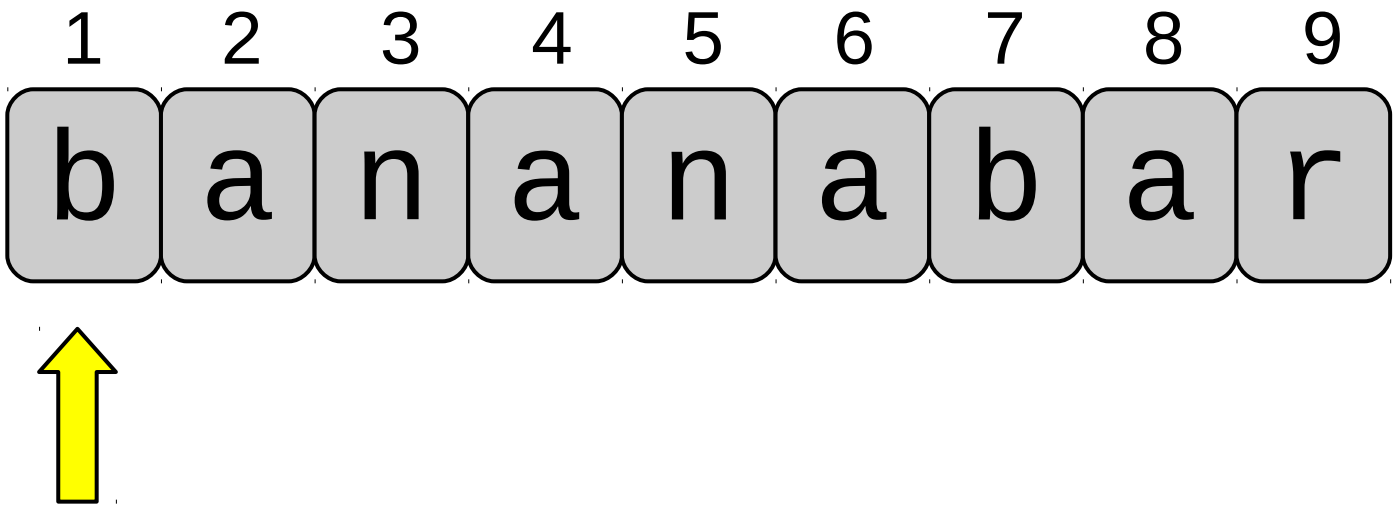
Two showcases for tudocomp:

- LZ77 (without window)
- lcpcomp (new algorithm)

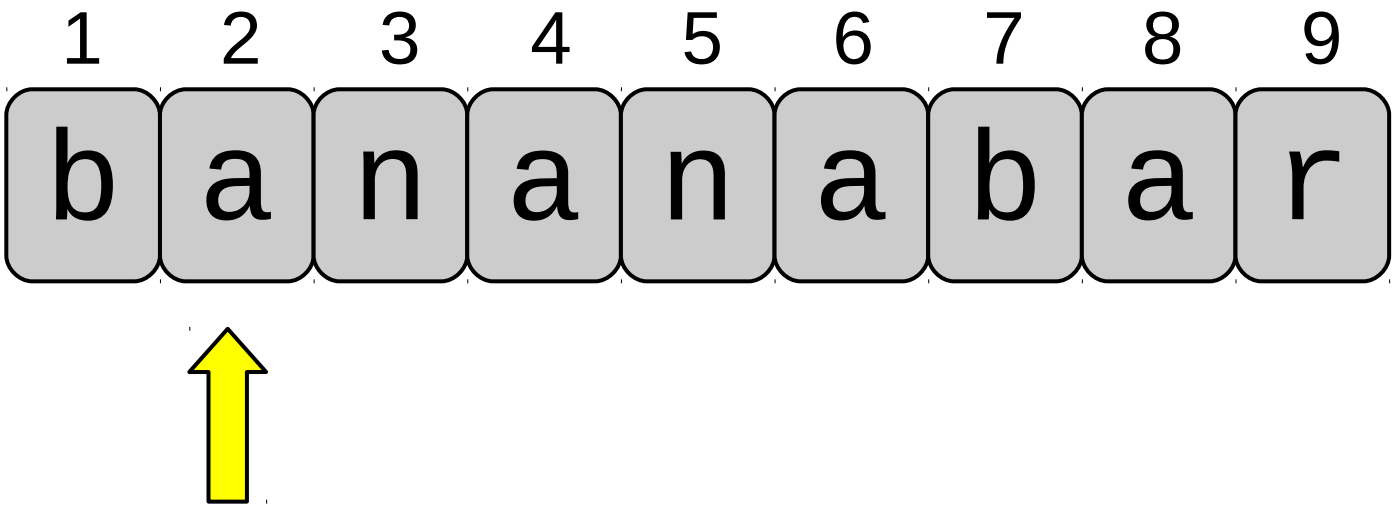
LZ77



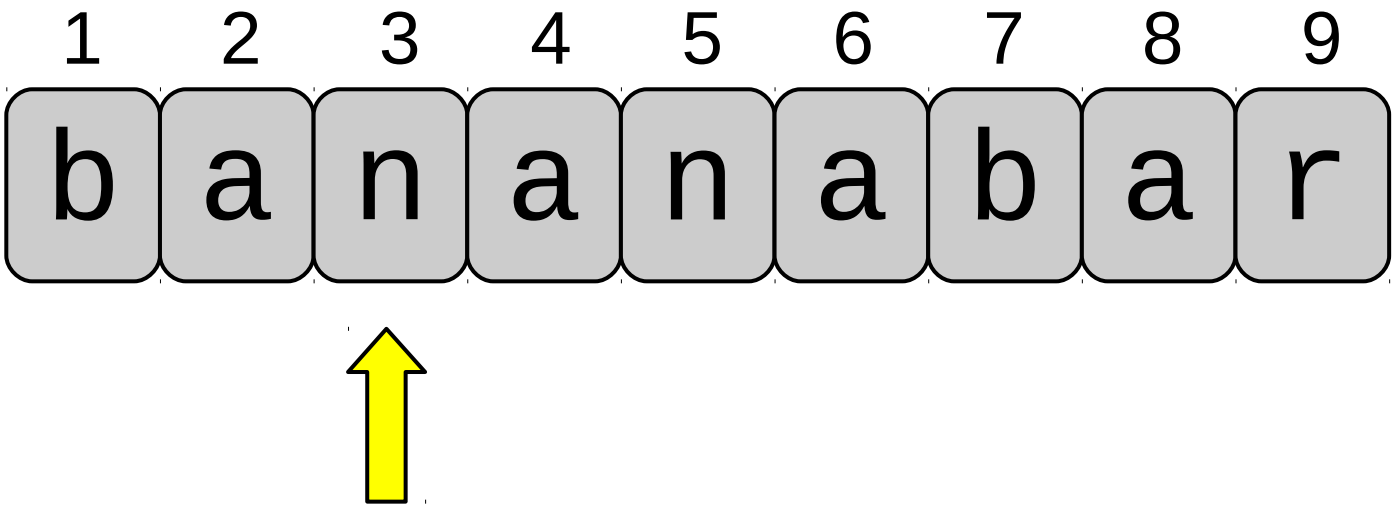
LZ77



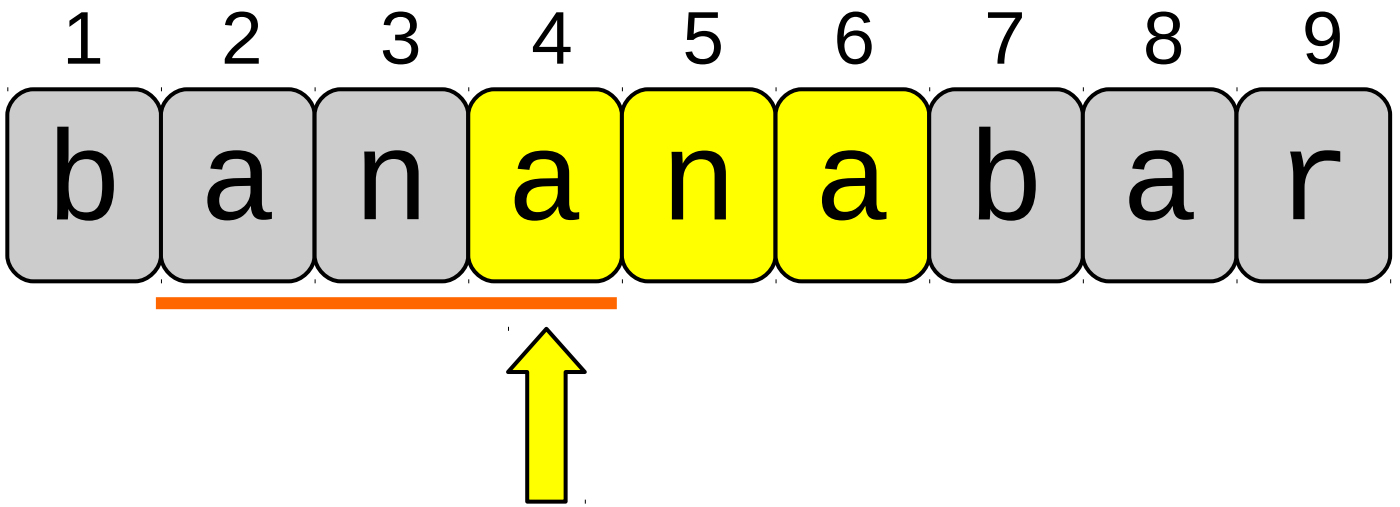
LZ77



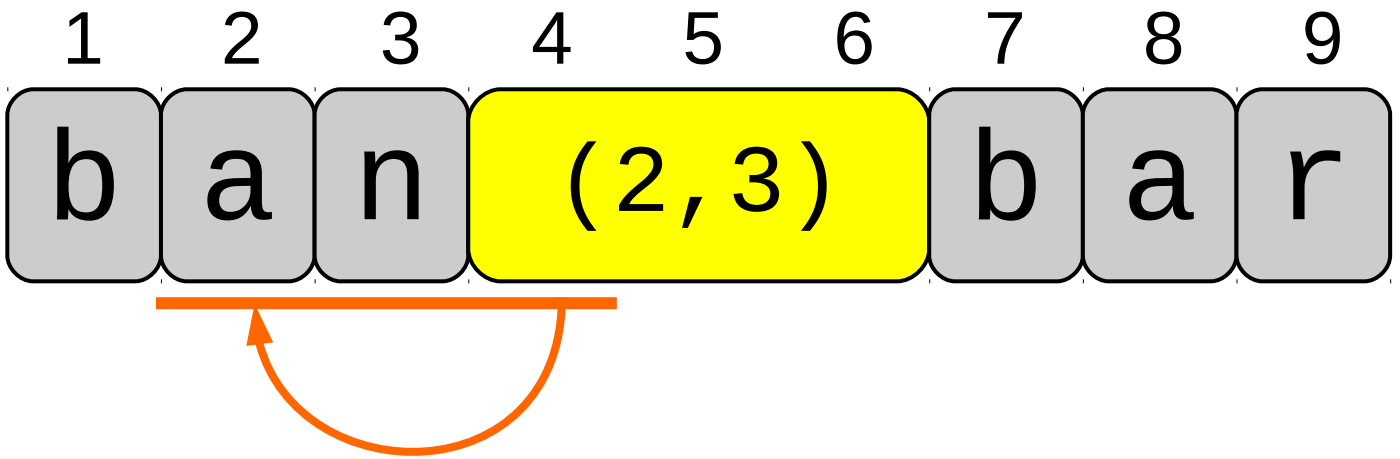
LZ77



LZ77

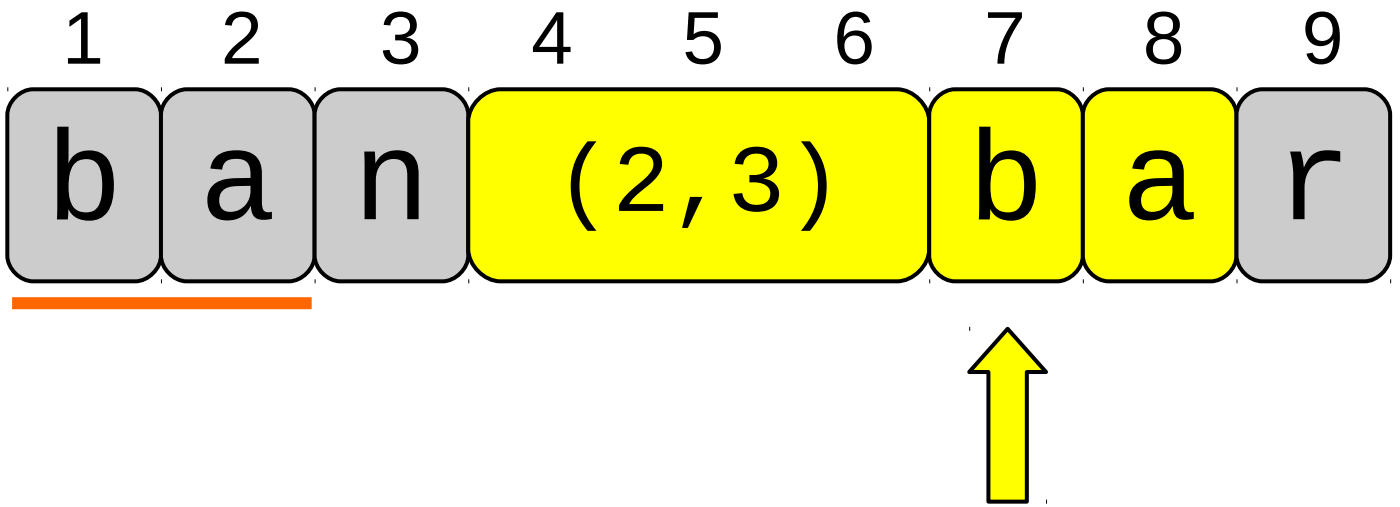


LZ77

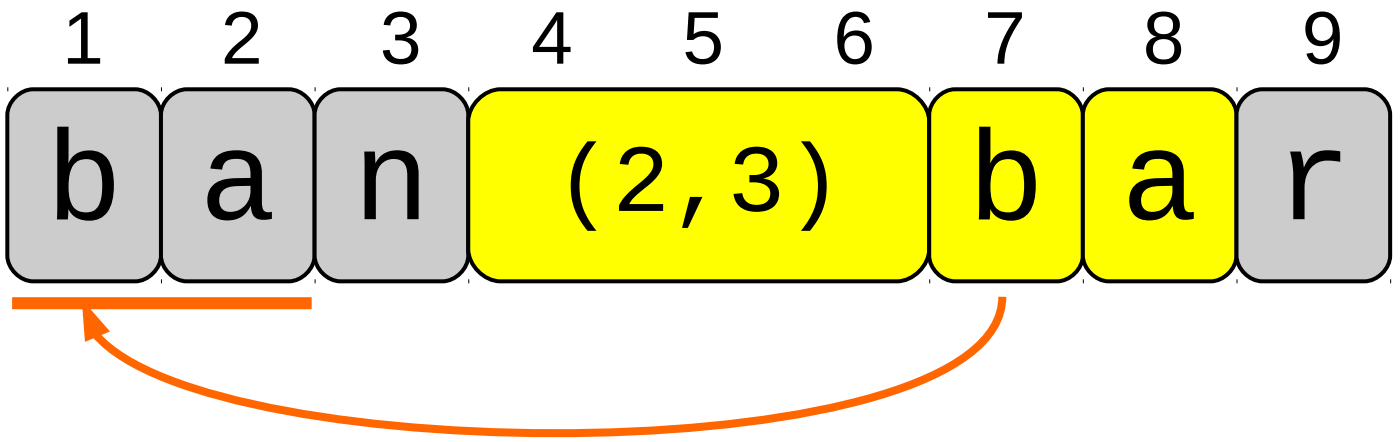


*Starting from position **2**, copy **3** symbols.*

LZ77

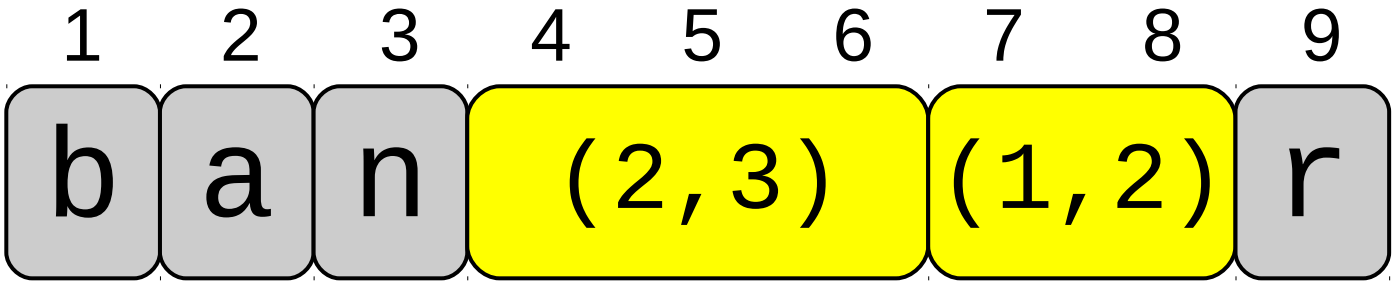


LZ77

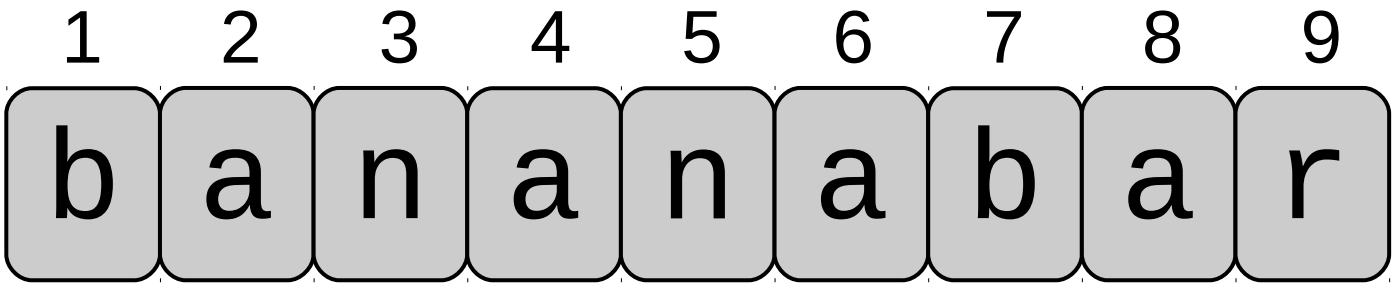


*Starting from position **1**, copy **2** symbols.*

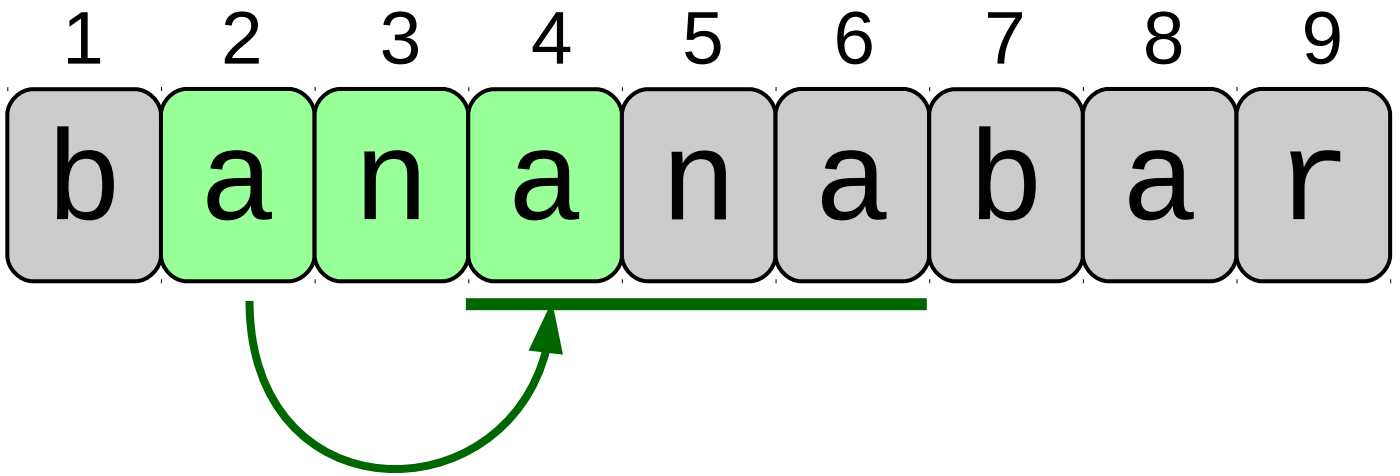
LZ77



lcpcomp

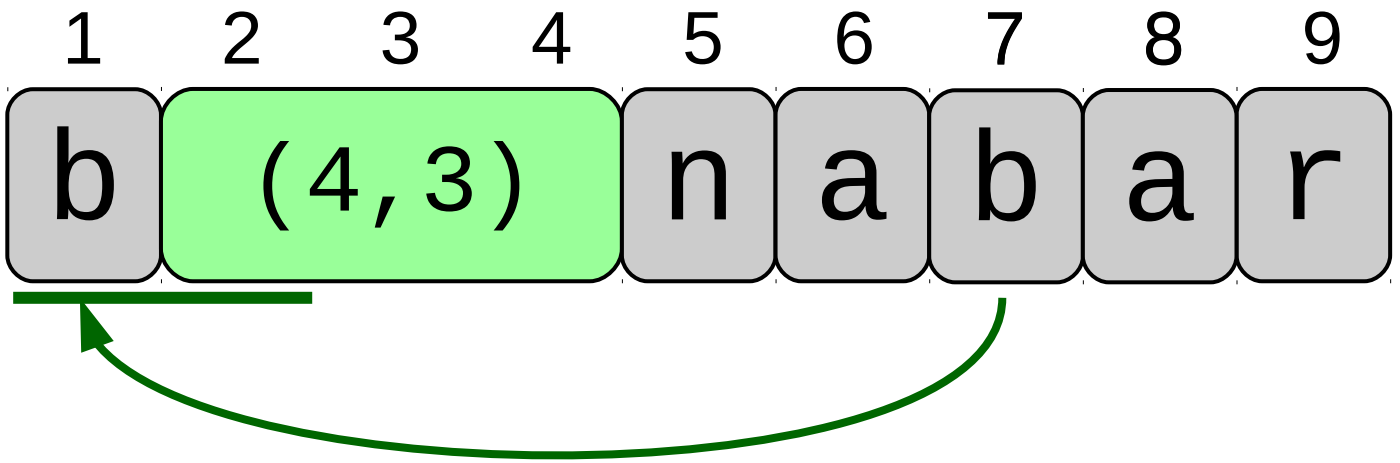


lcpcomp



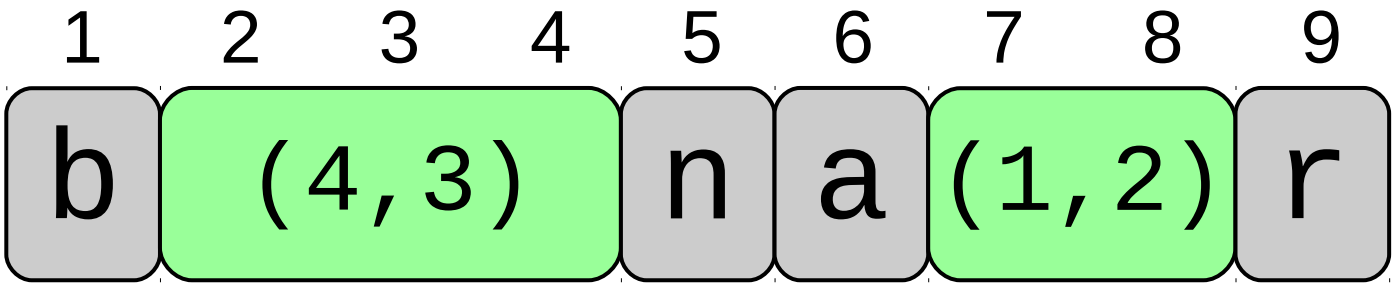
*Starting from position **4**, copy **3** symbols.*

lcpcomp

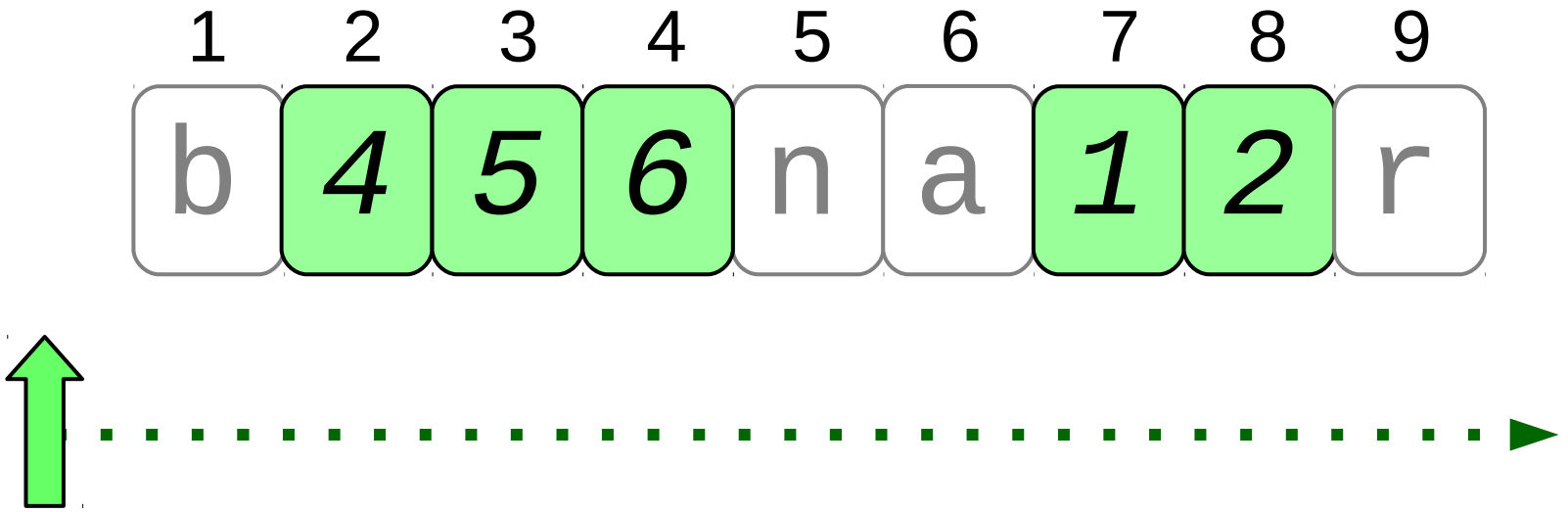


*Starting from position **1**, copy **2** symbols.*

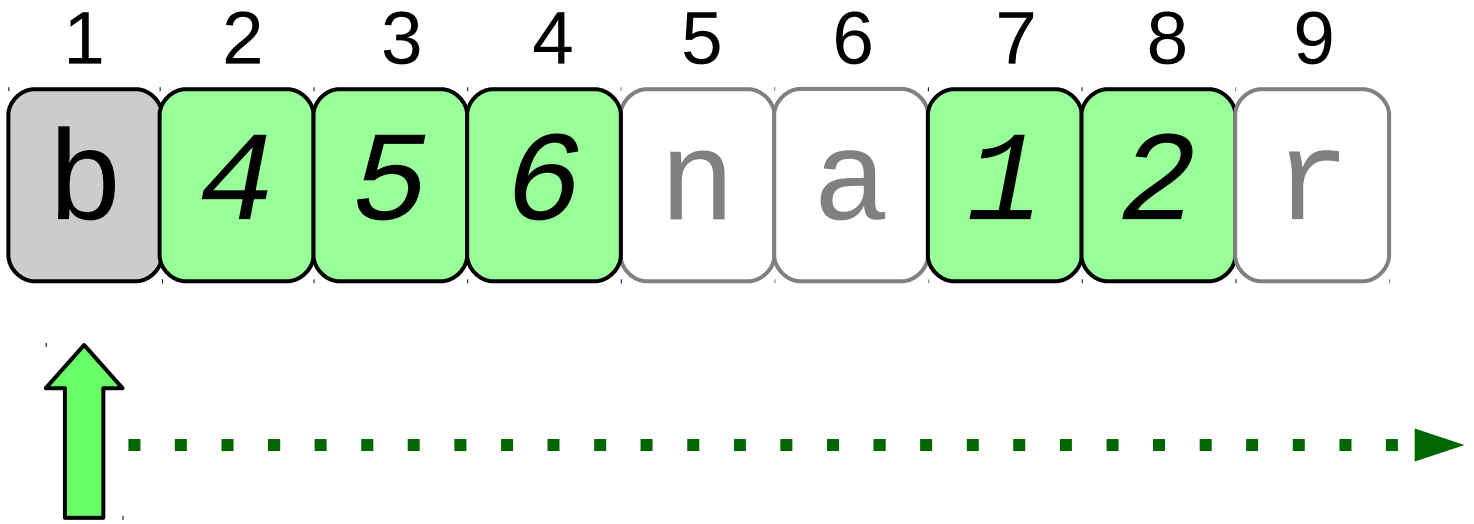
lcpcomp



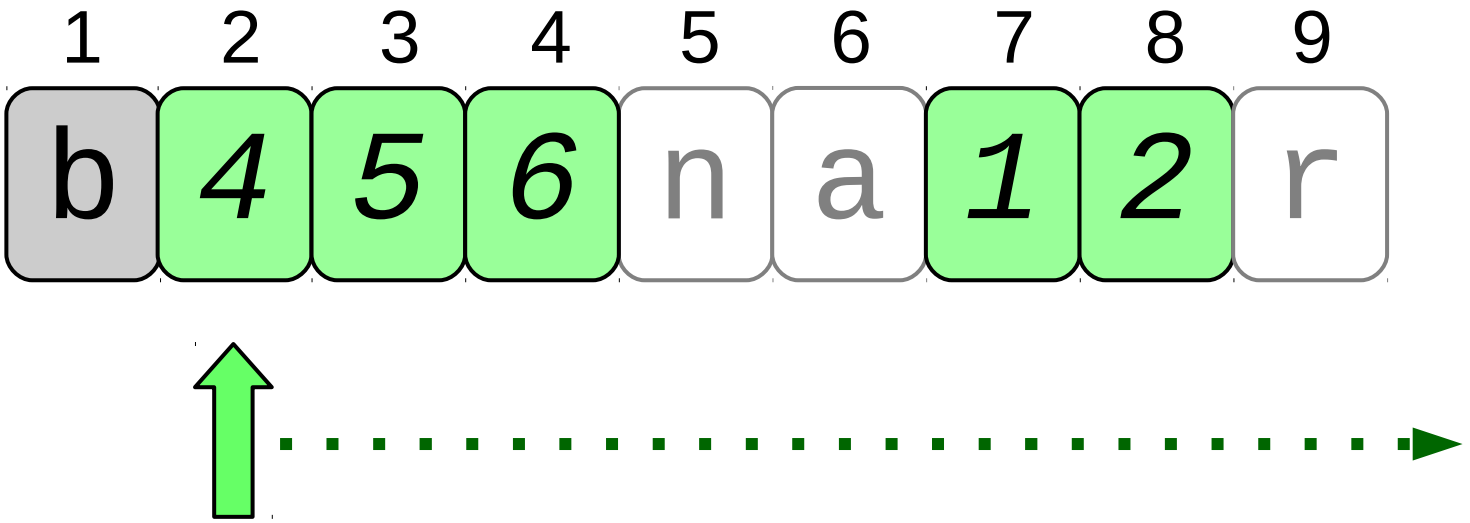
lcpcomp – Decoding



lcpcomp – Decoding

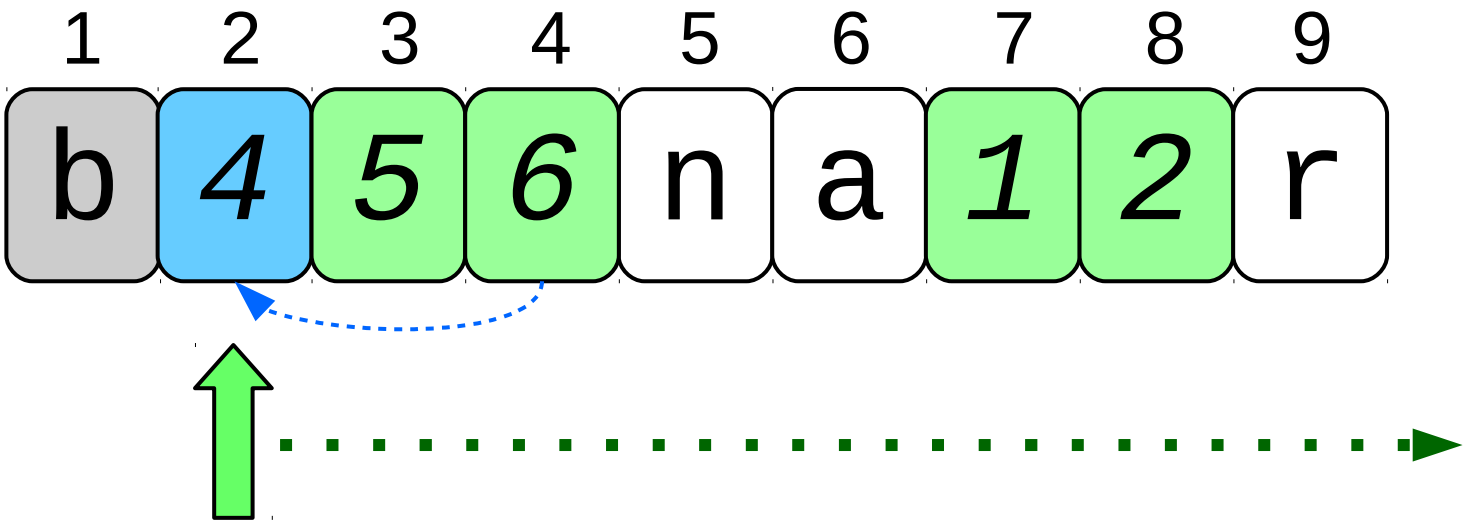


lcpcomp – Decoding



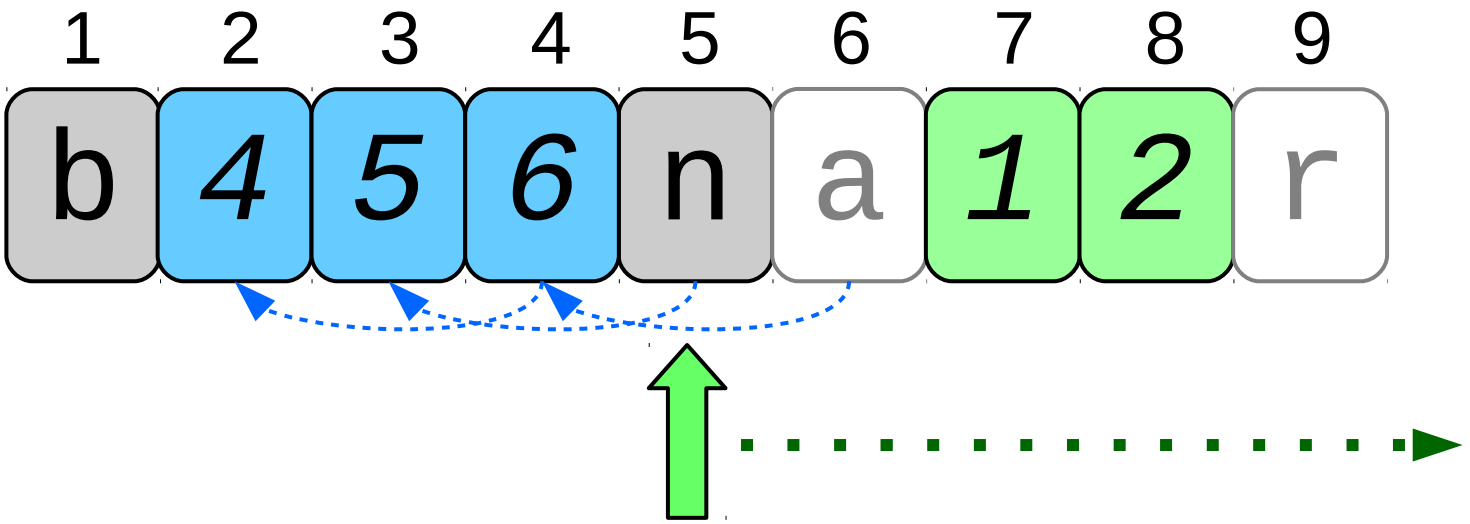
Position 4 not yet decoded → “Wait”

lcpcomp – Decoding



Position 4 not yet decoded → “Wait”

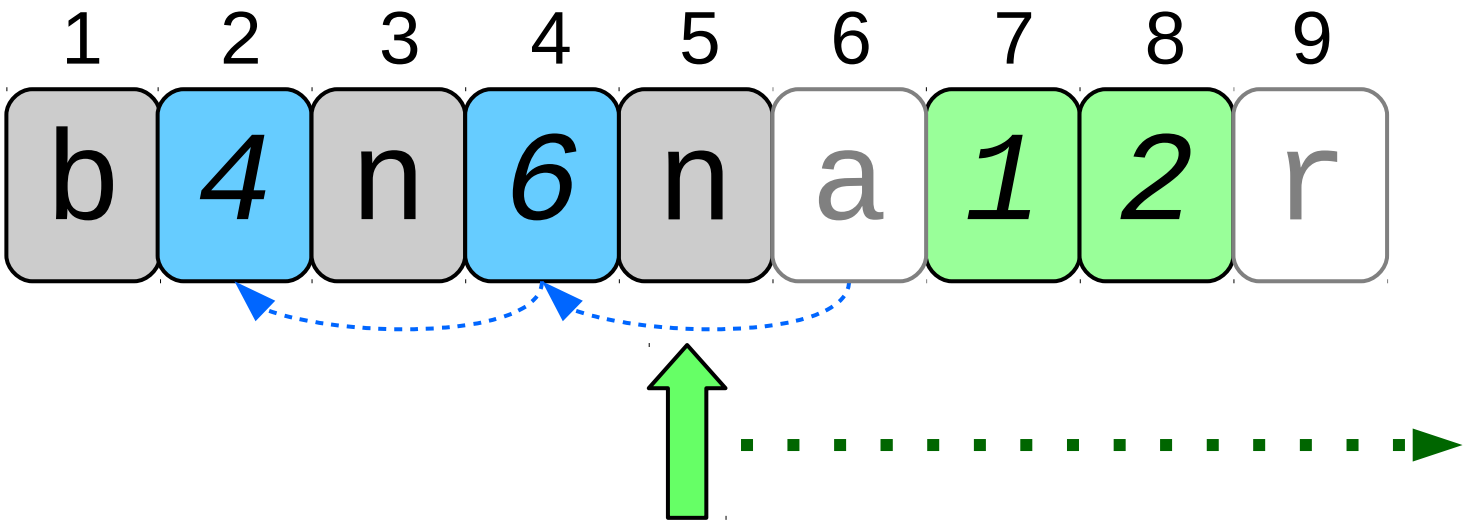
lcpcomp – Decoding



Position 5 is now decoded

→ *“Tell everyone who is waiting for 5.”*

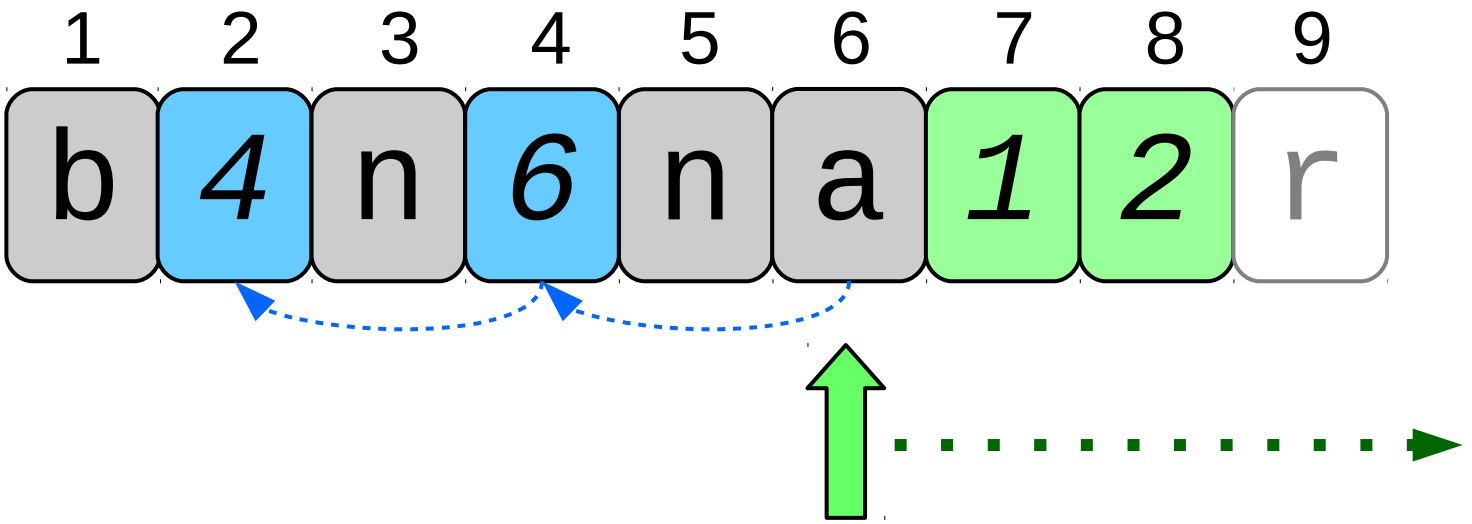
lcpcomp – Decoding



Position 5 is now decoded

→ *“Tell everyone who is waiting for 5.”*

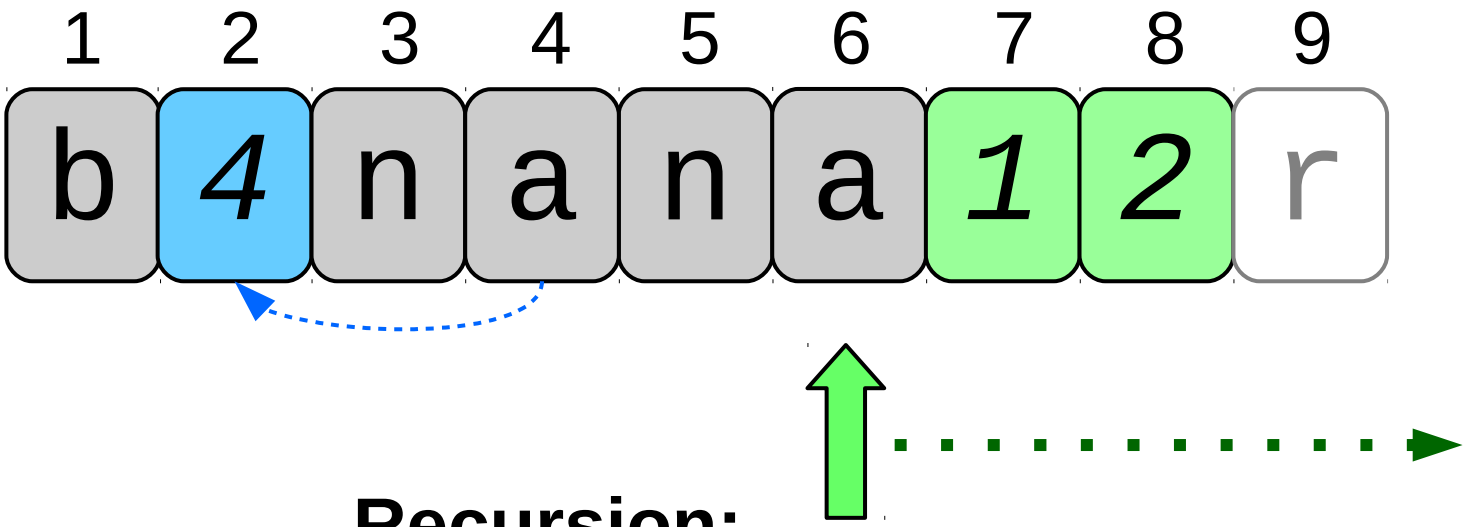
lcpcomp – Decoding



Position 6 is now decoded

→ *“Tell everyone who is waiting for 6.”*

lcpcomp – Decoding

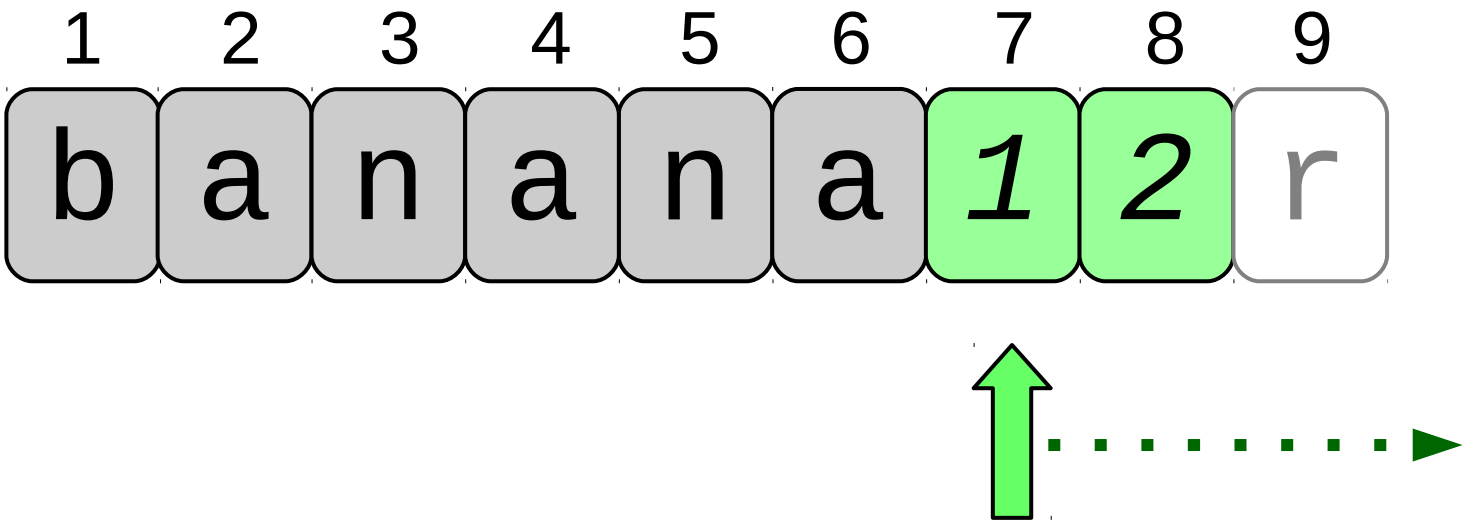


Recursion:

Position 4 is now decoded

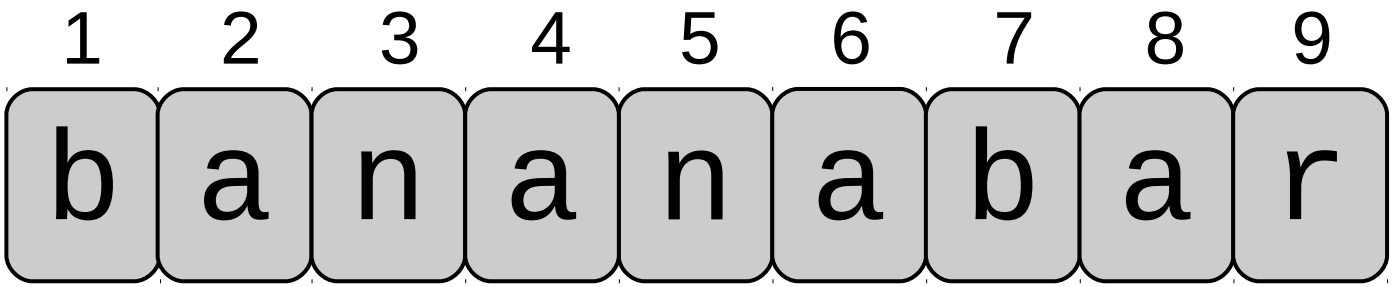
→ *“Tell everyone who is waiting for 4.”*

lcpcomp – Decoding



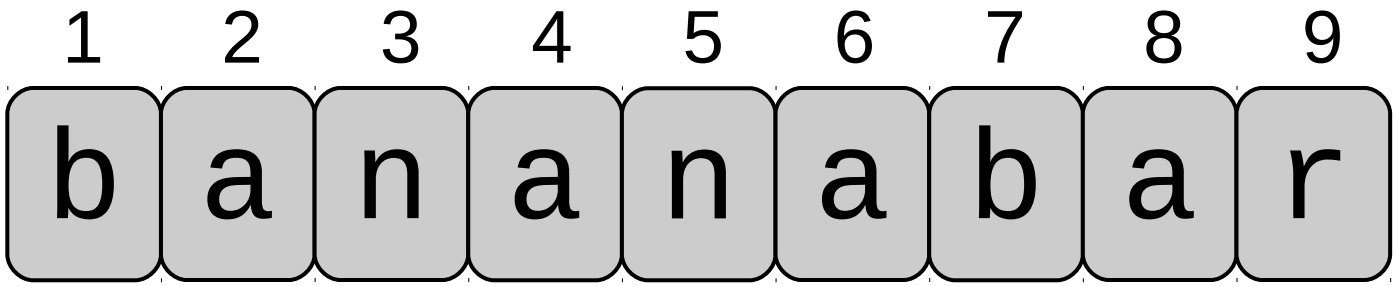
Positions 1 and 2 are already decoded → “Read”

lcpcomp – Decoding

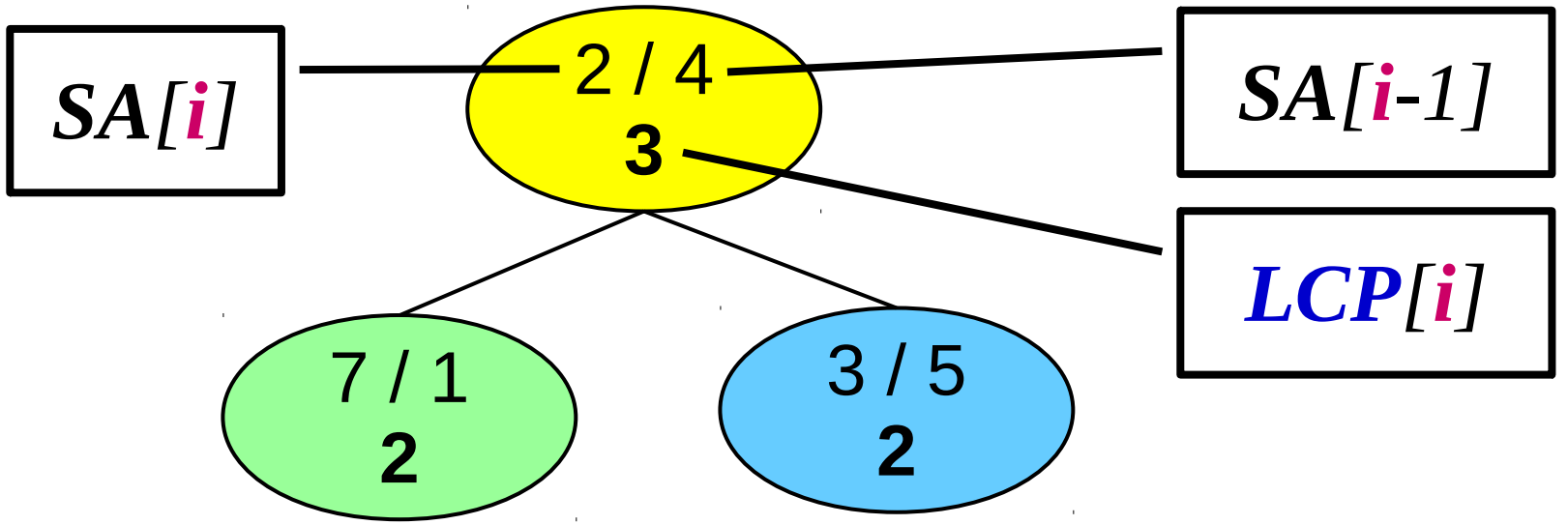


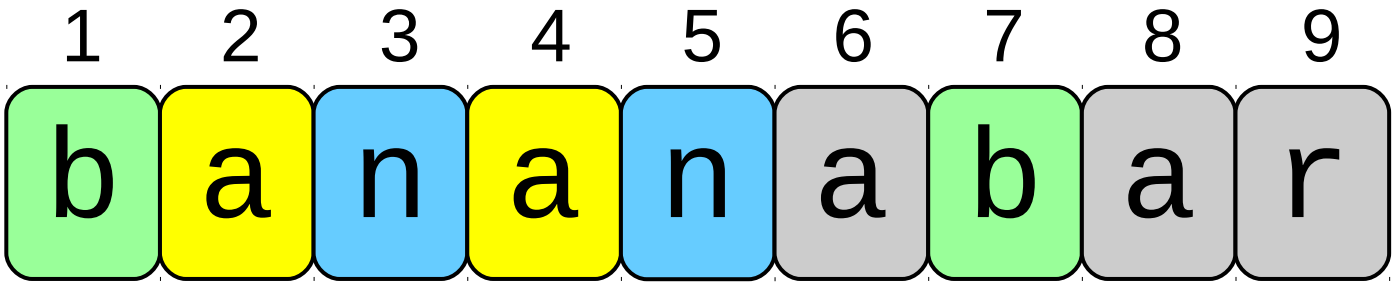
lcpcomp – Example

1) Compute:
   - Suffix Array ***SA***
   - LCP Array ***LCP***
2) Put ***i*** in an ***LCP***-keyed max-heap if ***LCP[i]*** > *1*

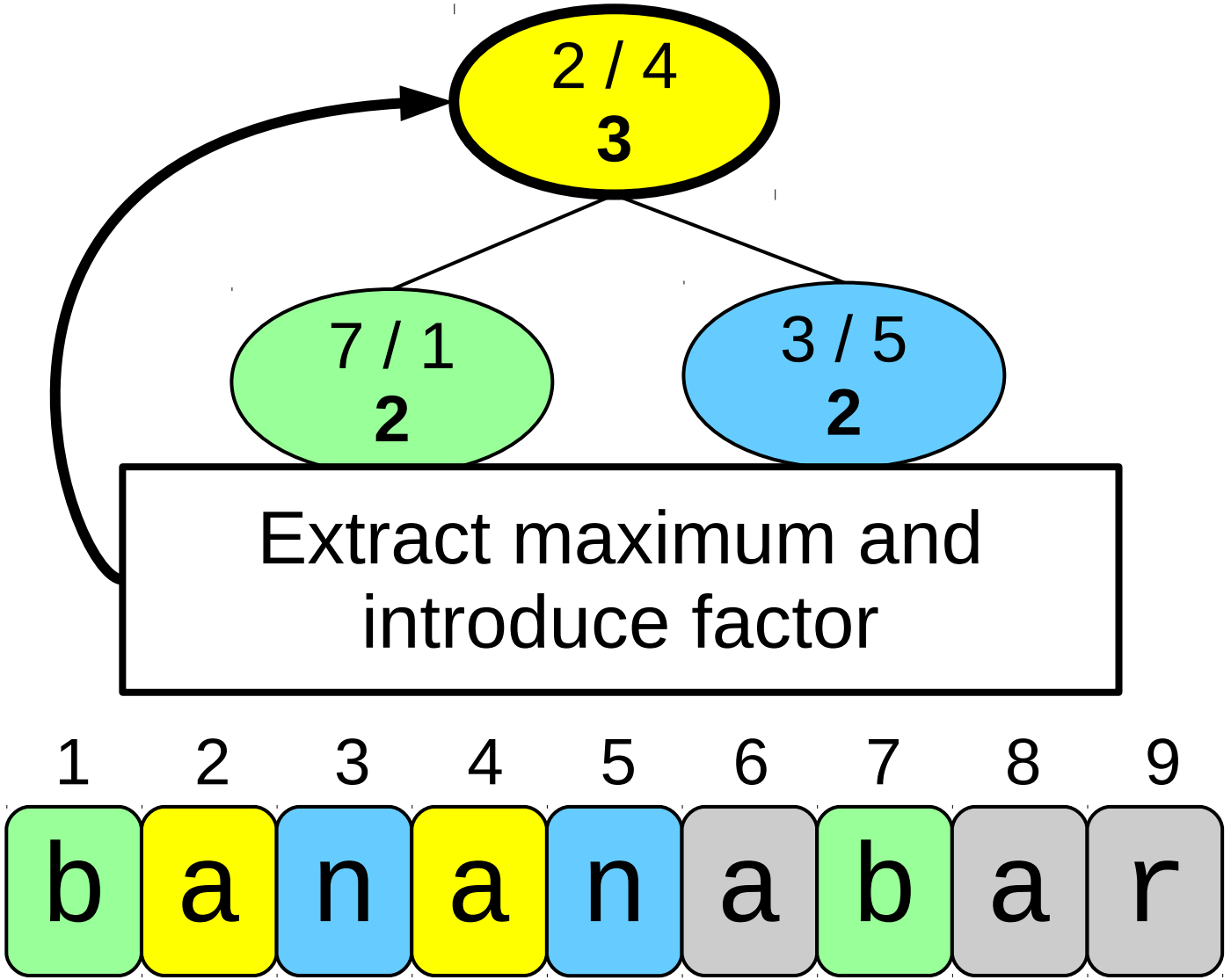


lcpcomp – Example

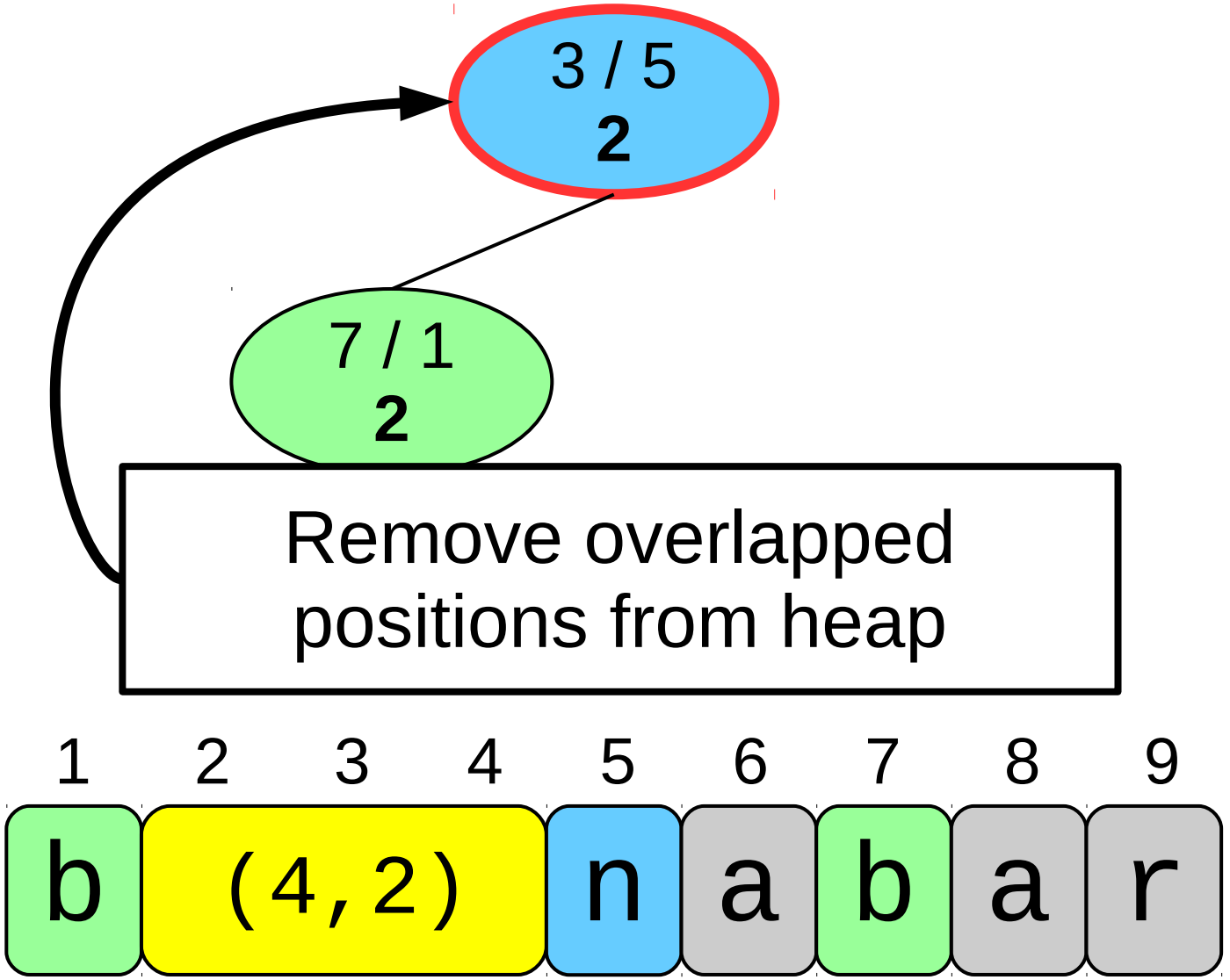




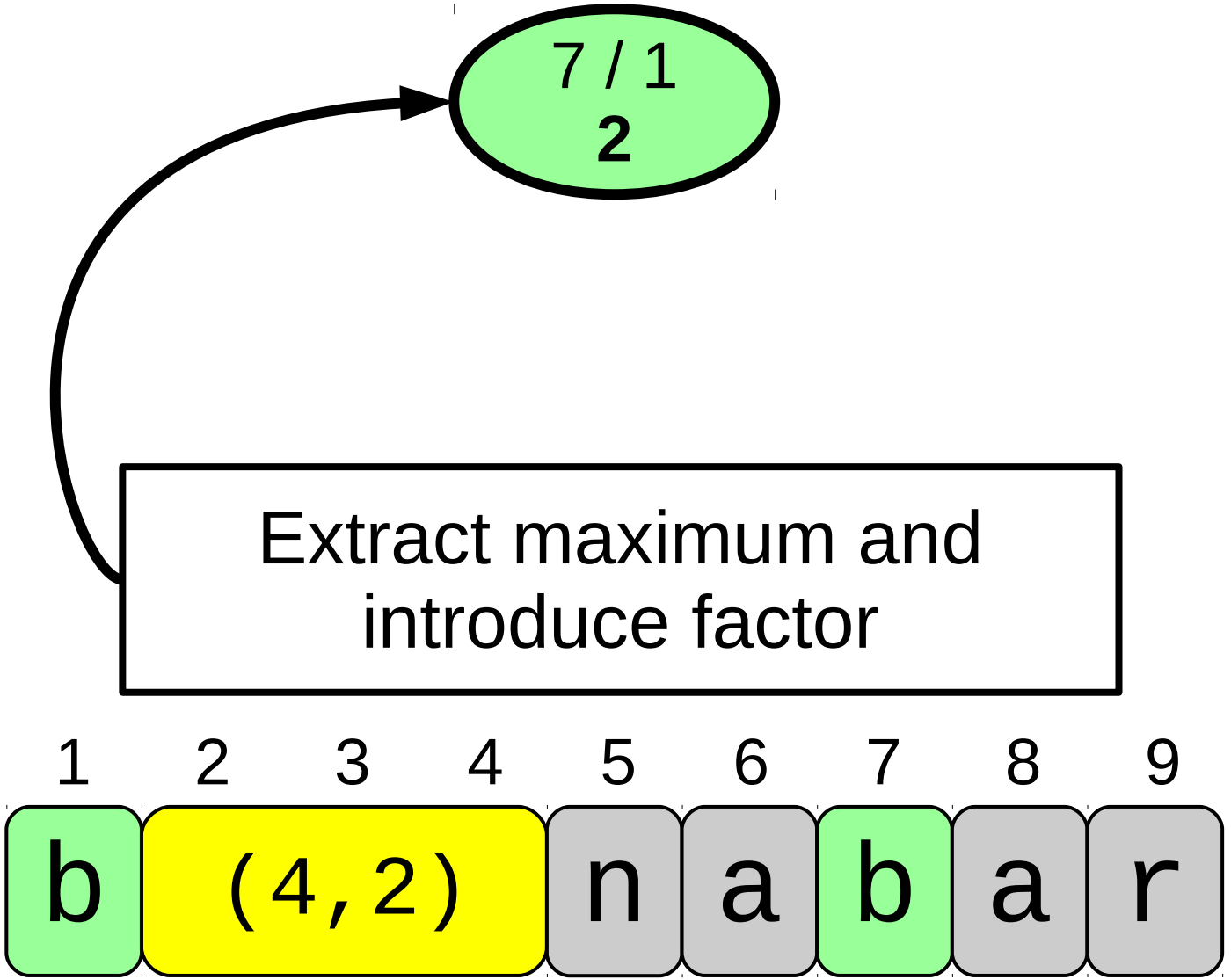
lcpcomp – Example



lcpcomp – Example



lcpcomp – Example



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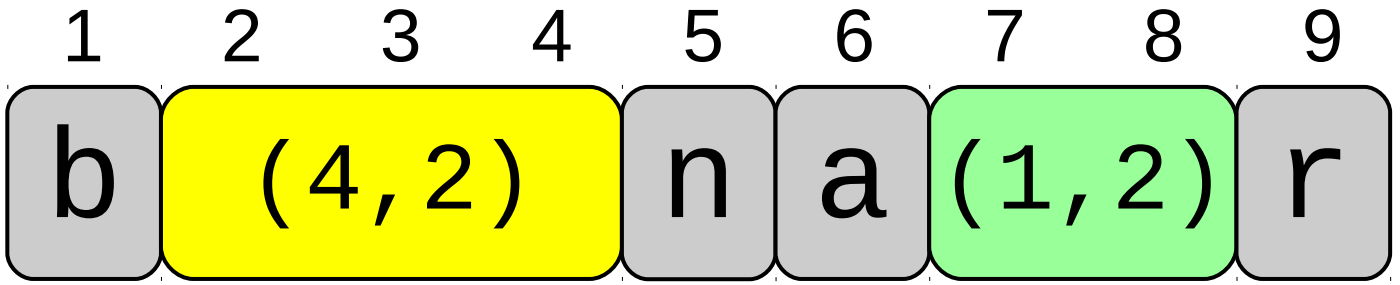
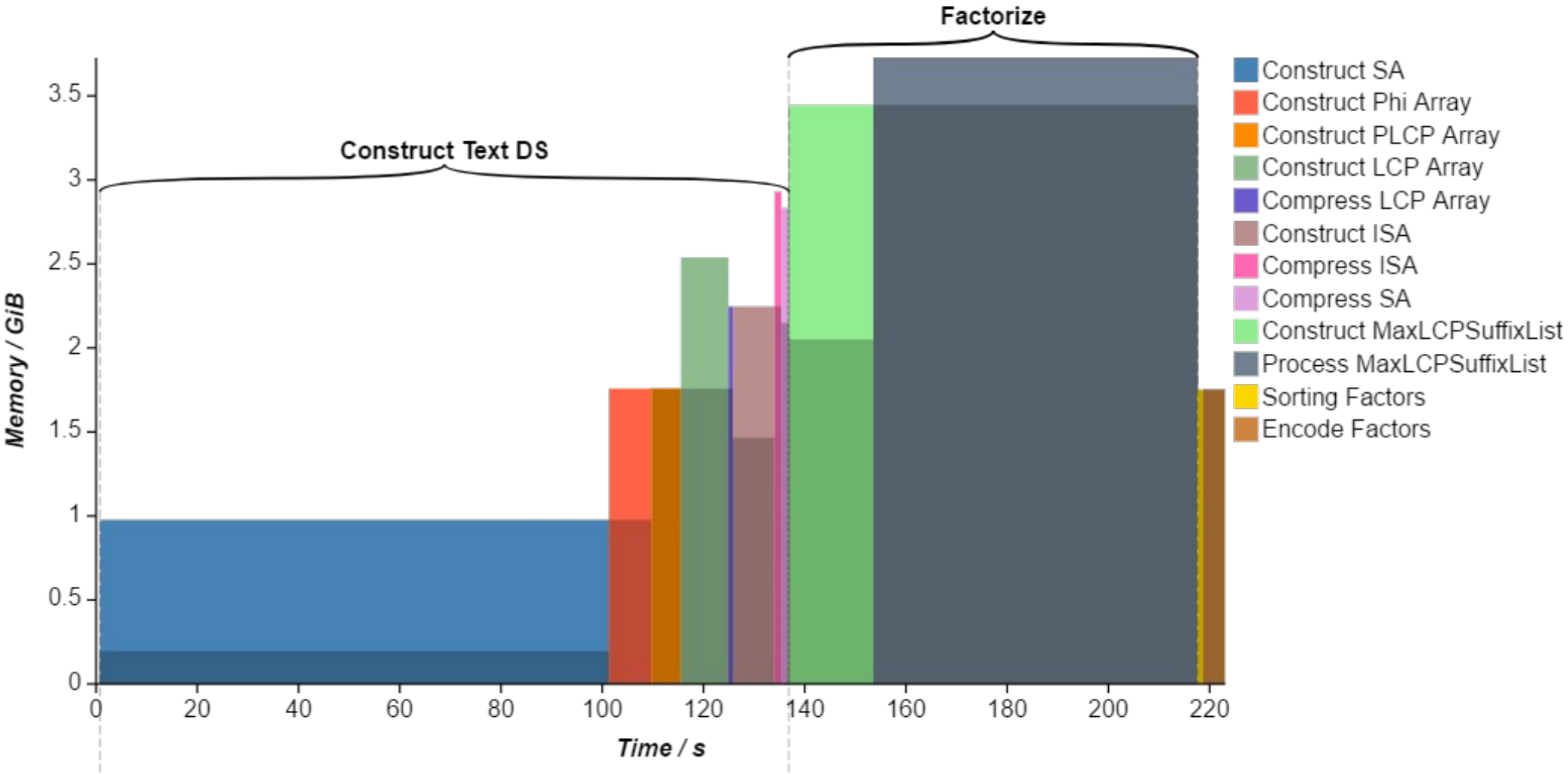


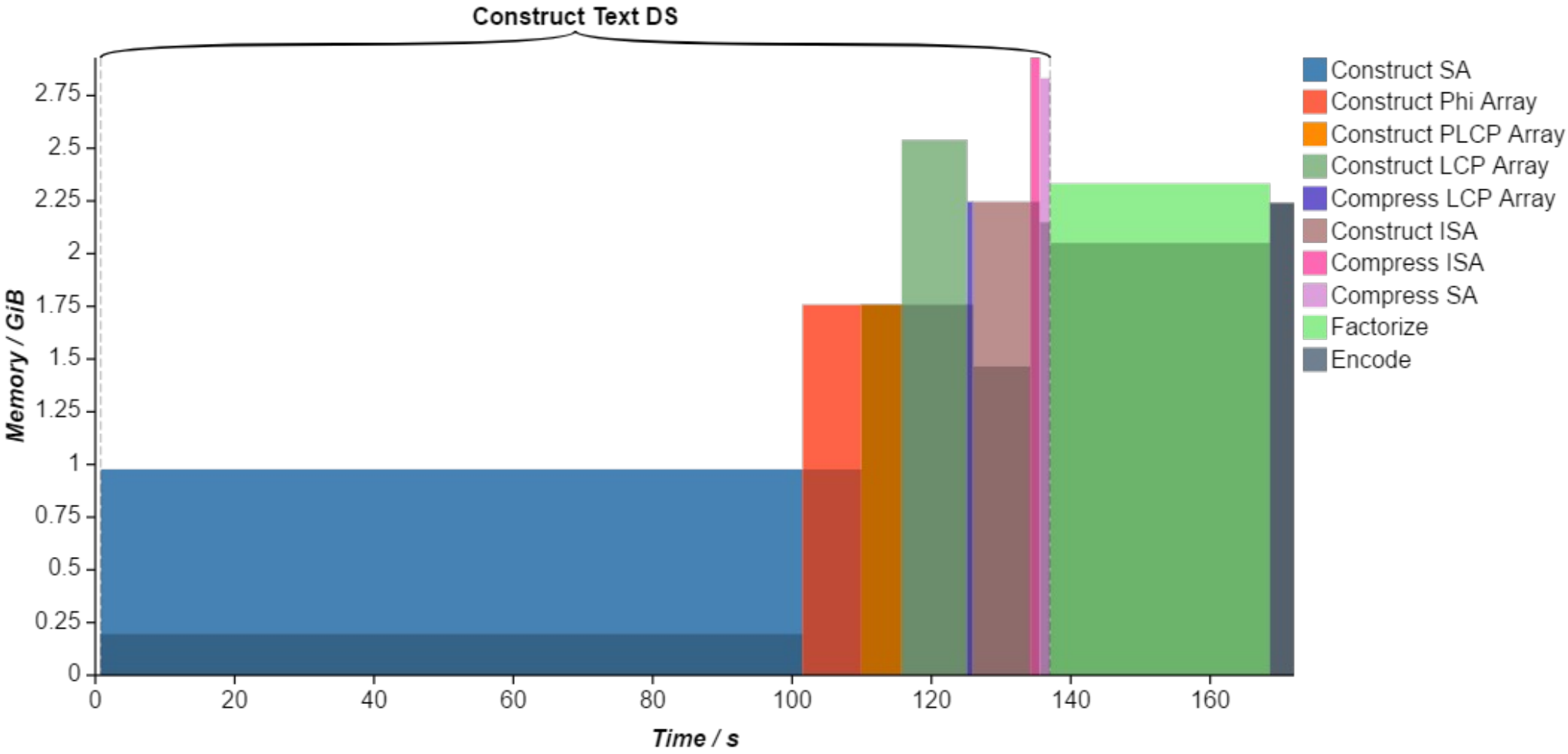
lcpcomp – Practical Results

lcpcomp: pcr_cere (200 MiB, highly repetitive)



lcpcomp – Comparison: LZ77

LZ77: pcr_cere (200 MiB, highly repetitive)



lcpcomp – Evaluation

pcr_cere (200 MiB, σ = 6, highly repetitive)

Compressor	C Time	C Memory	C Rate	D Time	D Memory	chk
lcpcomp	103.1s	3.2GiB	2.8505%	36.6s	7.6GiB	OK
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lzma -9	138.6s	691.7MiB	1.9047%	337.3ms	82.7MiB	OK

Summary

tudocomp

- Highly modular C++14 framework
- Helpers
  - Benchmarks
  - Memory tracking
  - Data visualization
- Standard library for compression
  - Text data structures (SA, LCP)
  - Bit vectors
  - Bitwise I/O
- Classic compressors (baseline)
- Common coders

lcpcomp

- LZ77-based
- forward references allowed
- less factors than LZ77
- runs in O(n) time (see paper)

Outlook

- better coders (like ANS, CABAC)
- grammar compressors
- external memory algorithms