Sorting Algorithms

1. Selection
2. Bubble
3. Insertion
4. Merge
5. Quick
6. Shell

Divide and Conquer

- **Metode Divide and Conquer, setiap kali memecah persoalan menjadi setengahnya, namun menggunakan hasil dari kedua bagian tersebut:**
  - **cut the problem in half until the problem is trivial → tidak ber-problem lagi**
  - **solve for both halves**
  - **combine the solutions**

Mergesort

- ***A divide-and-conquer algorithm:***

  Membagi unsorted array menjadi 2 bagian hingga menghasilkan sub-arrays yang hanya berisi satu elemen
- ***Merge together* solusi dari sub-problem**

  HOW?
  - **Bandingkan elemen pertama dari 2 sub-array**
  - **Ambil elemen yang terkecil dan letakkan pada array hasil**
  - **Teruskan proses pembandingan dan pengambilan, sampai seluruh elemen sub-array dipindahkan ke array hasil**

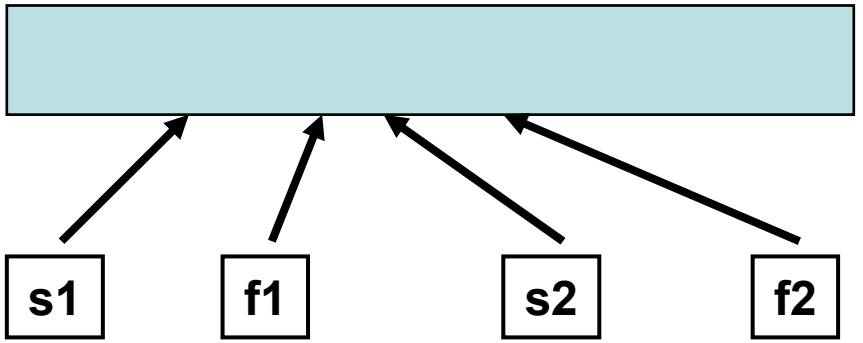
37	23	6	89	15	12	2	19

Algorithm

```
Mergesort(Passed an array)
  Jika ukuran array > 1
    Bagi array menjadi dua
    Panggil fungsi Mergesort untuk bagian pertama
    Panggil fungsi Mergesort untuk bagian kedua
    Merge dua bagian tersebut.

Merge(Passed two arrays)
  Bandingkan elemen pertama dari kedua array
  Pilih yang lebih kecil dan tempatkan pada array
  hasil, update posisi elemen pertama pd array
  yang telah diambil elemennya
    (Jika salah satu array input telah kosong,
      maka letakkan elemen yang tersisa dari
      array lainnya ke array hasil)
```

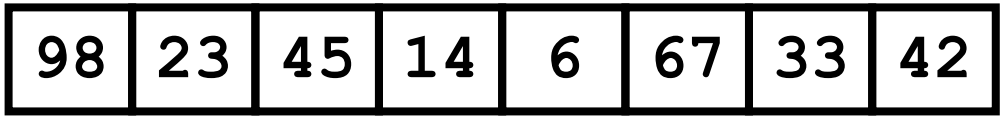
More TRUTH in CS

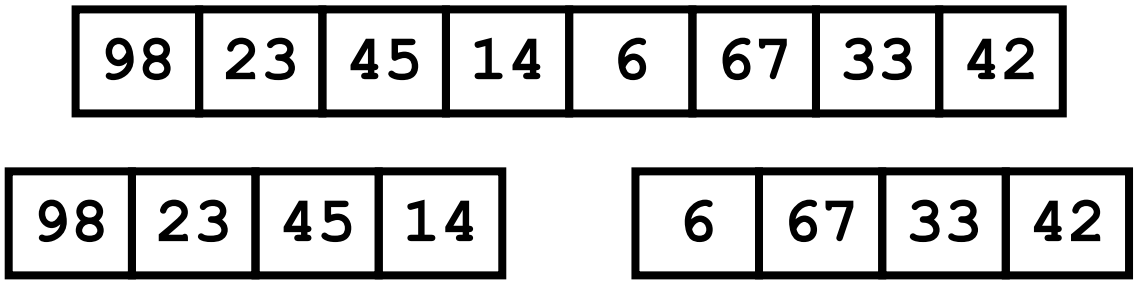
- *We don't really pass in two arrays!*
- Sebenarnya kita hanya melewatkan satu aray, dengan sebuah variabel indikator yang akan menandai di mana satu set data dimulai dan diakhiri, berikutnya di mana set data lainnya dimulai dan diakhiri.

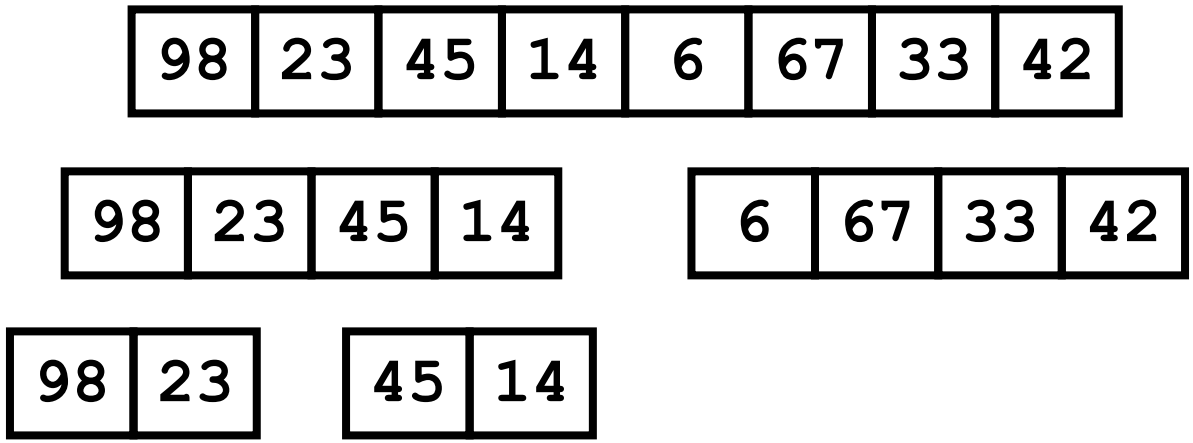


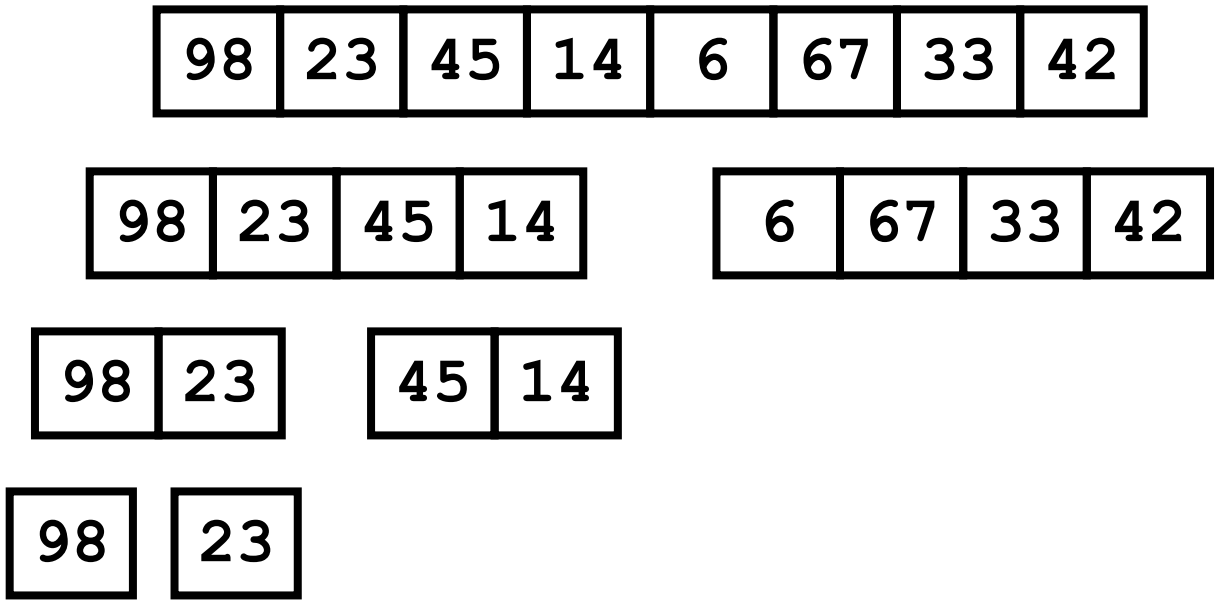
Algorithm

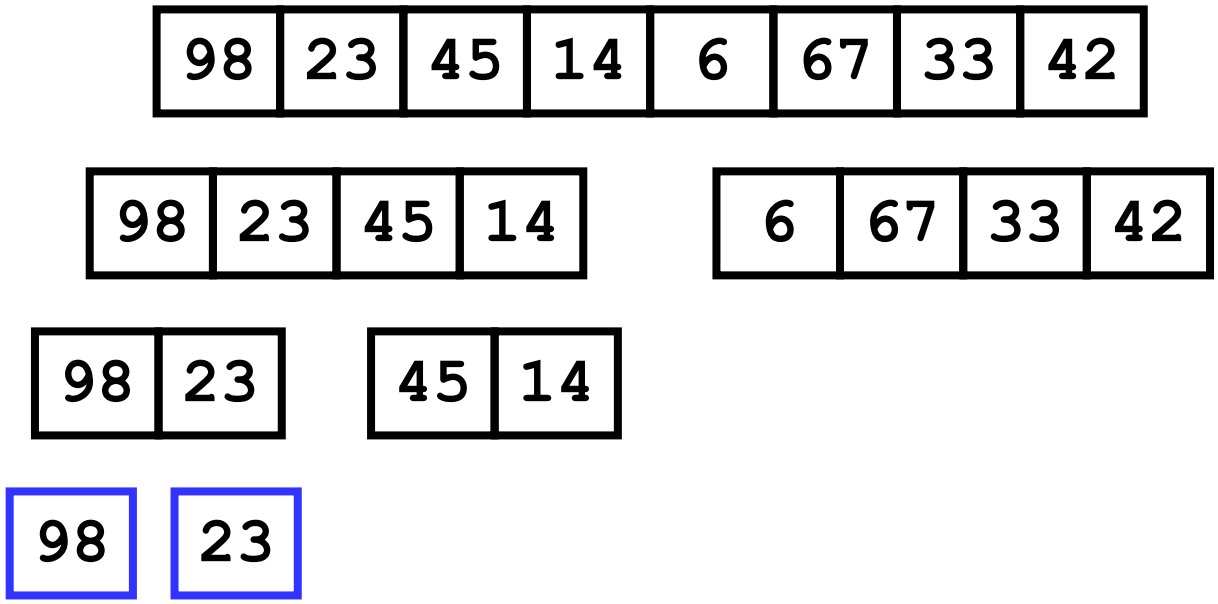
```
Mergesort(Passed an array)
  if array size > 1
    Divide array in half
    Call Mergesort on first half.
    Call Mergesort on second half.
    Merge two halves.

Merge(Passed two arrays)
  Compare leading element in each array
  Select lower and place in new array.
    (If one input array is empty then place
     remainder of other array in output array)
```

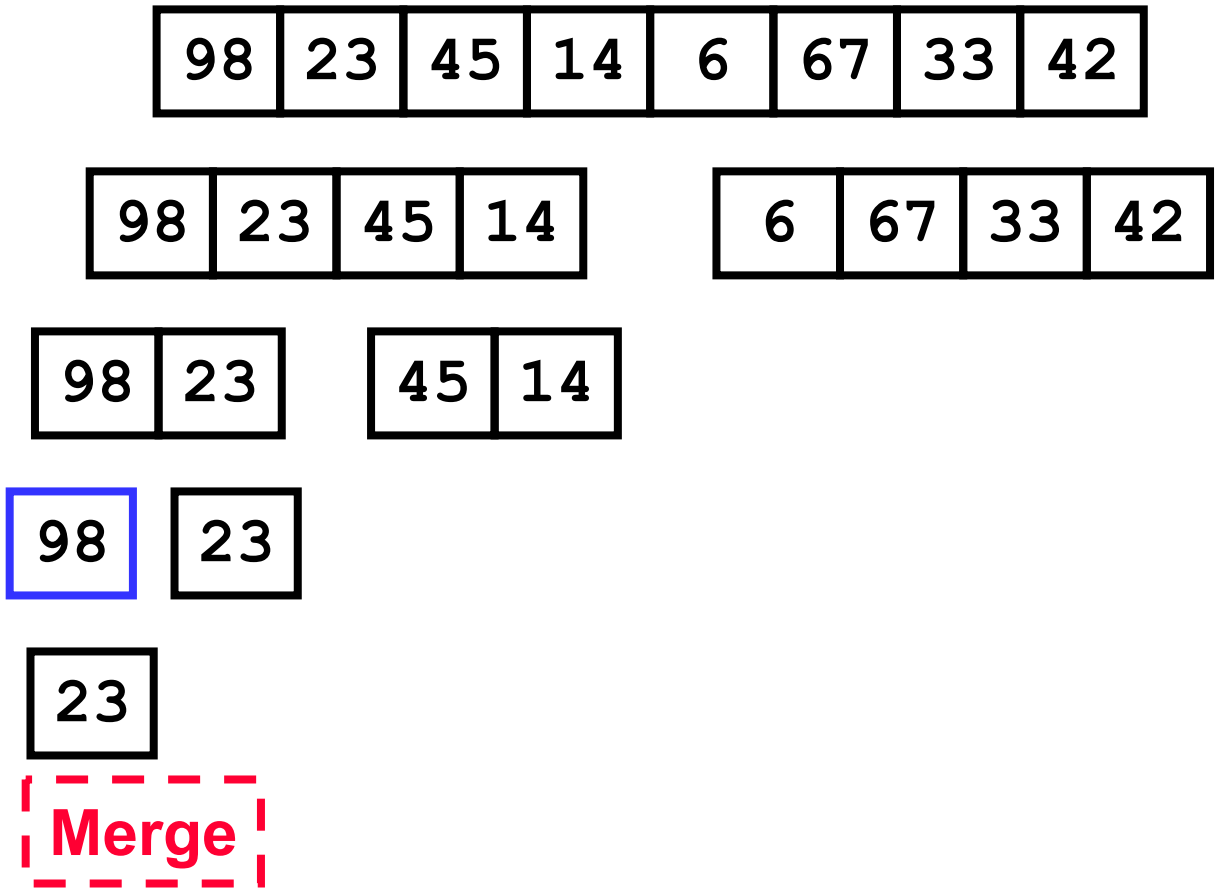

98
23
45
14
6
67
33
42

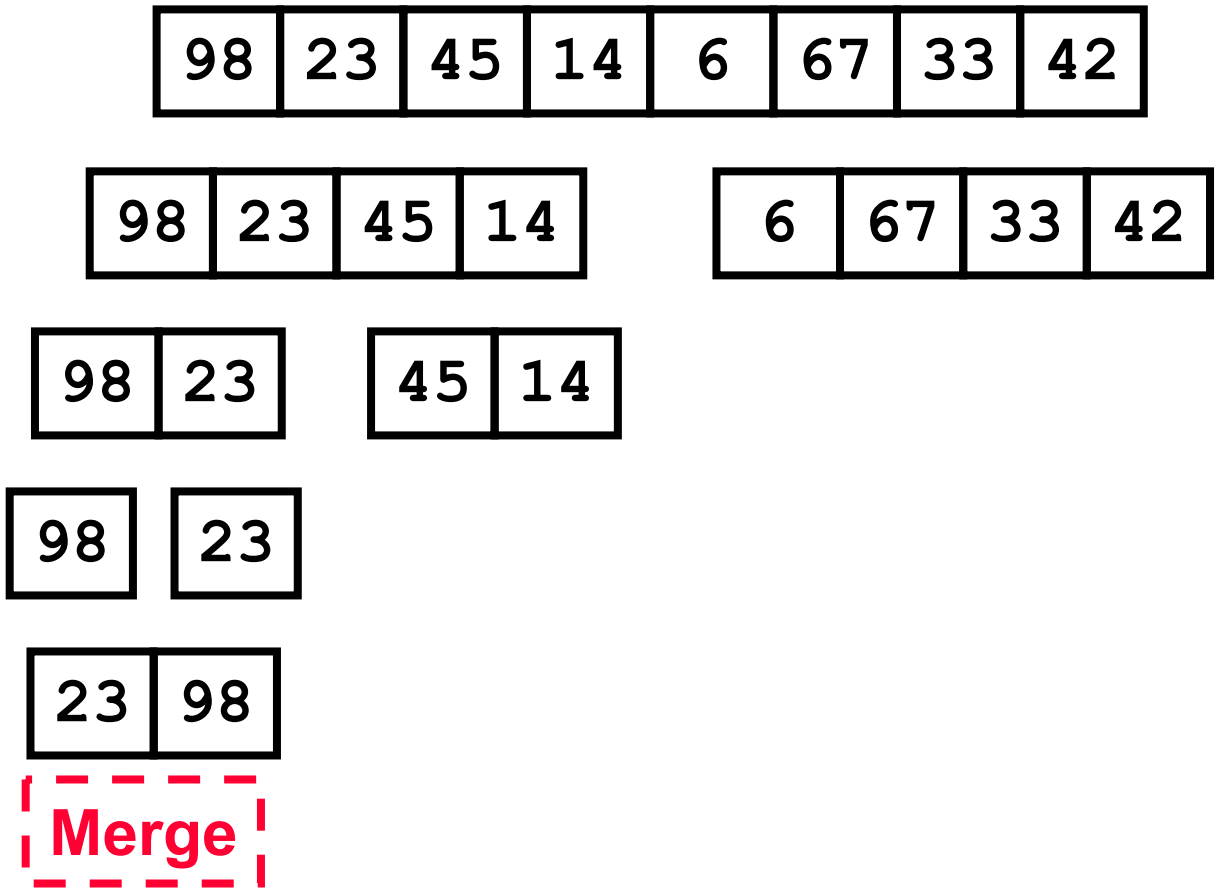

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42

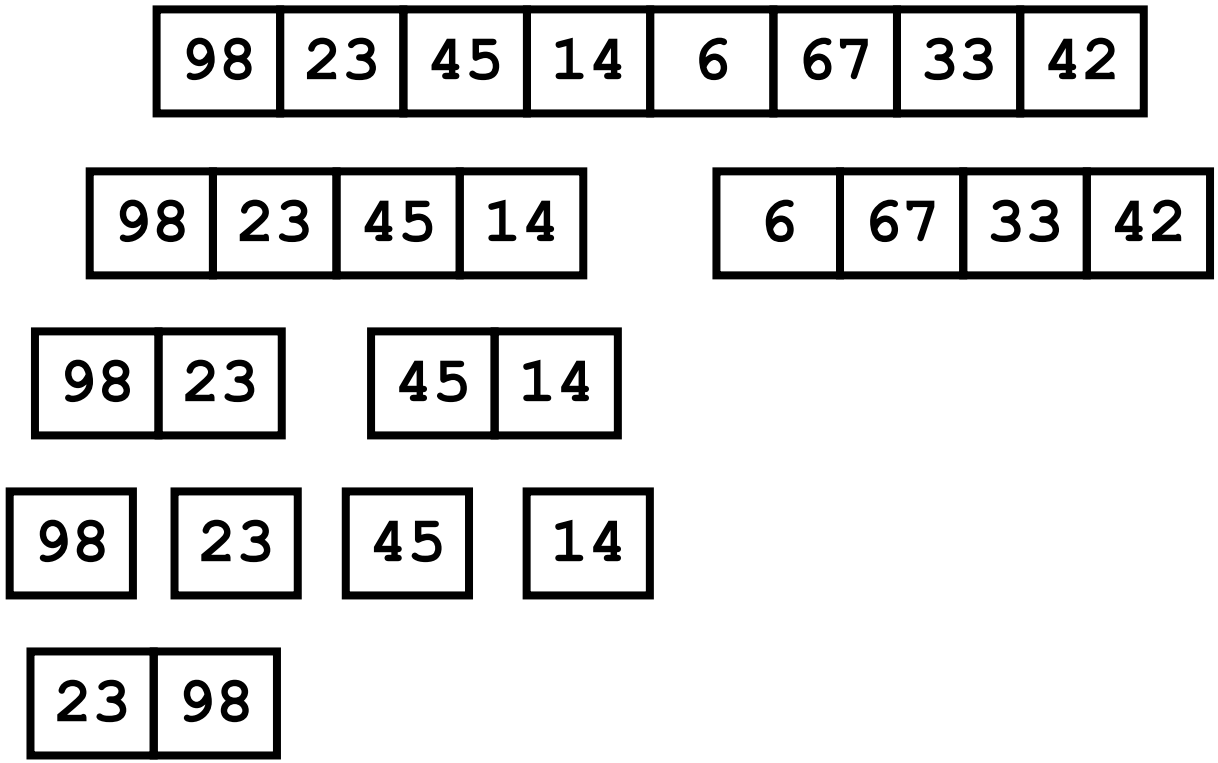

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14

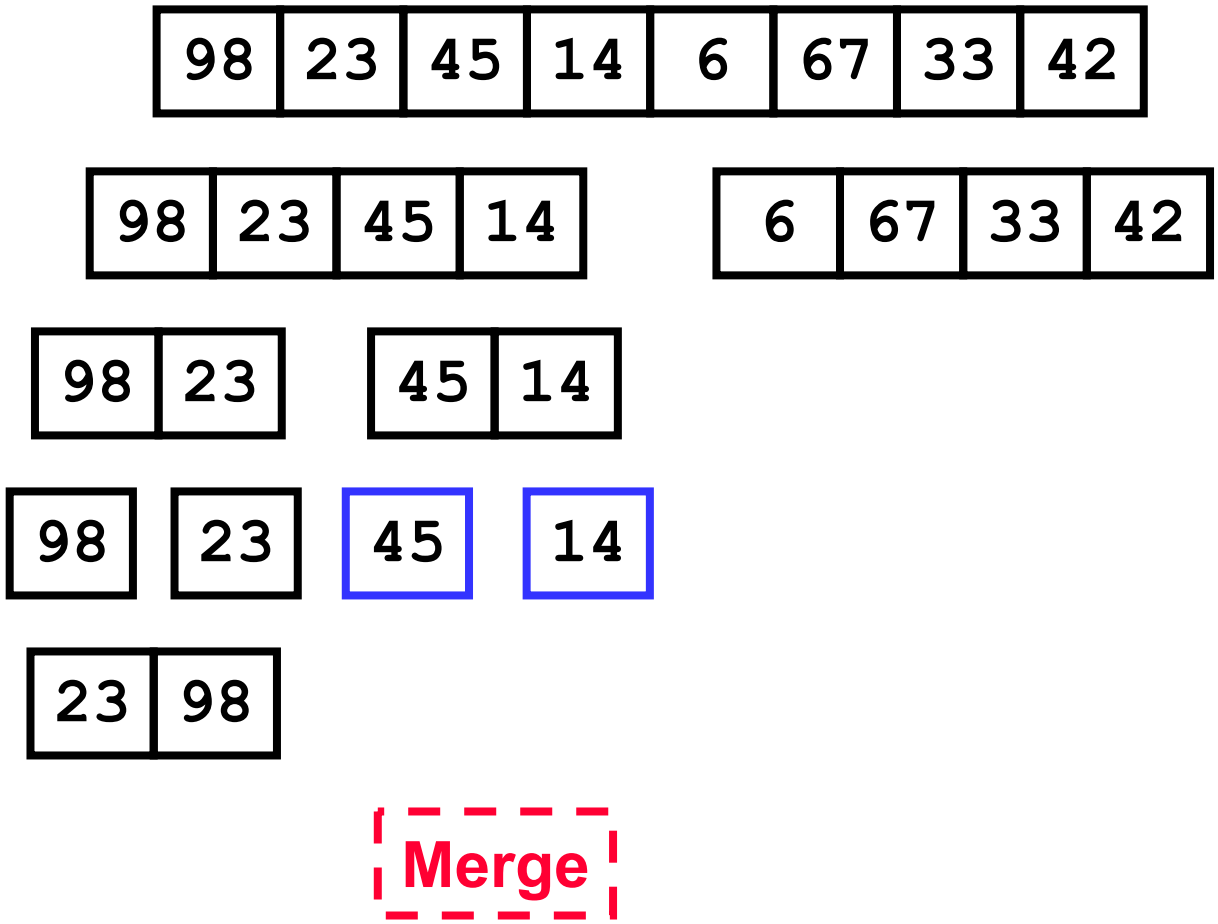

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23

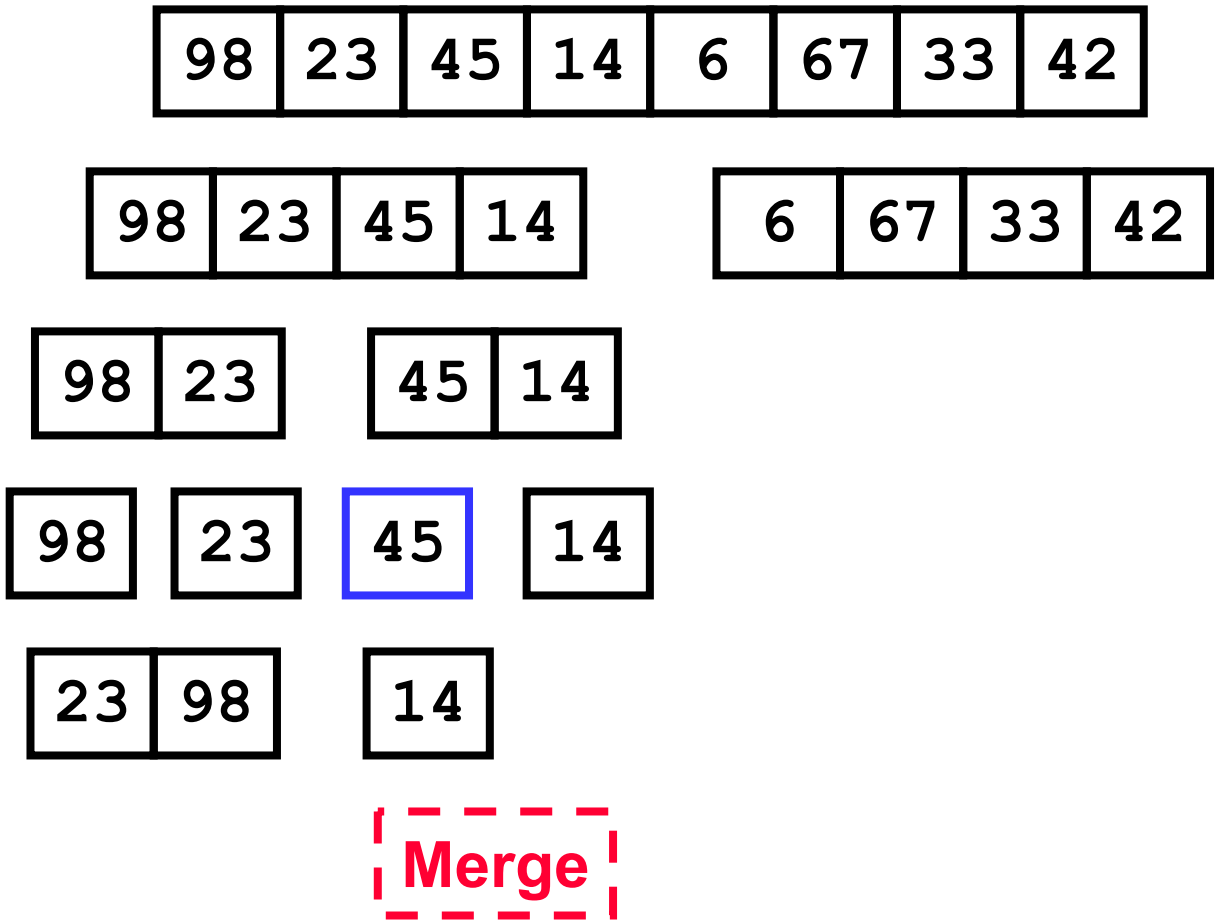

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23
Merge

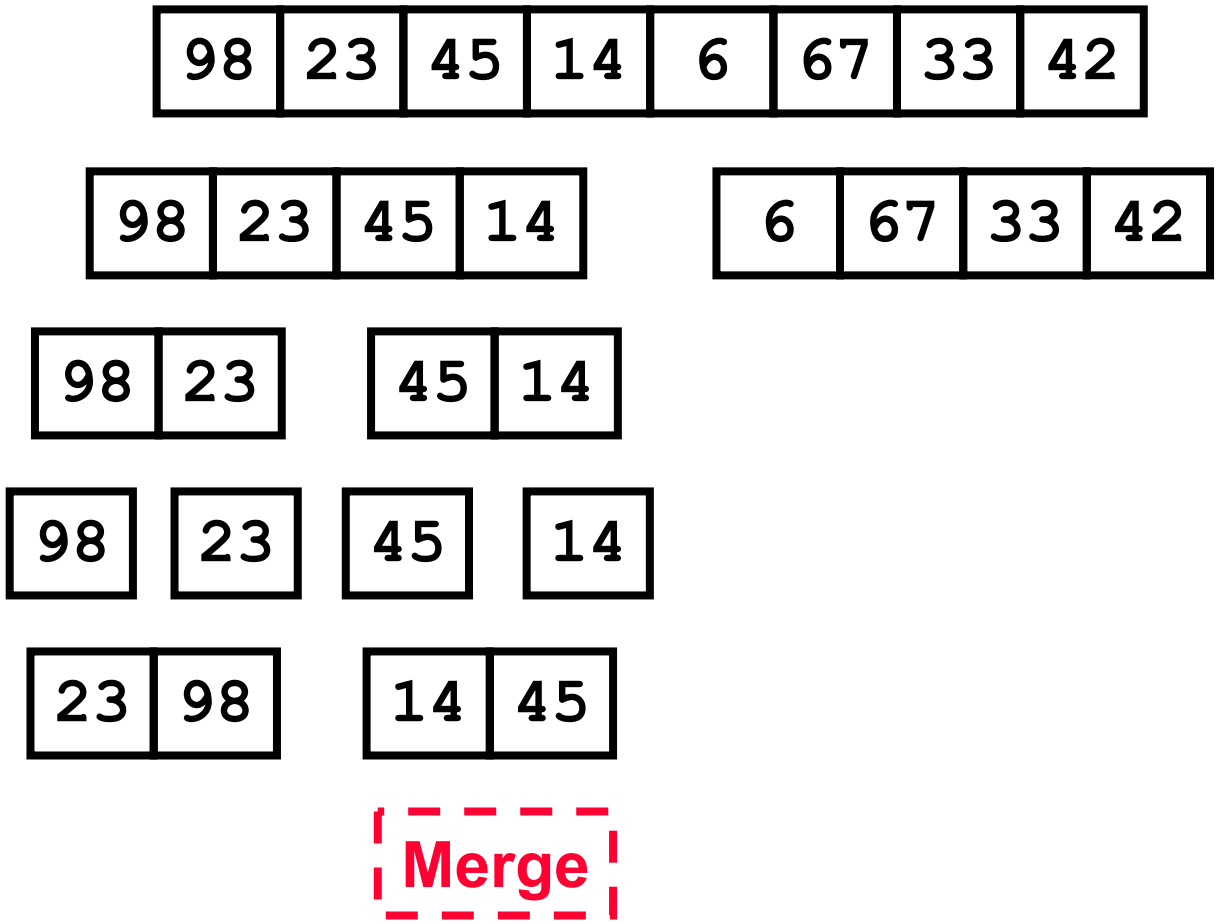

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23
23
Merge

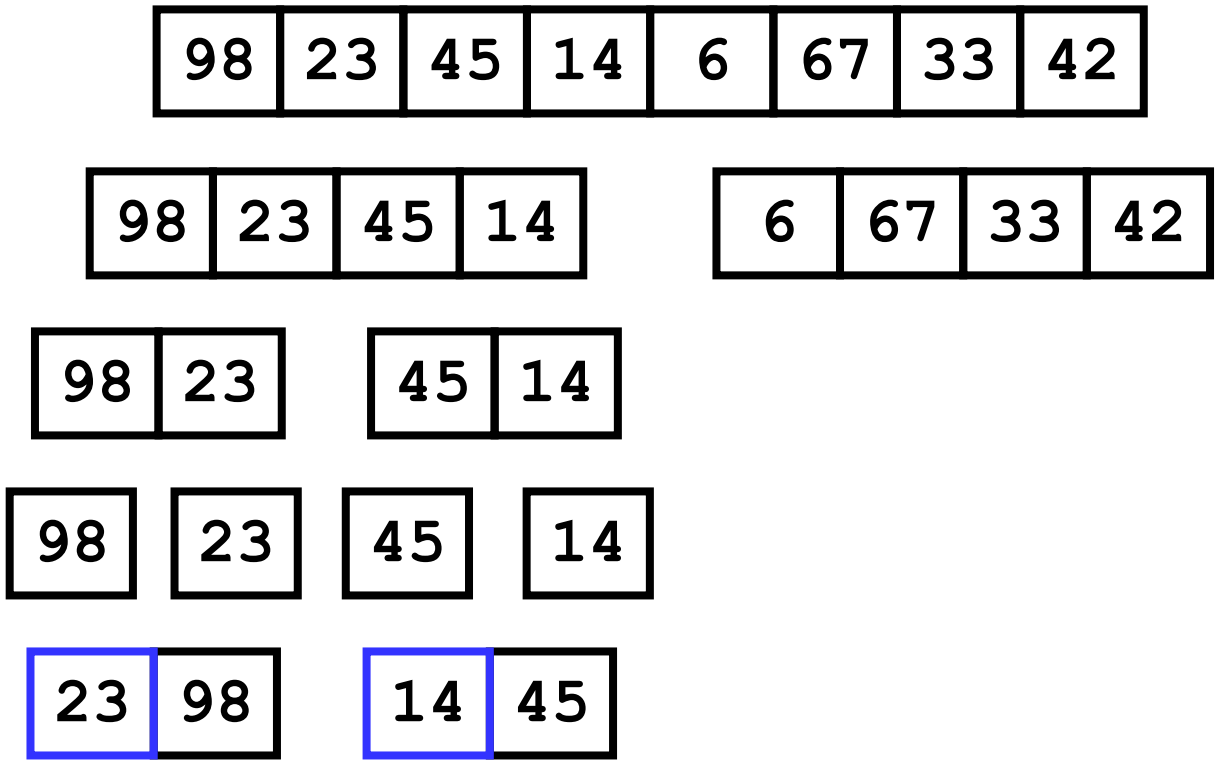

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23
23 98
Merge

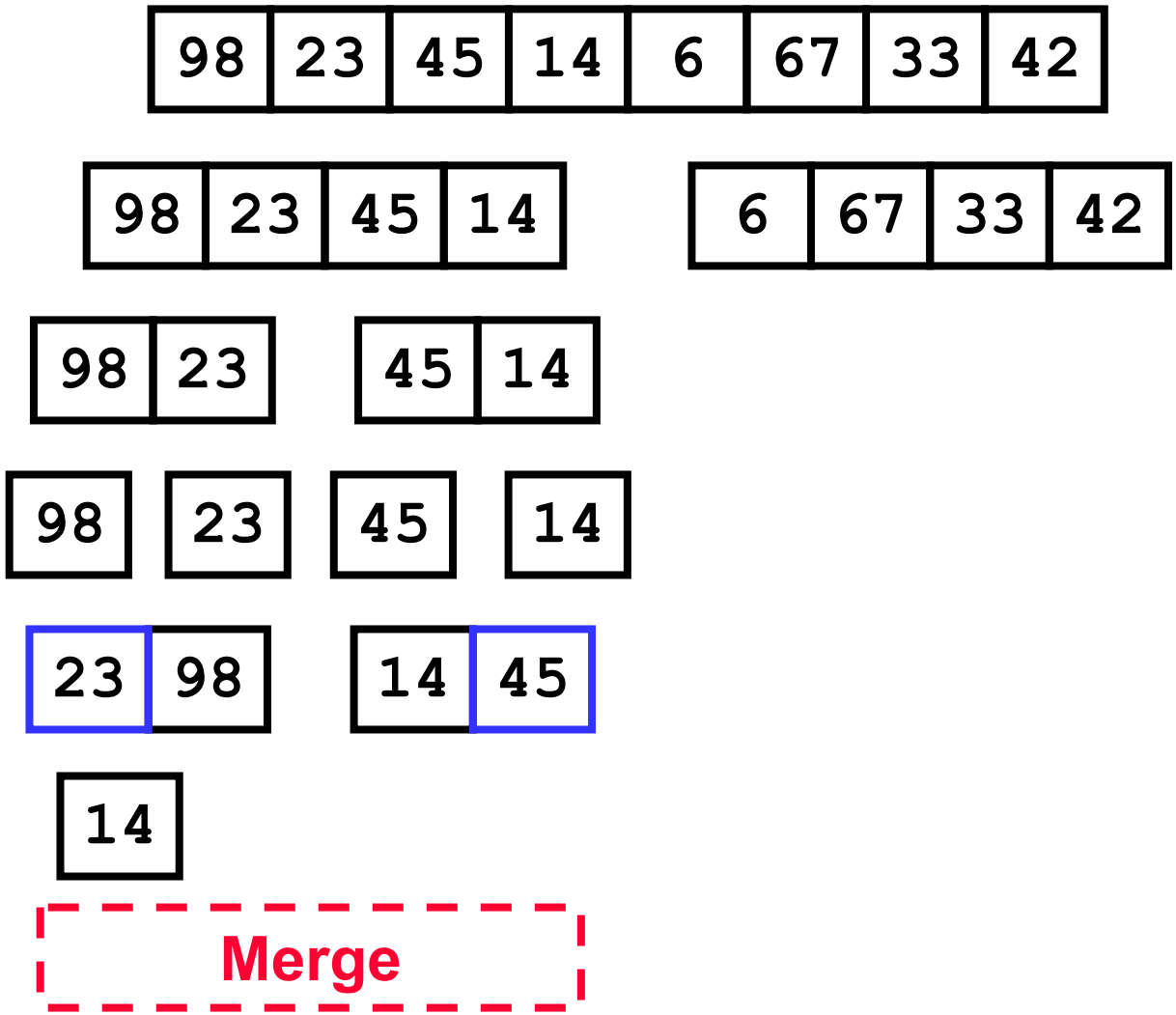

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23
45
14
23 98

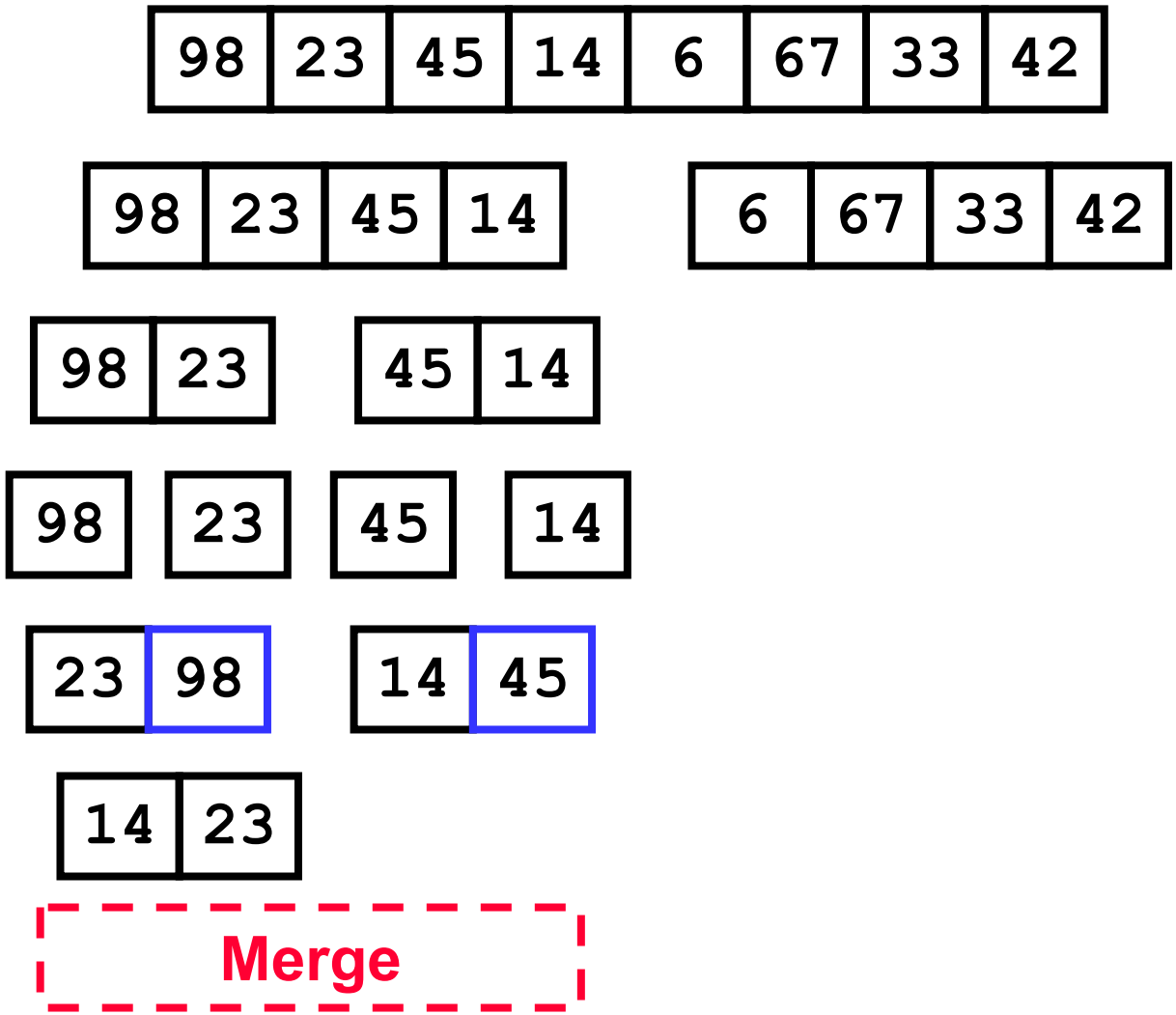

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23
45
14
23 98
Merge

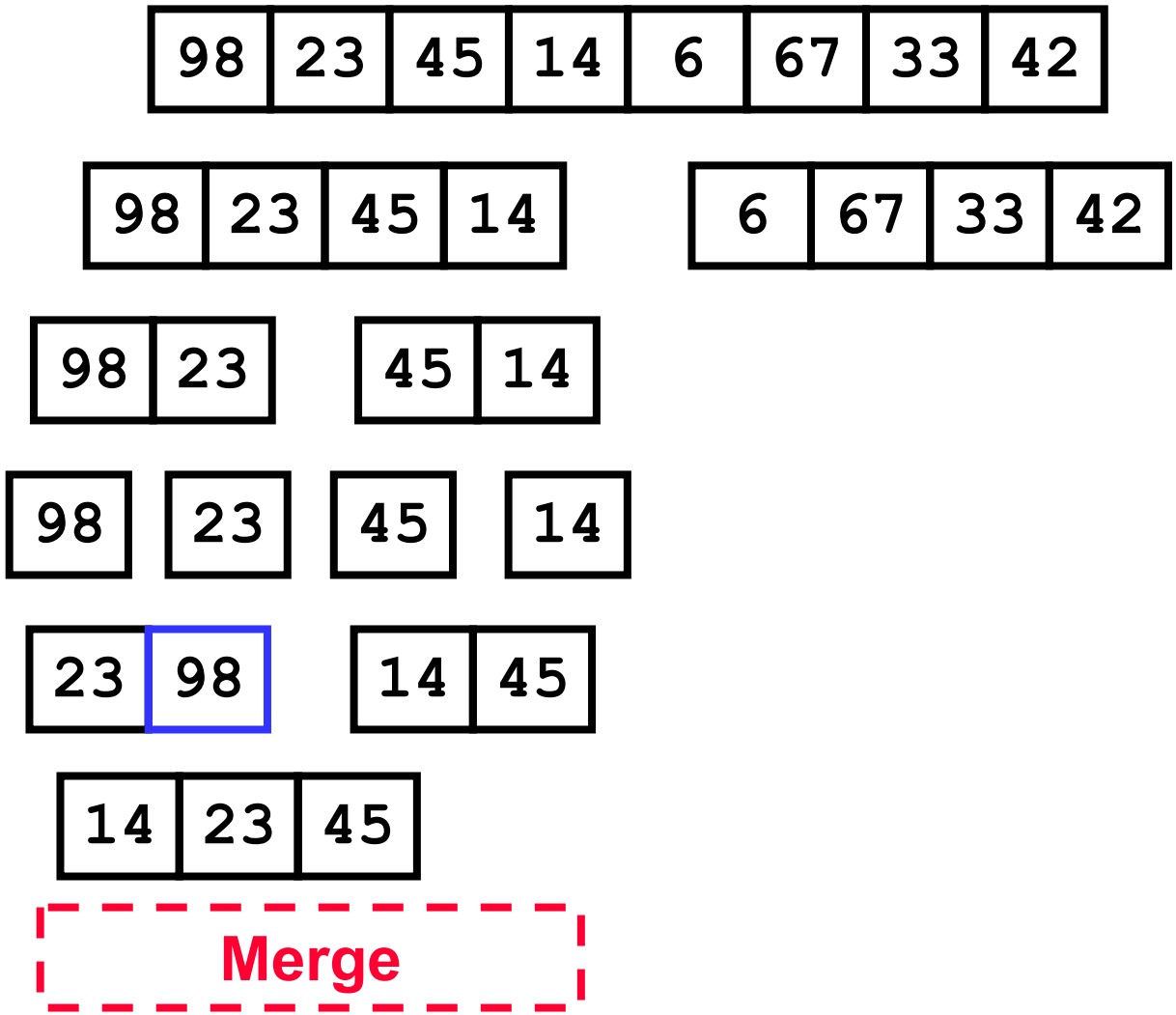

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23
45
14
23 98
14
Merge

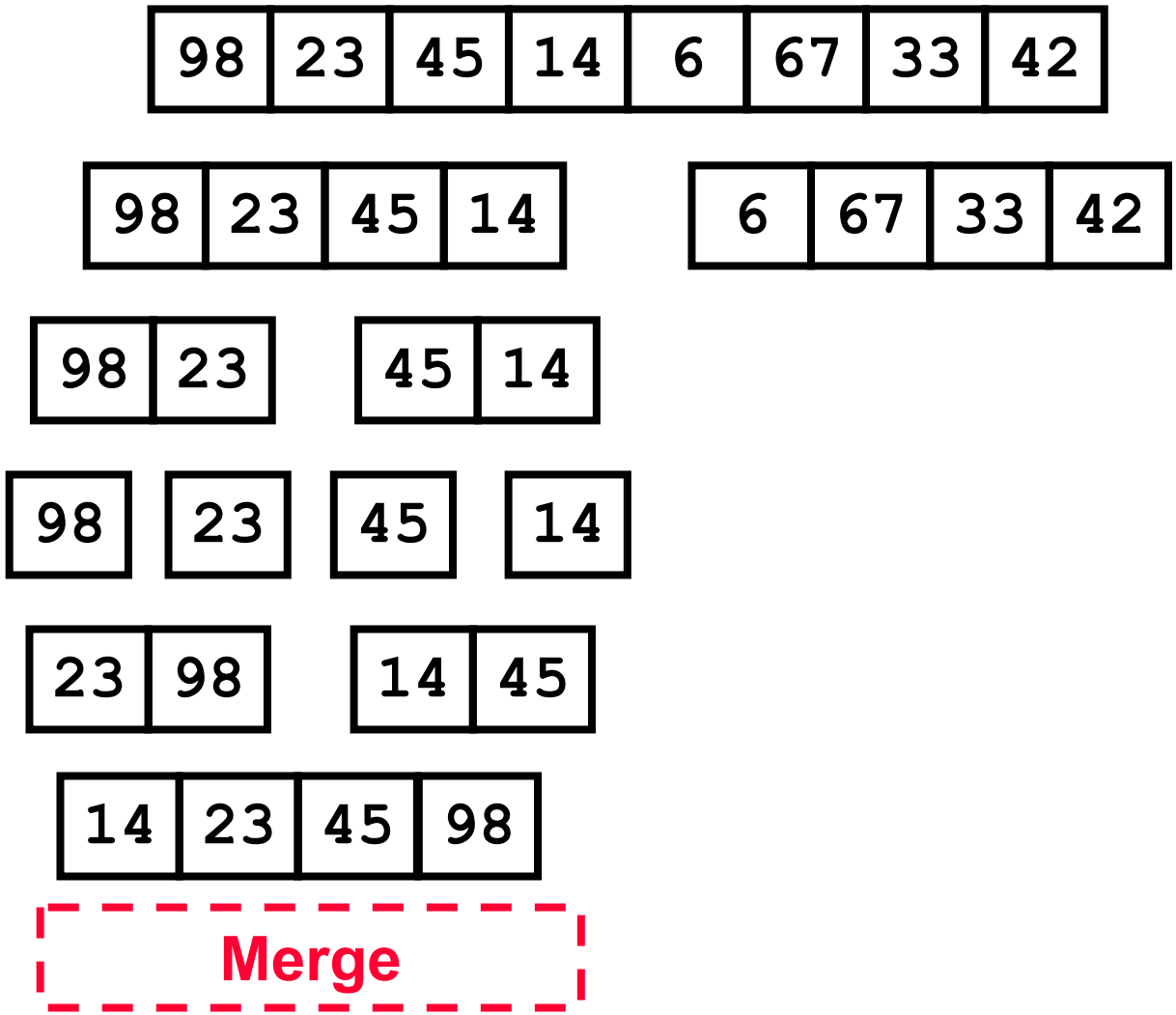

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23
45
14
23 98
14 45
Merge

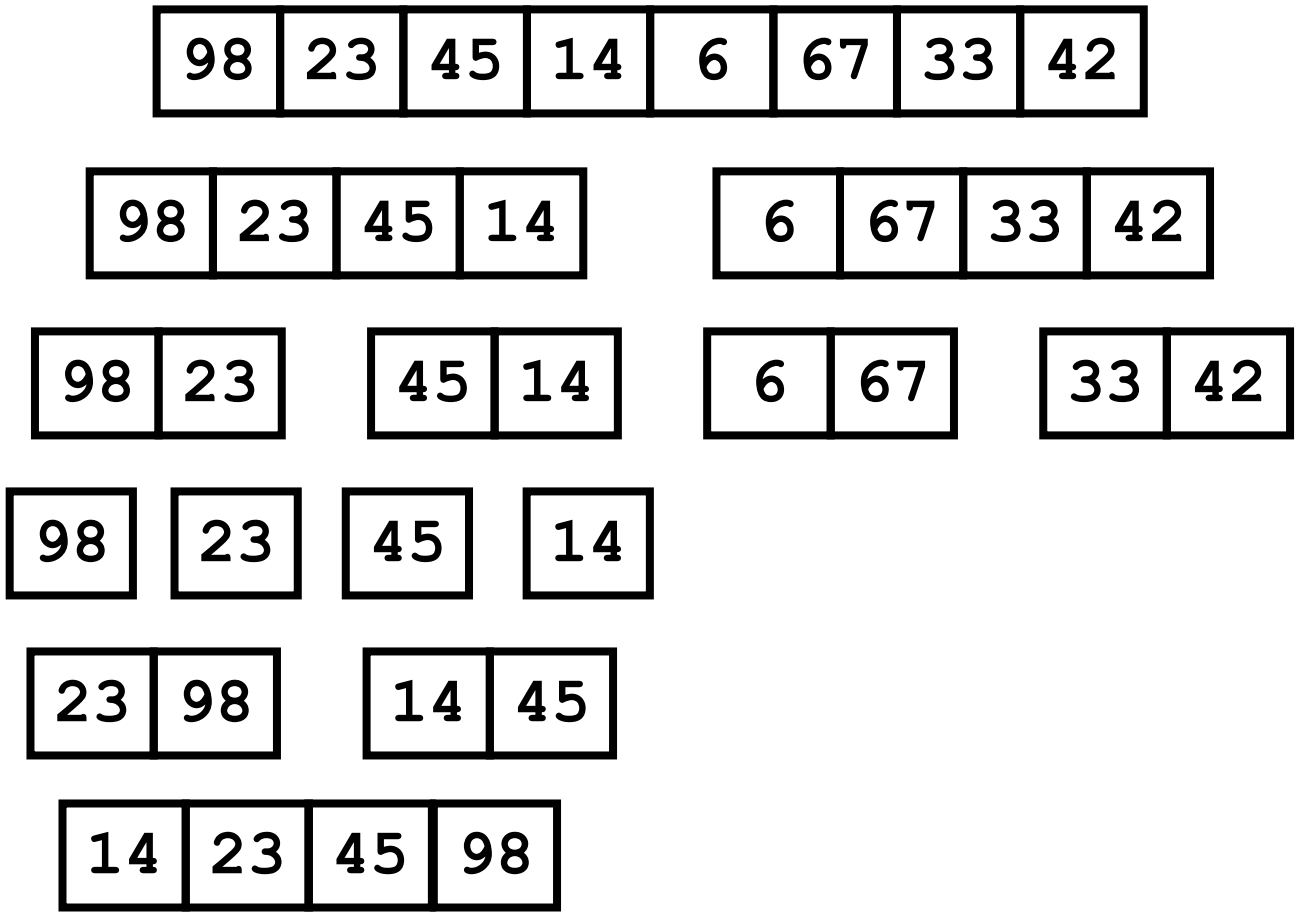

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23
45
14
23 98
14 45
Merge

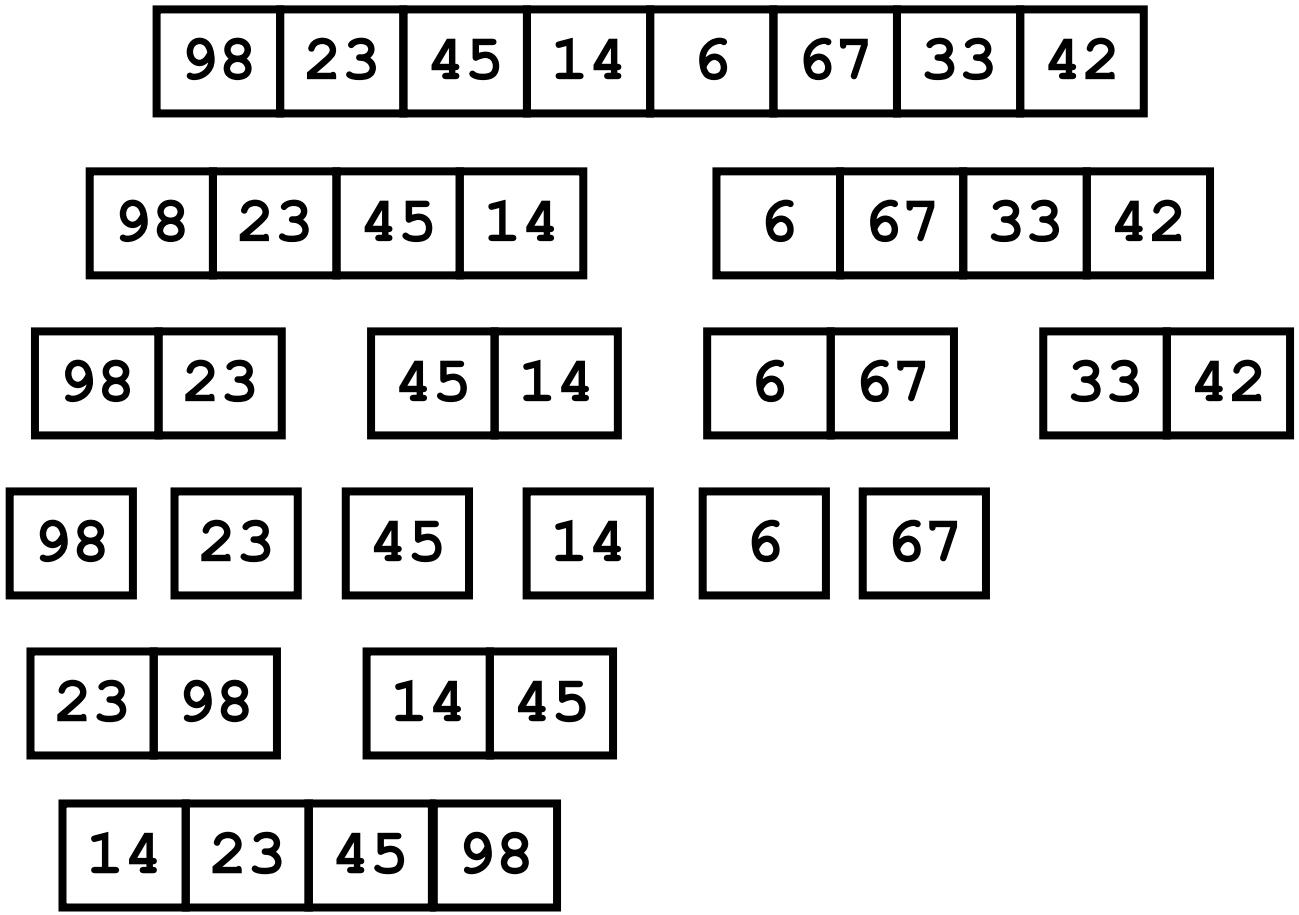

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23
45
14
23 98
14 45
14
Merge

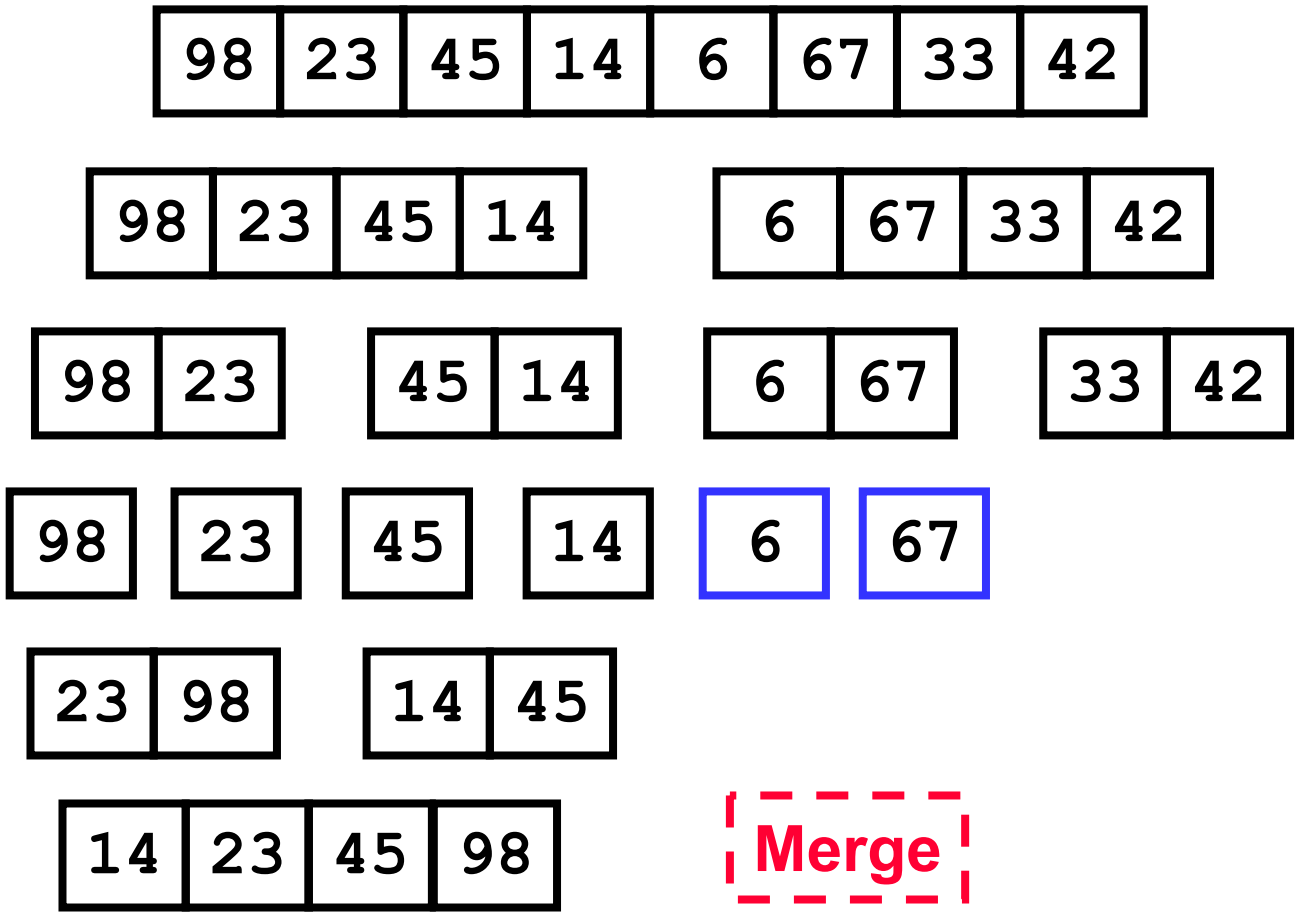

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23
45
14
23 98
14 45
14 23
Merge

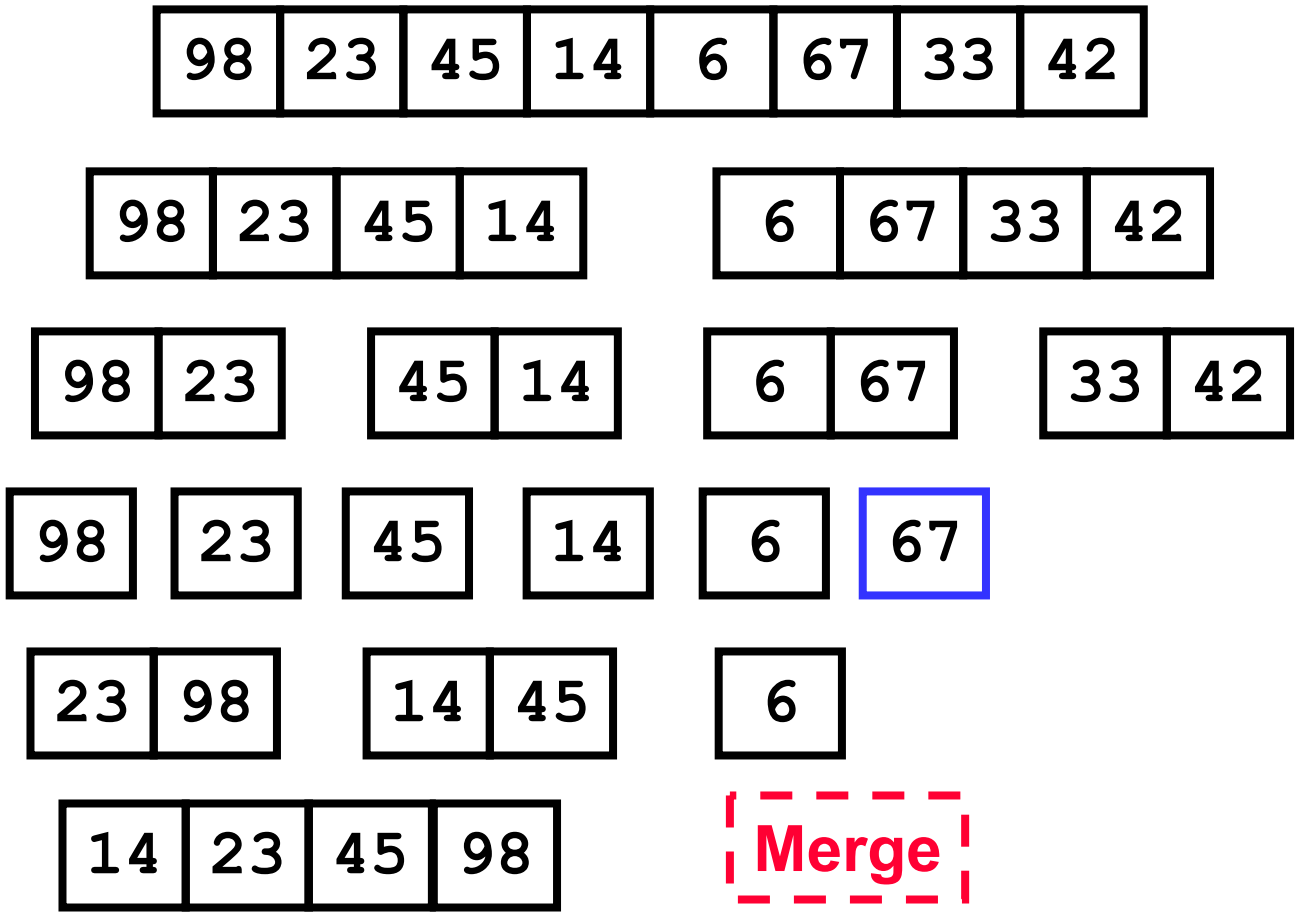

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23
45
14
23 98
14 45
14 23 45
Merge

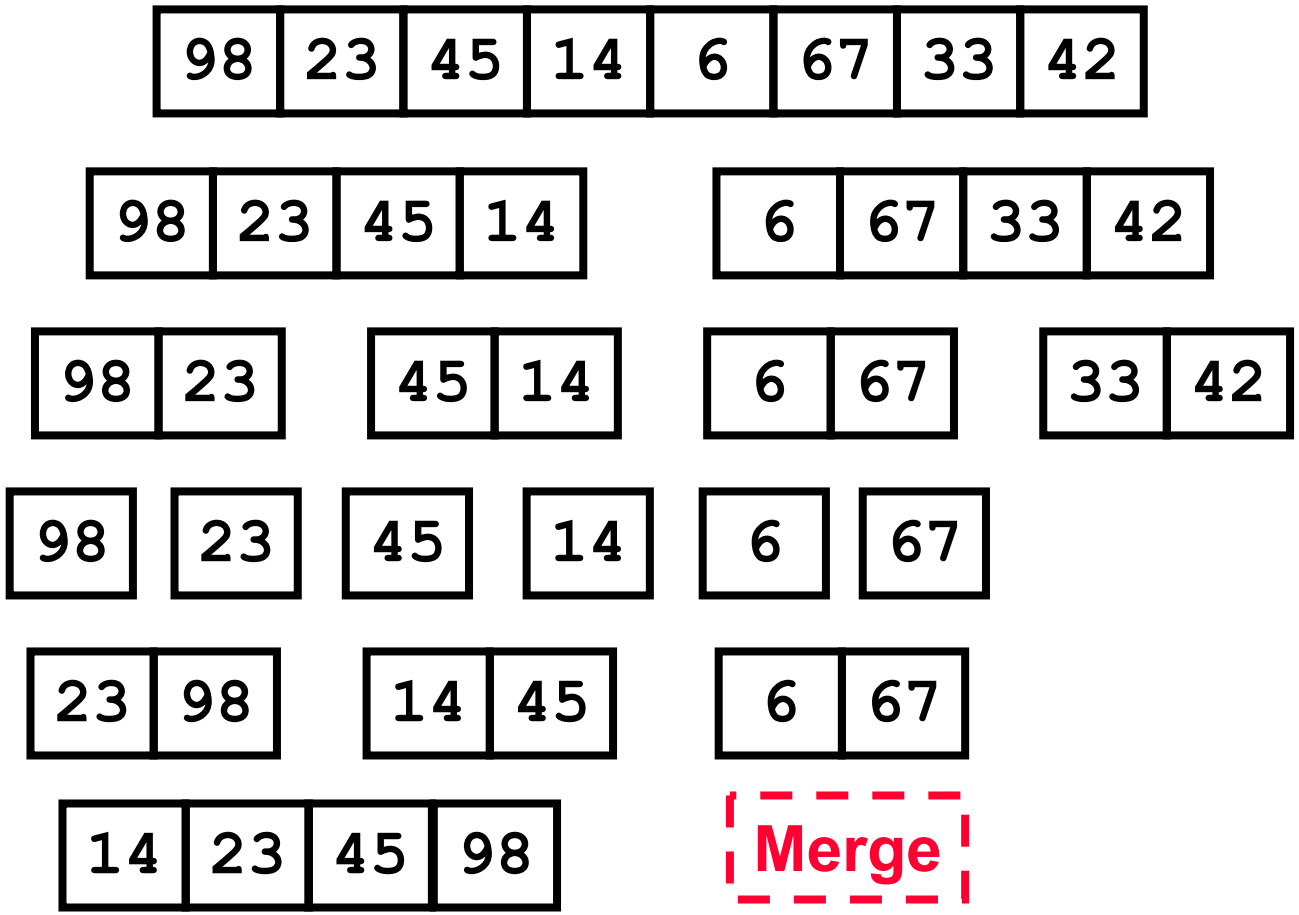

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
98
23
45
14
23 98
14 45
14 23 45 98
Merge

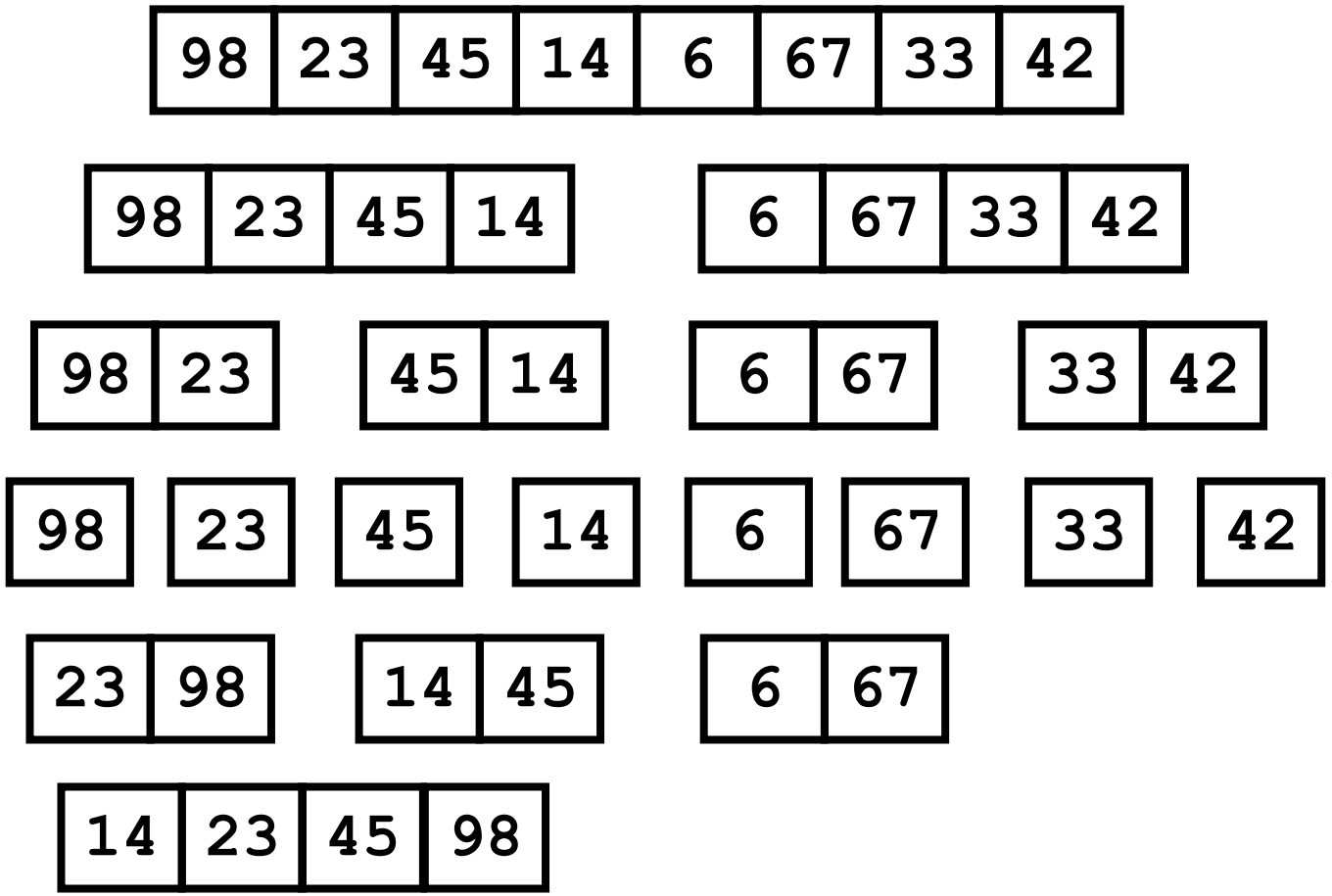

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
23 98
14 45
14 23 45 98

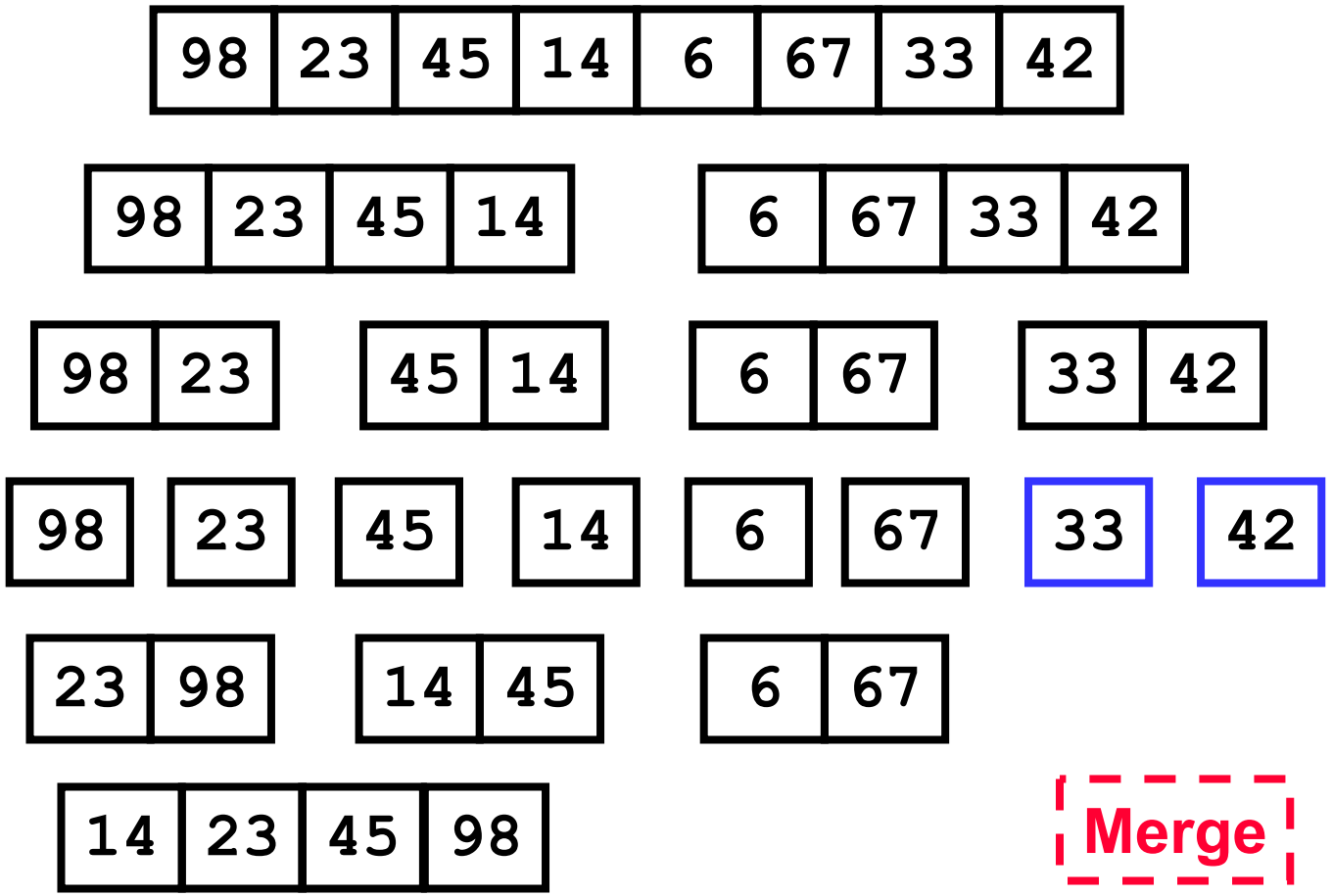

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
23 98
14 45
14 23 45 98

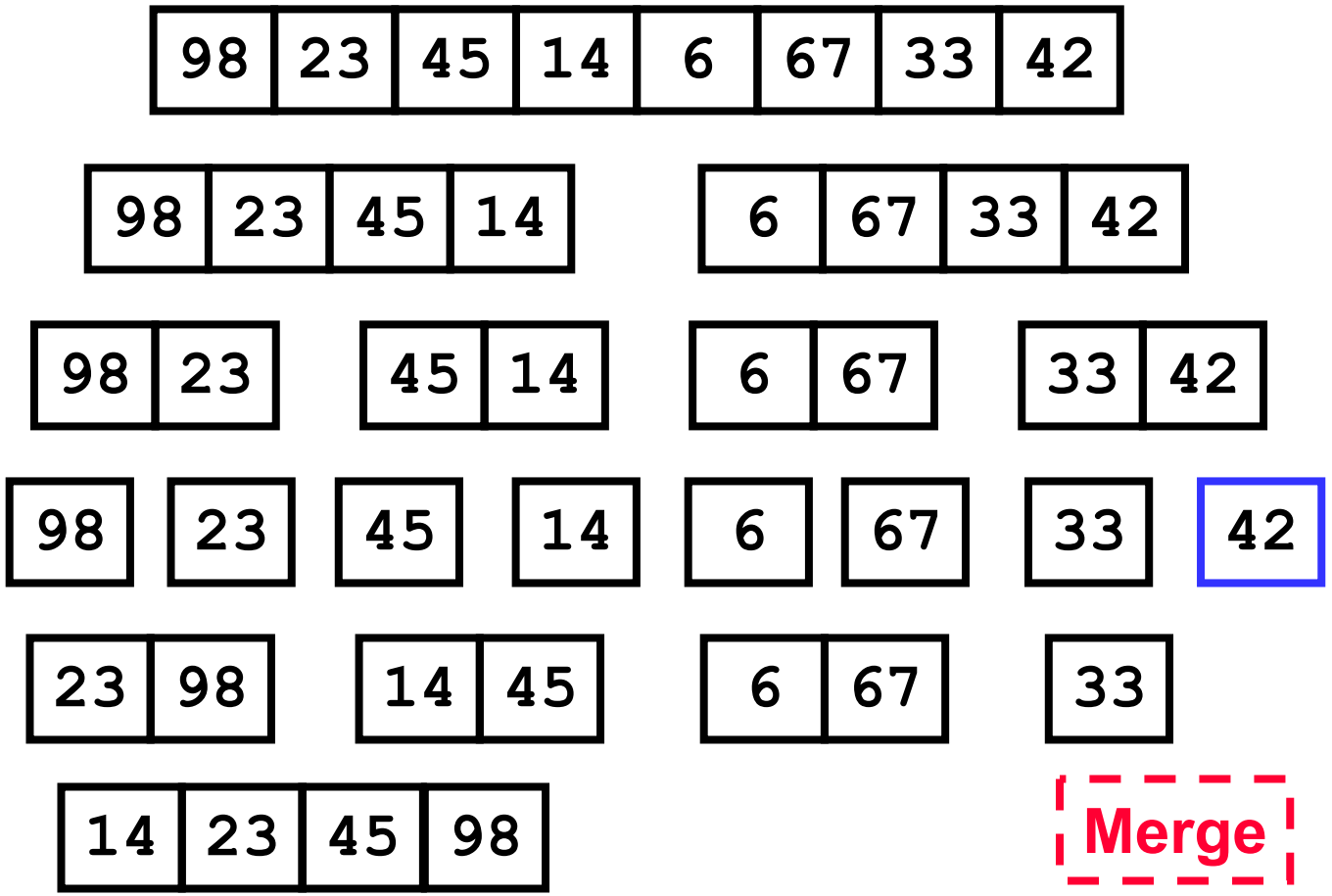

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
23 98
14 45
14 23 45 98
Merge

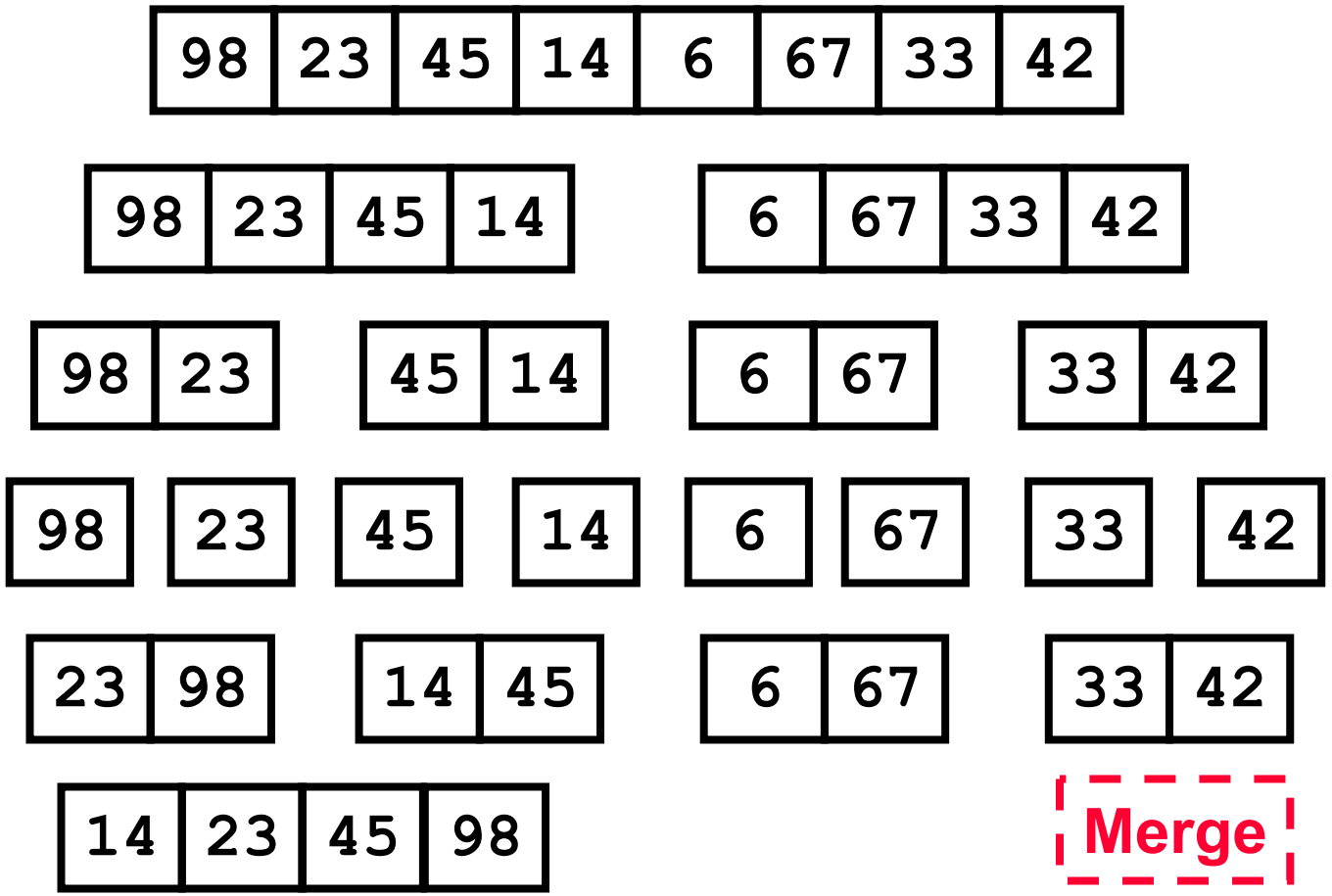

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
23 98
14 45
6
14 23 45 98
Merge

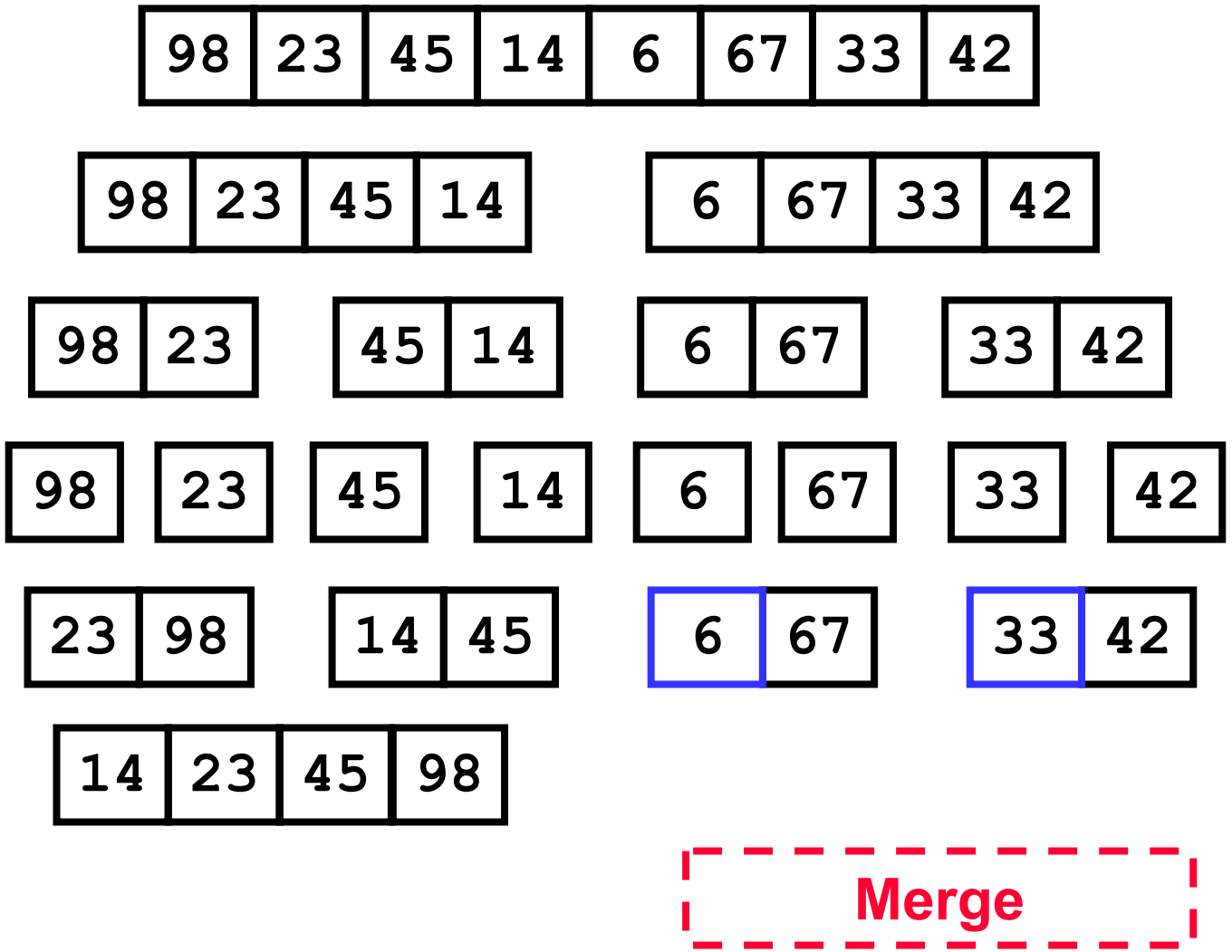

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
23 98
14 45
6 67
14 23 45 98
Merge

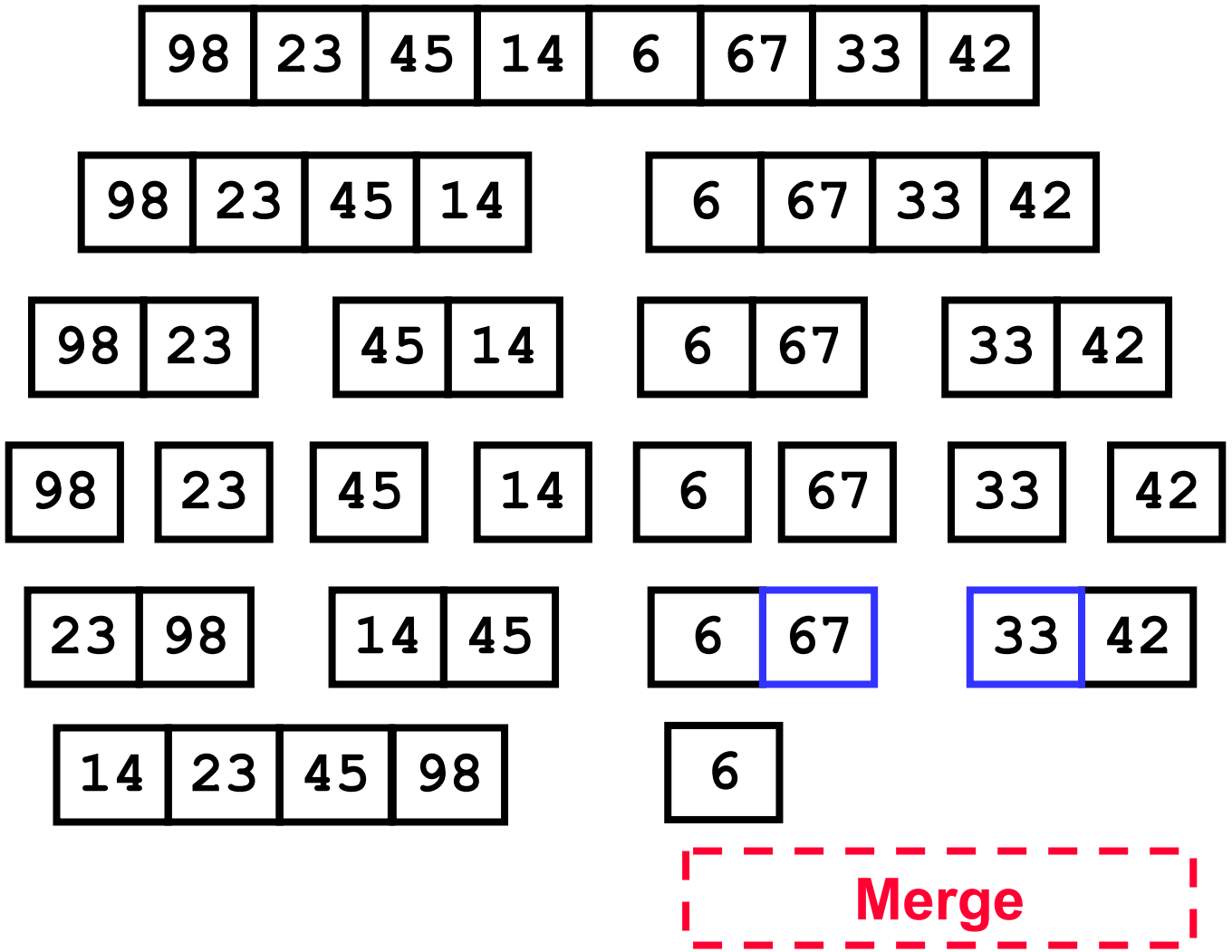

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
14 23 45 98

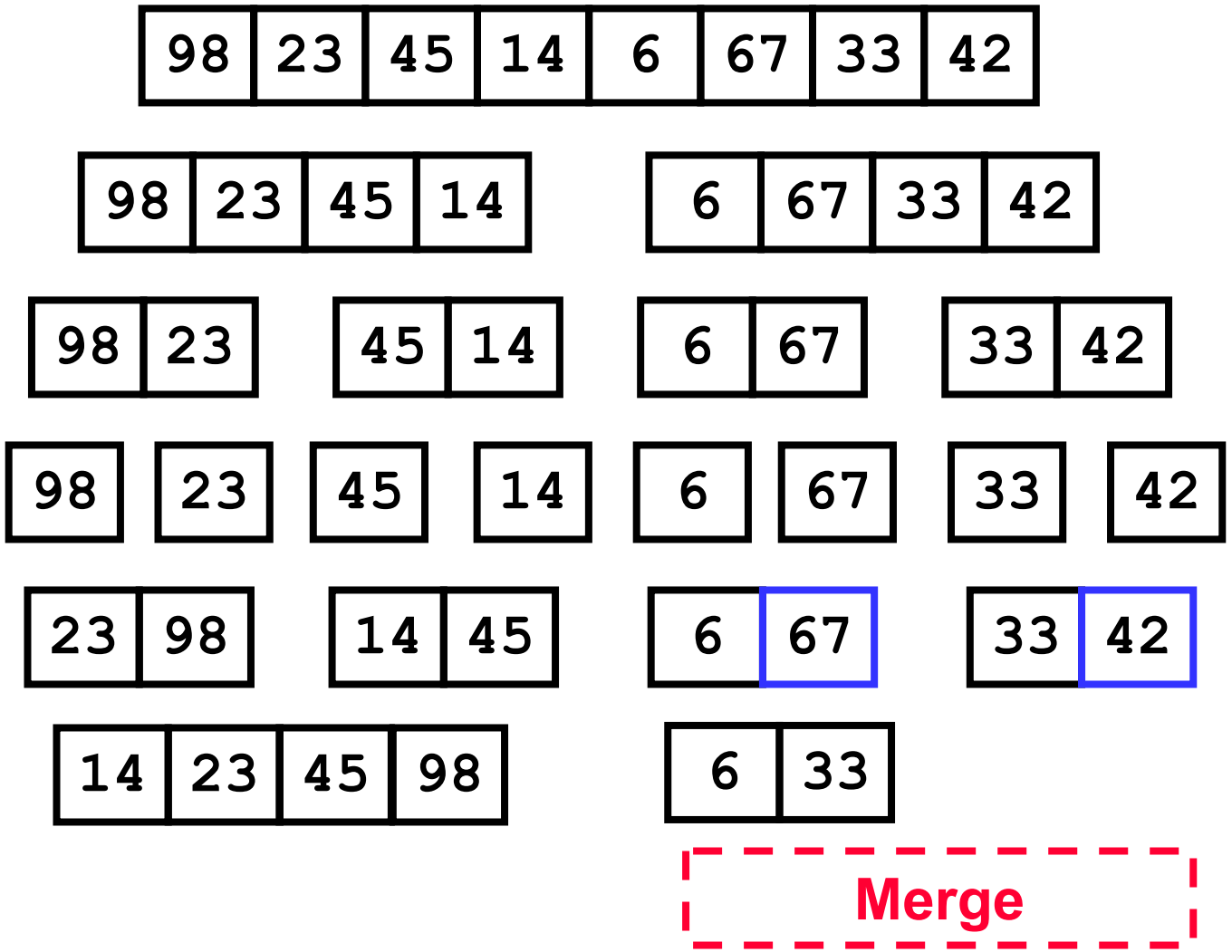

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
14 23 45 98
Merge

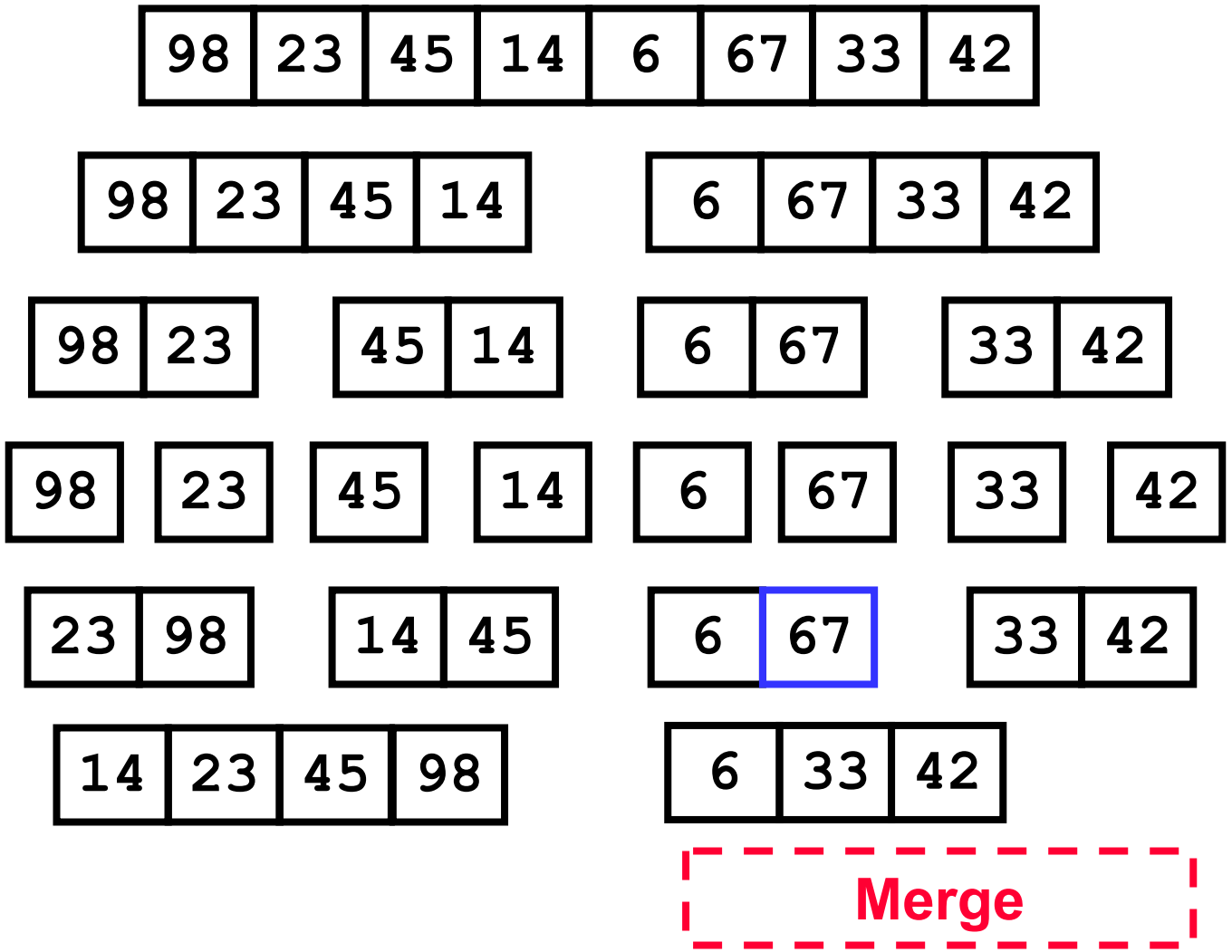

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33
14 23 45 98
Merge

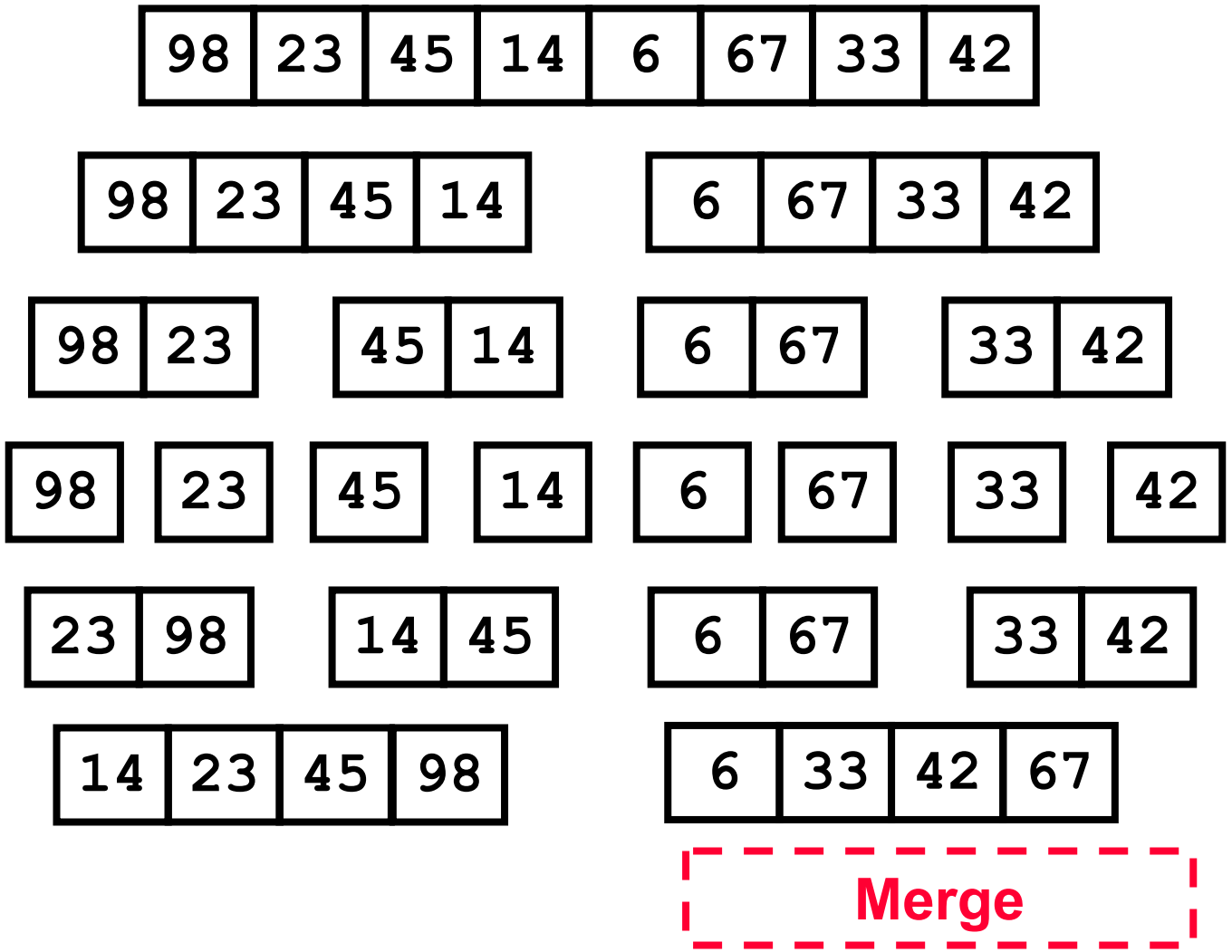

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
Merge

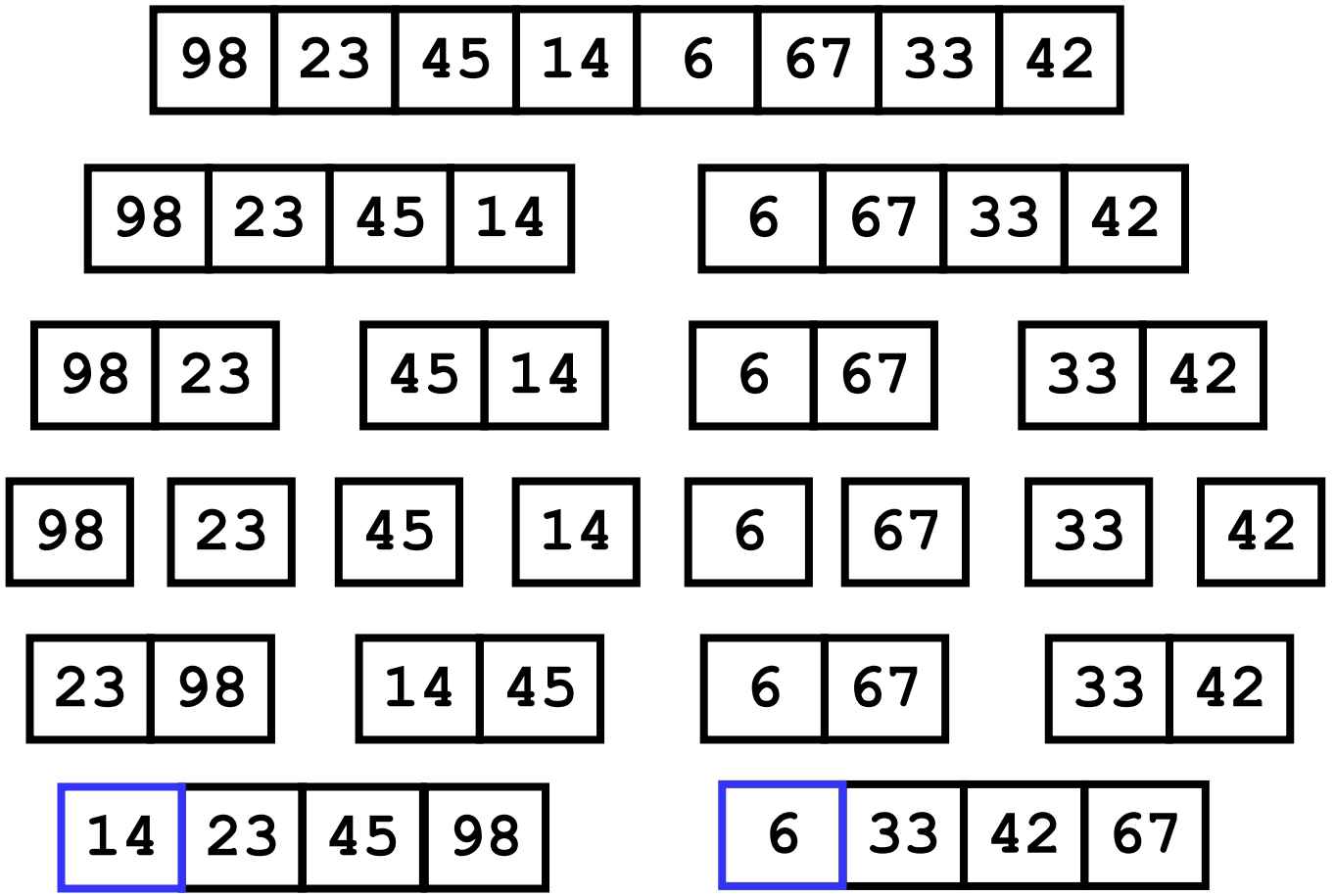

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
Merge

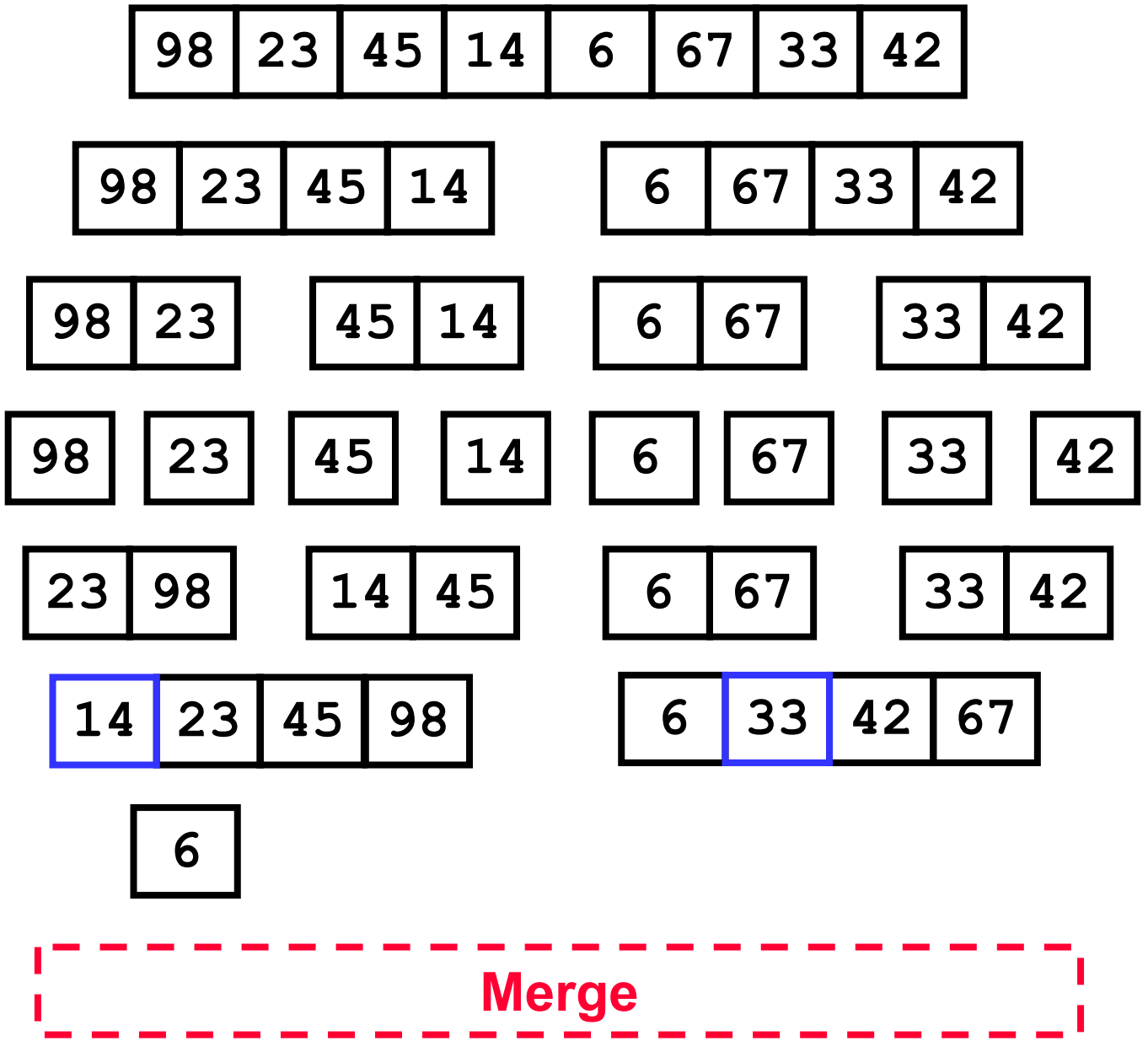

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6
Merge

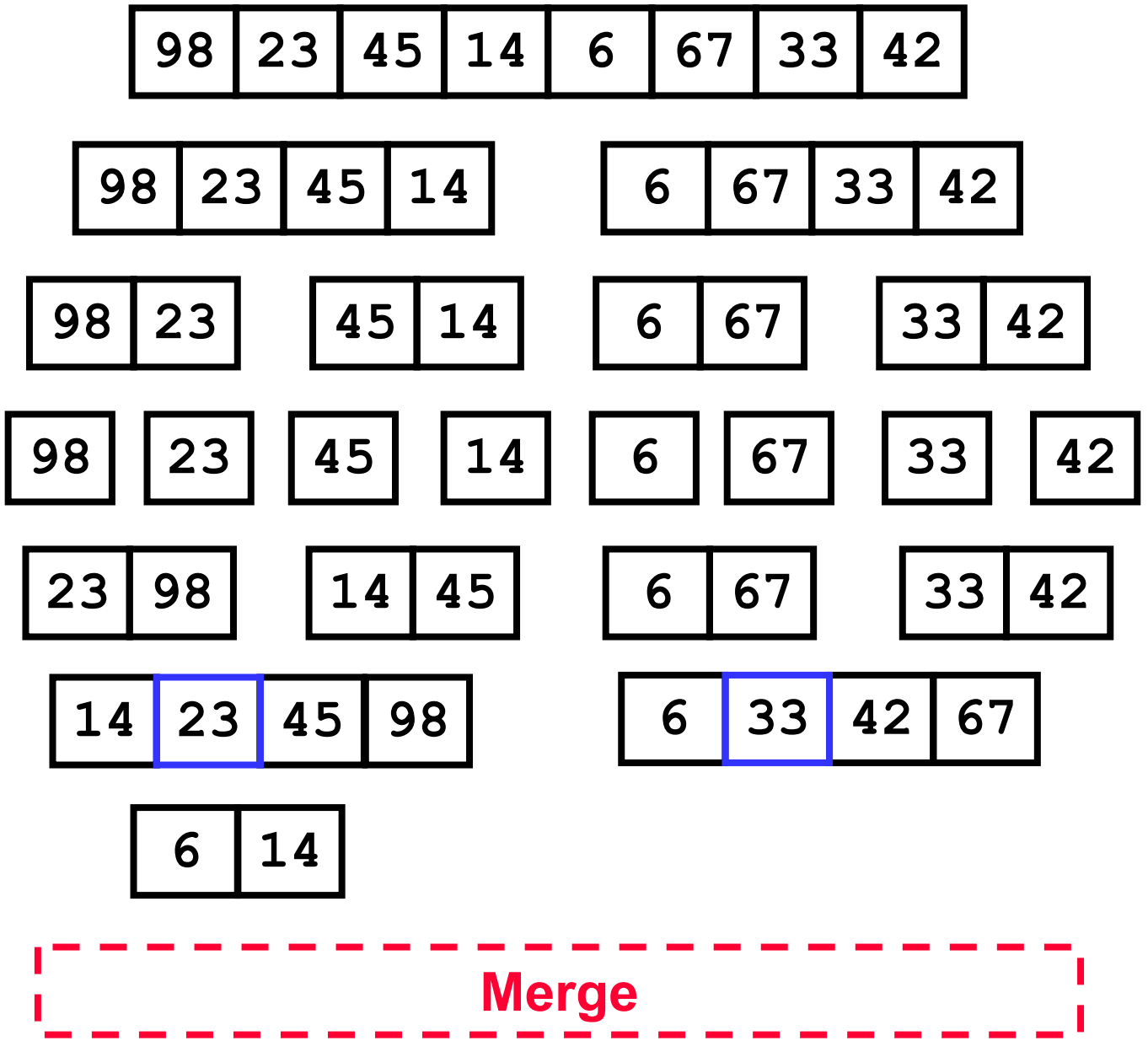

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33
Merge

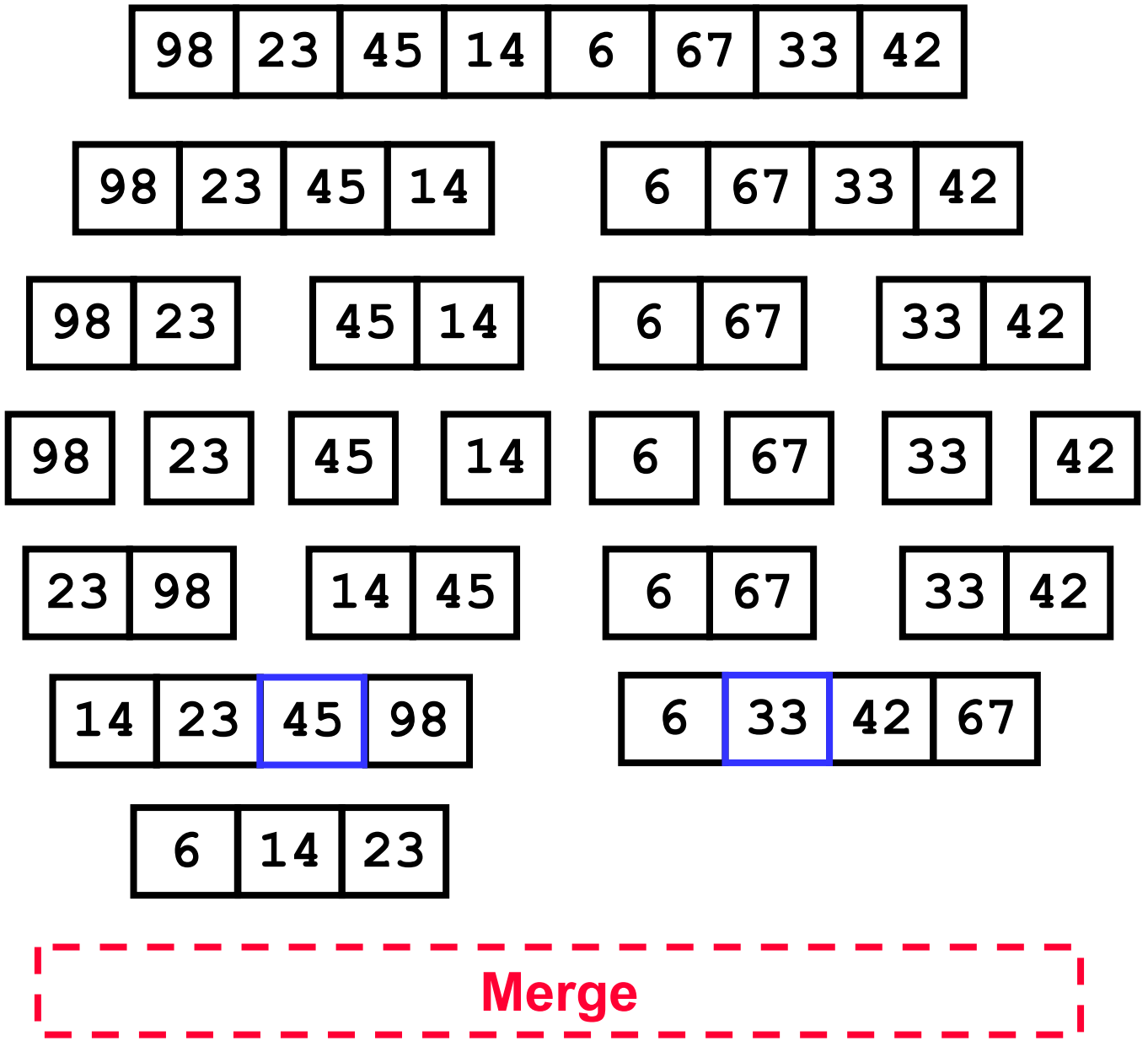

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33 42
Merge

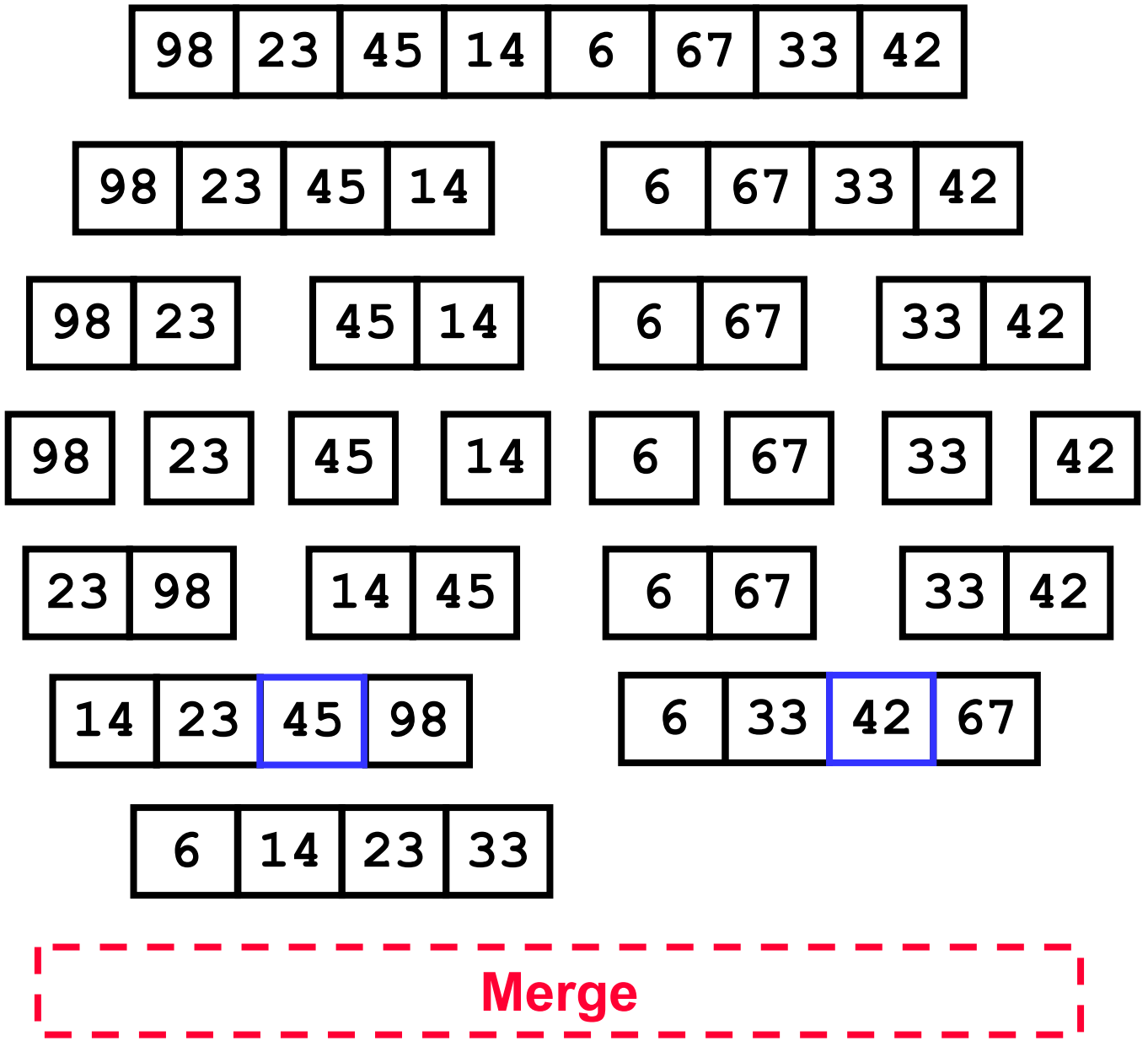

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33 42 67
Merge

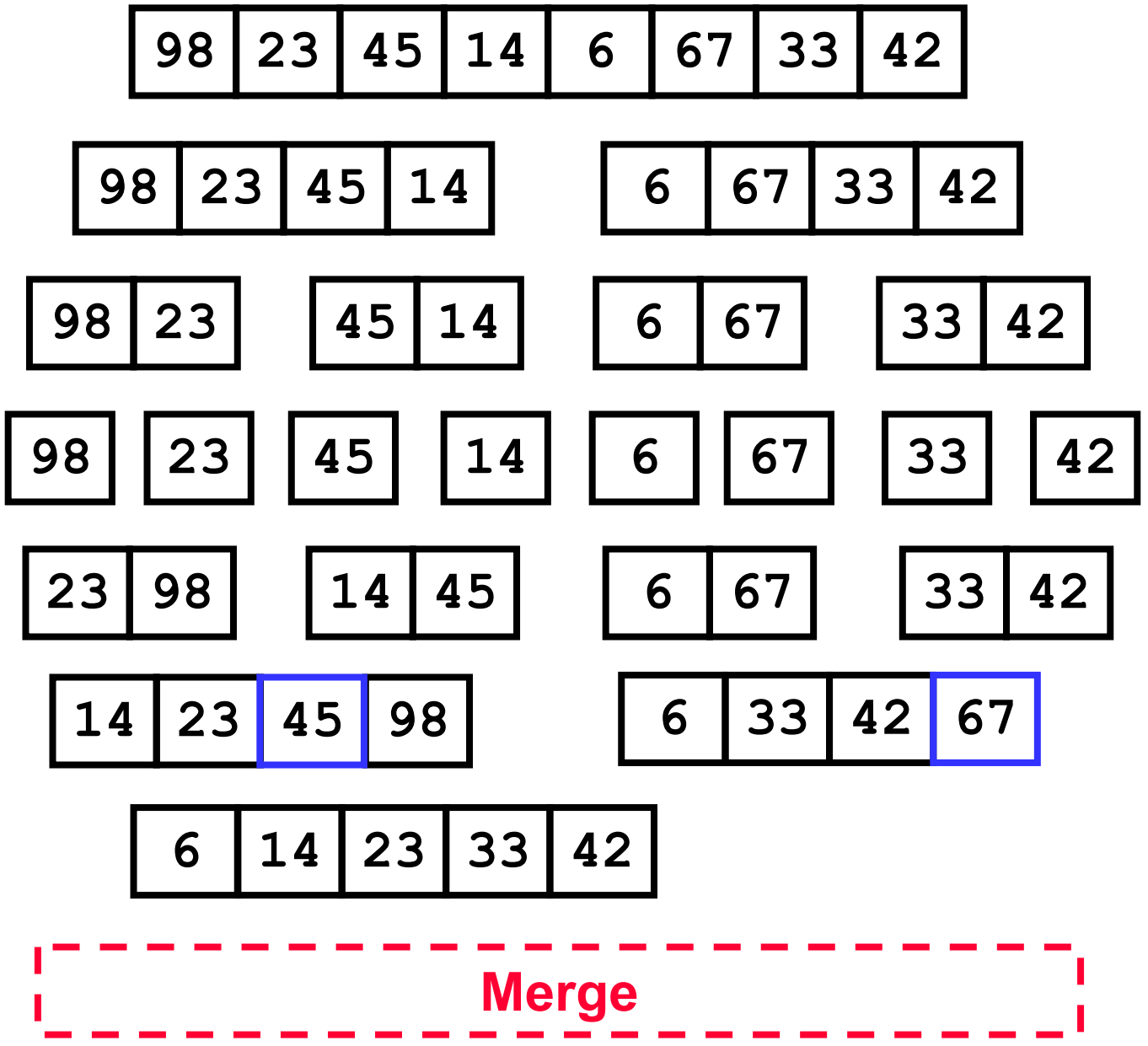

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33 42 67
Merge

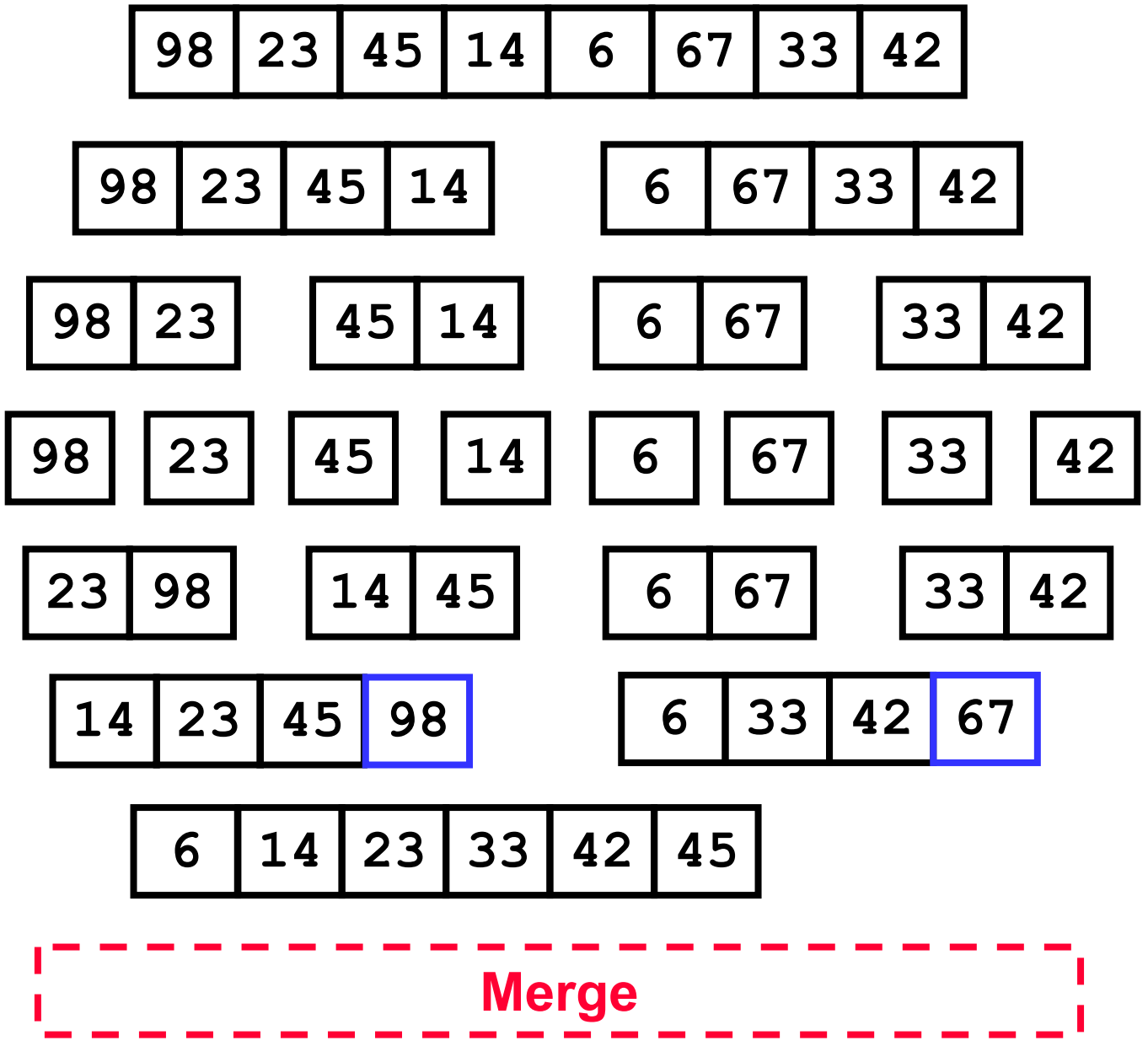

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33 42 67
6
Merge

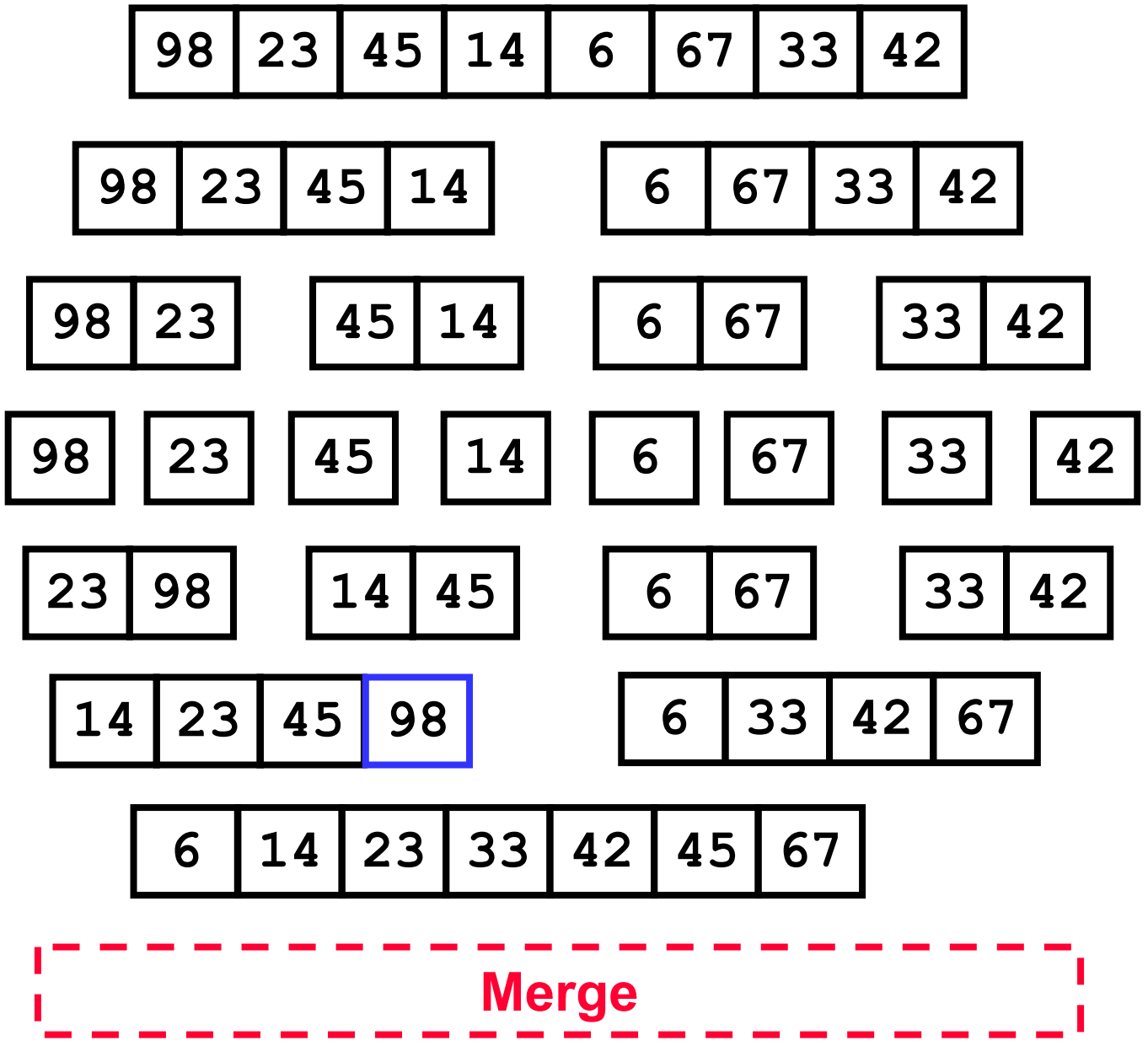

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33 42 67
6 14
Merge

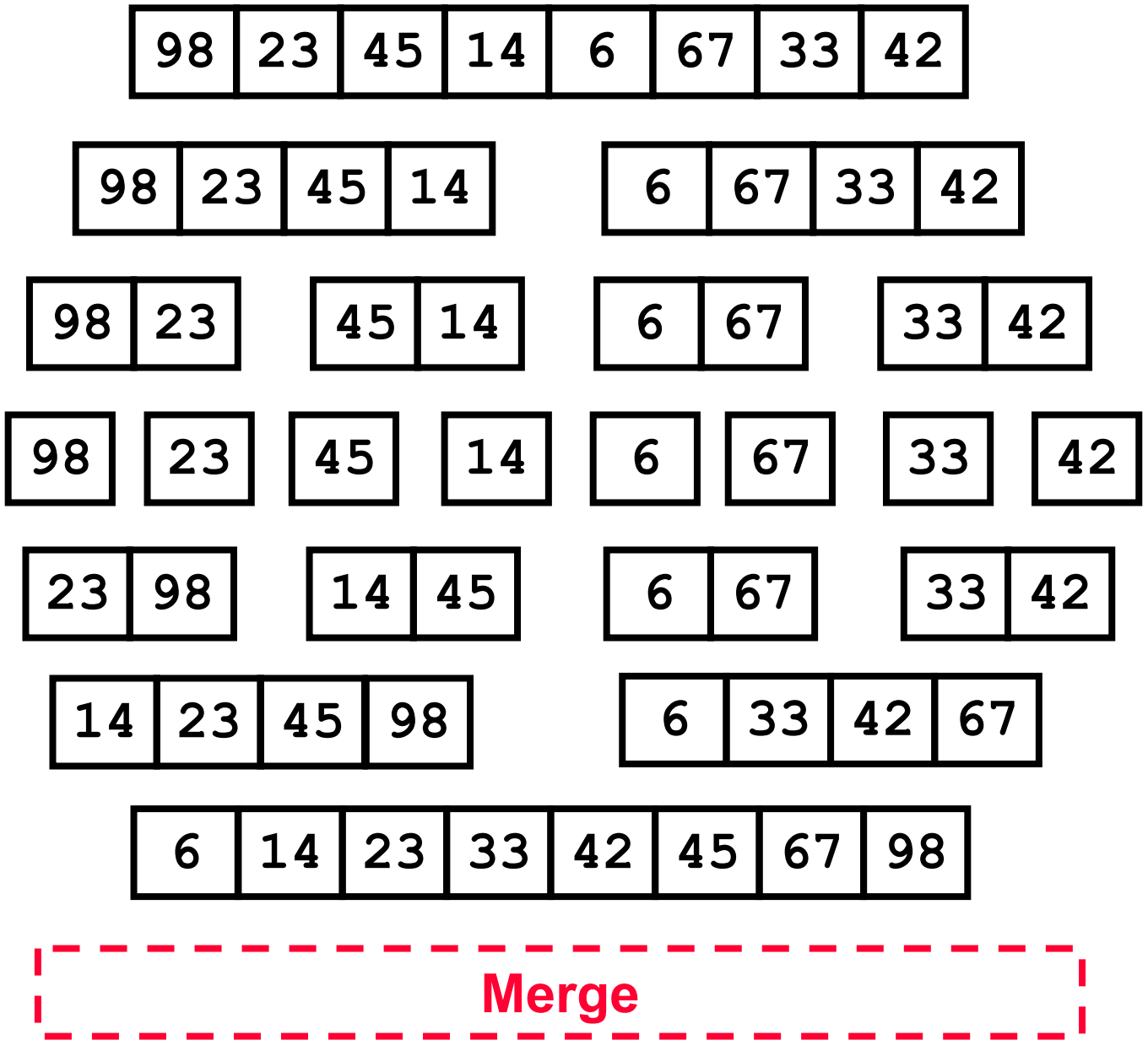

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33 42 67
6 14 23
Merge

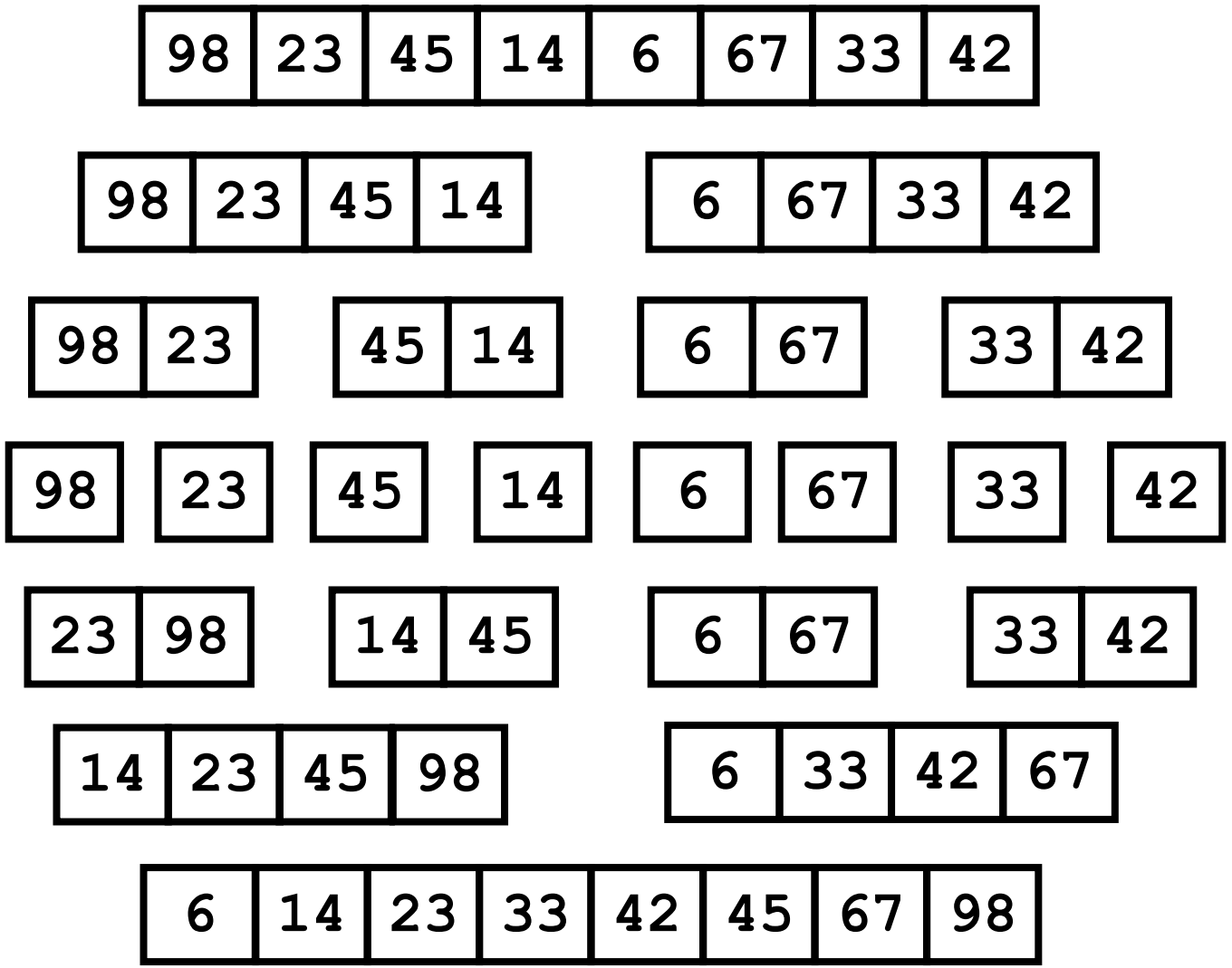

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33 42 67
6 14 23 33
Merge

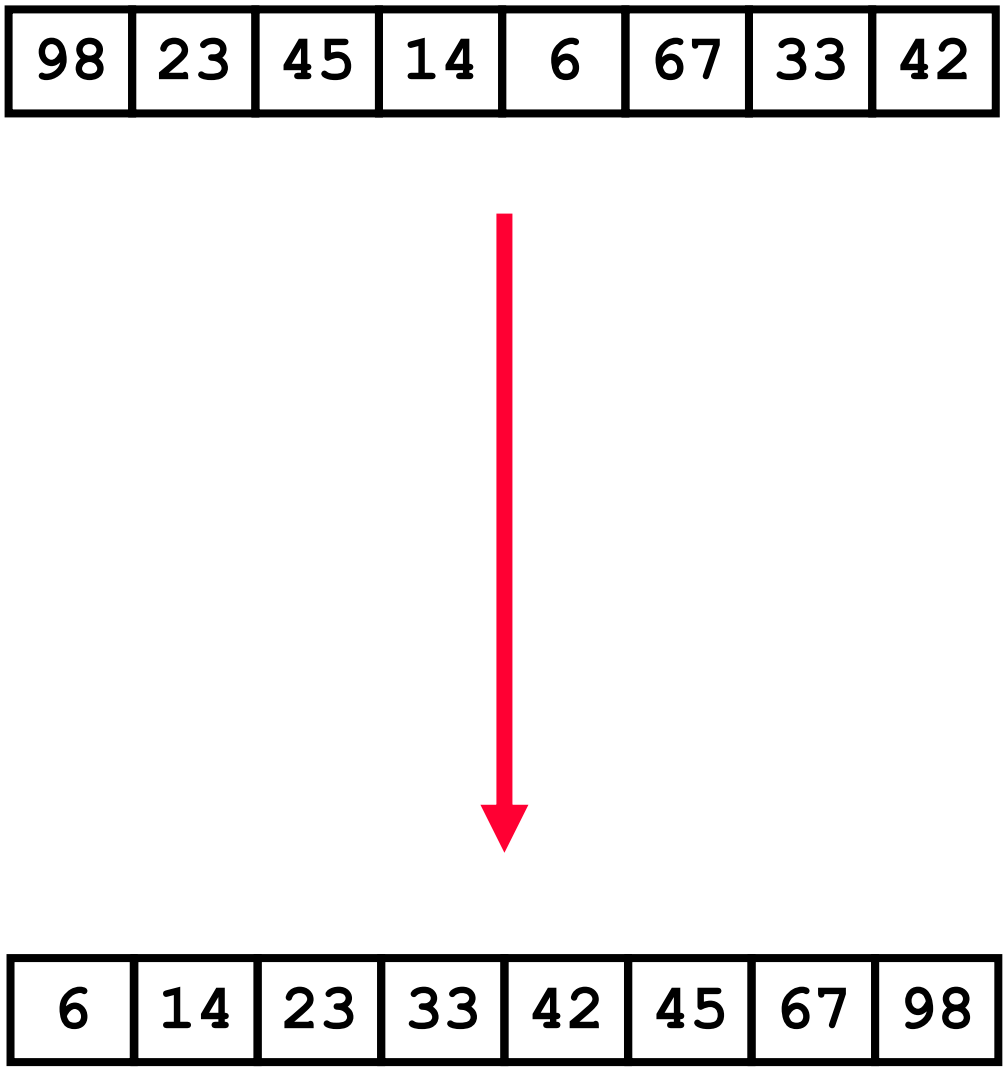

98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33 42 67
6 14 23 33 42
Merge


98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33 42 67
6 14 23 33 42 45
Merge


98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33 42 67
6 14 23 33 42 45 67
Merge


98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33 42 67
6 14 23 33 42 45 67 98
Merge


98 23 45 14 6 67 33 42
98 23 45 14
6 67 33 42
98 23
45 14
6 67
33 42
98
23
45
14
6
67
33
42
23 98
14 45
6 67
33 42
14 23 45 98
6 33 42 67
6 14 23 33 42 45 67 98


98 23 45 14 6 67 33 42
6 14 23 33 42 45 67 98

Algoritma Merge Sort

```
void MergeSortRekursif(l, r)
1. jika (l < r) maka kerjakan baris 2-5
2.          med = (l+r) / 2 ;
3.          MergeSortRekursif(l,med);
4.          MergeSortRekursif(med+1,r);
5.          Merge(l,med,r);
```

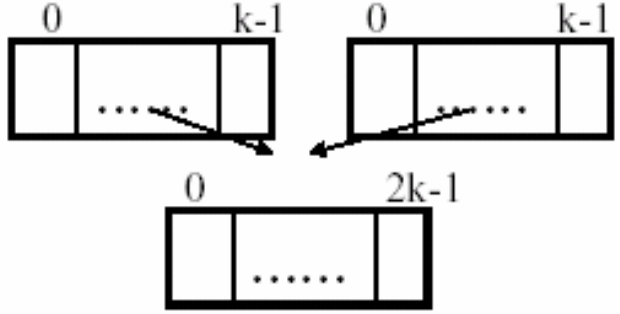
Fungsi Merge

```
void Merge(left, median, right)
1.  kiri1 ← left
2.  kanan1 ← median
3.  kiri2 ← median+1
4.  kanan2 ← right
5.  i ← left;
6.  selama (kiri1<=kanan1) dan (kiri2<=kanan2) kerjakan 7-13
7.     jika (Data[kiri1] <= Data[kiri2]) kerjakan 8-9
8.            hasil[i] = Data[kiri1];
9.            kiri1++
10.    jika tidak kerjakan baris 11-12
11.           hasil[i] = Data[kiri2];
12.           kiri2++
13.    i++
```

```
14. selama (kiri1<=kanan1) kerjakan baris 15-17
15.     hasil[i] = Data[kiri1]
16.     kiri1++
17.     i++

18. selama (kiri2<=kanan2) kerjakan baris 19-21
19.     hasil[i] = Data[kiri2]
20.     i++
21.     kiri2++

22.j ← left
23.selama (j <=right) kerjakan baris 24-25
24.     Data[j] = hasil[j]
25.     j++
```

Mergesort – Analysis of Merge (cont.)

Merging two sorted arrays of size ***k***



- ***Best-case:***
  - All the elements in the first array are smaller (or larger) than all the elements in the second array.
  - The number of moves: 2k + 2k
  - The number of key comparisons: k
- ***Worst-case:***
  - The number of moves: 2k + 2k
  - The number of key comparisons: 2k-1

Summary

- **Divide the unsorted collection into two**
- **Until the sub-arrays only contain one element**
- **Then merge the sub-problem solutions together**