Merge Sort

```
public static void mergeSort( Comparable [ ] a ) {
      Comparable [ ] tmpArray = new Comparable[ a.length ];
      mergeSort( a, tmpArray, 0, a.length - 1 );
   }
private static void mergeSort( Comparable [ ] a, Comparable [ ]
    tmpArray,
            int left, int right )
   {
      if( left < right )
      {
         int center = ( left + right ) / 2;
         mergeSort( a, tmpArray, left, center );
         mergeSort( a, tmpArray, center + 1, right );
         merge( a, tmpArray, left, center + 1, right );
      }
   }
```

Merge in Merge Sort

```
private static void merge( Comparable [ ] a, Comparable [ ] tmpArray,
                           int leftPos, int rightPos, int rightEnd )
  {
     int leftEnd = rightPos - 1;
     int tmpPos = leftPos;
     int numElements = rightEnd - leftPos + 1;
     while( leftPos <= leftEnd && rightPos <= rightEnd )
        if( a[ leftPos ].compareTo( a[ rightPos ] ) < 0 )
                tmpArray[ tmpPos++ ] = a[ leftPos++ ];
        else
                 tmpArray[ tmpPos++ ] = a[ rightPos++ ];
     while( leftPos <= leftEnd )    // Copy rest of first half
        tmpArray[ tmpPos++ ] = a[ leftPos++ ];
     while( rightPos <= rightEnd )  // Copy rest of right half
        tmpArray[ tmpPos++ ] = a[ rightPos++ ];

    for( int i = 0; i < numElements; i++, rightEnd-- )
        a[ rightEnd ] = tmpArray[ rightEnd ];
  }
```

Figure 8.10 Quicksort

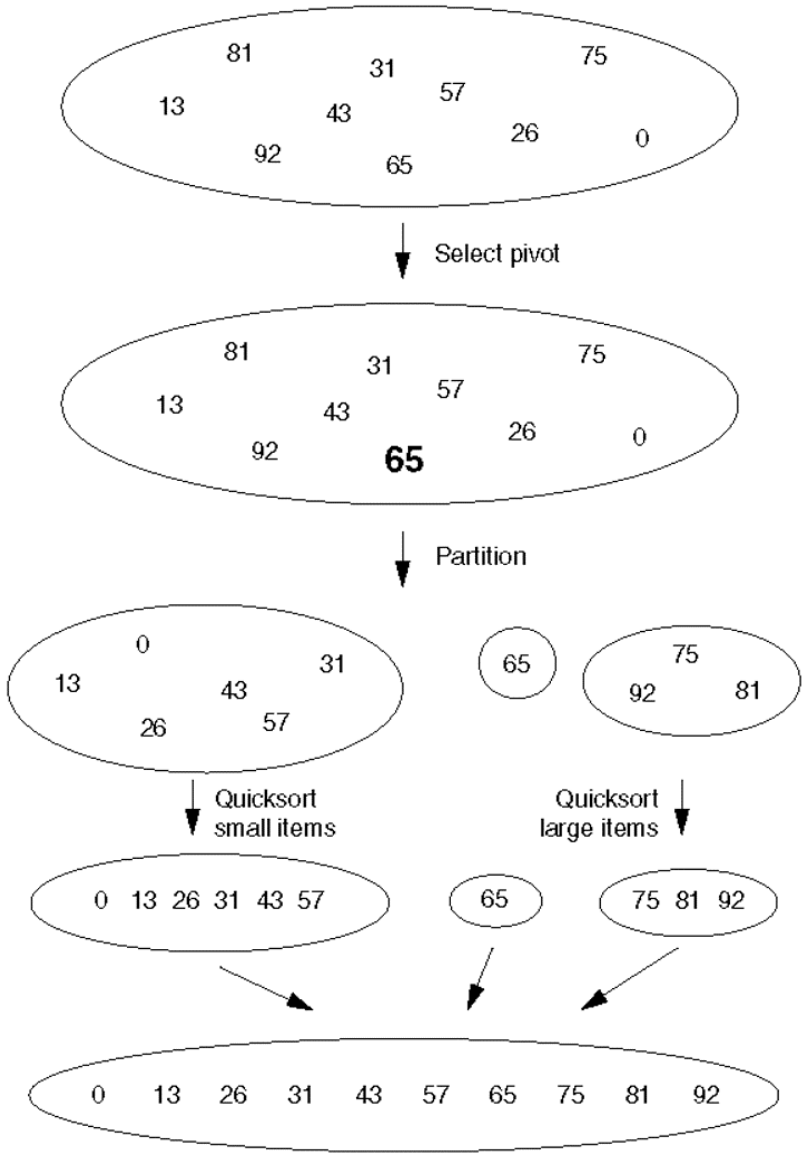


Figure 8.11 Partitioning algorithm: Pivot element 6 is placed at the end.

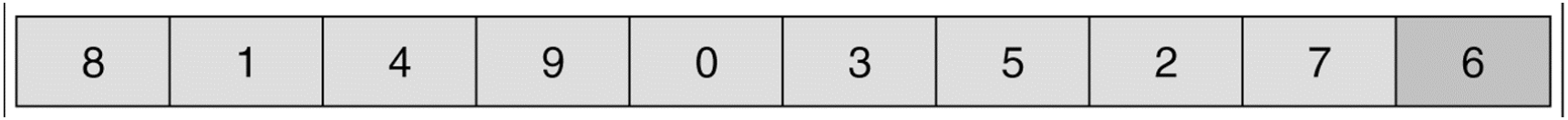


Figure 8.12 Partitioning algorithm: i stops at large element 8; j stops at small element 2.

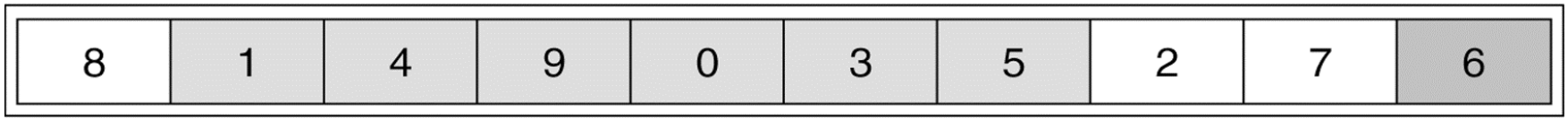


Figure 8.13 Partitioning algorithm: The out-of-order elements 8 and 2 are swapped.

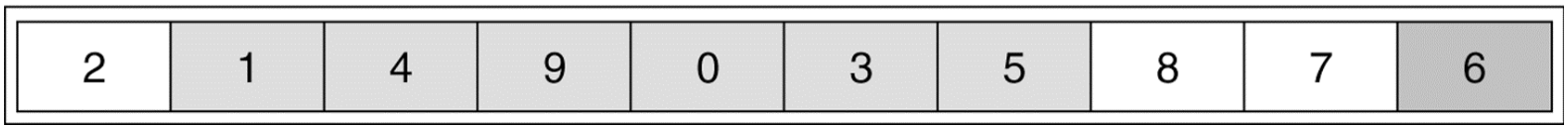


Figure 8.14 Partitioning algorithm: i stops at large element 9; j stops at small element 5.

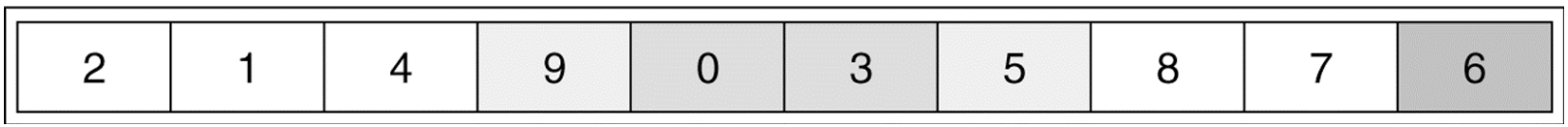


Figure 8.15 Partitioning algorithm: The out-of-order elements 9 and 5 are swapped.

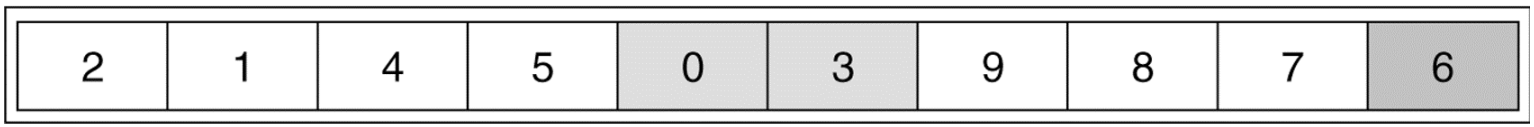


Figure 8.16 Partitioning algorithm: i stops at large element 9; j stops at small element 3.

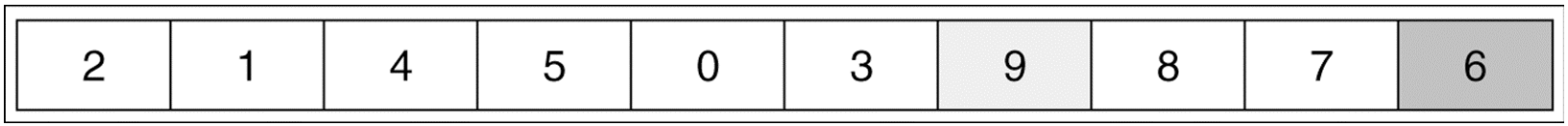


Figure 8.17 Partitioning algorithm: Swap pivot and element in position i.

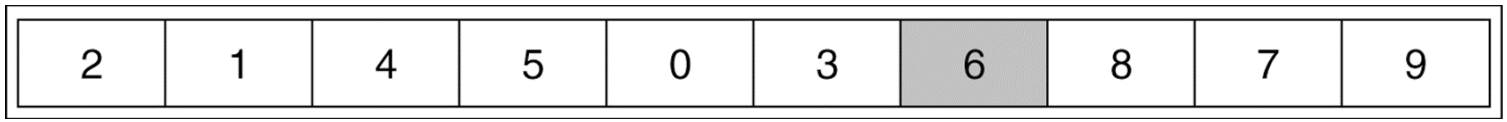


Figure 8.18 Original array

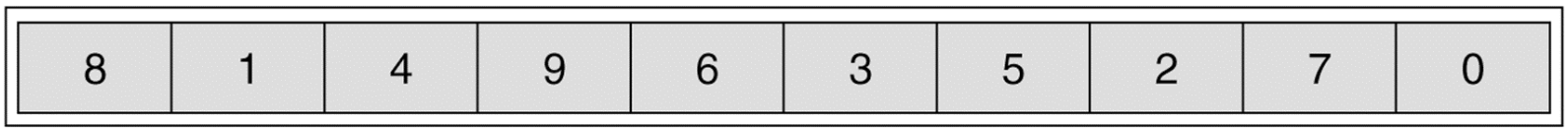


Figure 8.19 Result of sorting three elements (first, middle, and last)

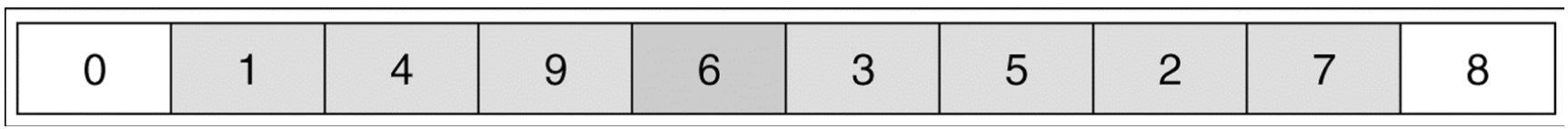
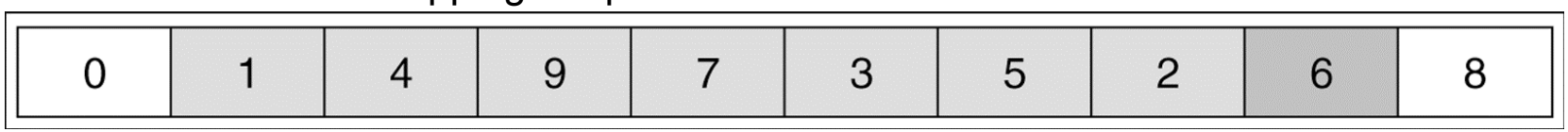


Figure 8.20 Result of swapping the pivot with the next-to-last element



Quicksort

```
public static void quicksort( Comparable [ ] a ) {  quicksort( a, 0, a.length - 1 );  }
private static void quicksort( Comparable [ ] a, int low, int high )
   {
      if( low + CUTOFF > high )  insertionSort( a, low, high );
      else  {  // Sort low, middle, high
         int middle = ( low + high ) / 2;
         if( a[ middle ].compareTo( a[ low ] ) < 0 )    swapReferences( a, low, middle );
         if( a[ high ].compareTo( a[ low ] ) < 0 )      swapReferences( a, low, high );
         if( a[ high ].compareTo( a[ middle ] ) < 0 )   swapReferences( a, middle, high );
         swapReferences( a, middle, high - 1 );        // Place pivot at position high - 1
         Comparable pivot = a[ high - 1 ];
         int i, j; // Begin partitioning
         for( i = low, j = high - 1; ; ) {
            while( a[ ++i ].compareTo( pivot ) < 0 ) /* Do nothing */     ;
            while( pivot.compareTo( a[ --j ] ) < 0 ) /* Do nothing */     ;
            if( i >= j )    break;
            swapReferences( a, i, j );
         }
        swapReferences( a, i, high - 1 );
         quicksort( a, low, i - 1 );    // Sort small elements
         quicksort( a, i + 1, high );   // Sort large elements
      }
   }
```

Figure 20.4

Linear probing hash table after each insertion

```
hash ( 89, 10 ) = 9
hash ( 18, 10 ) = 8
hash ( 49, 10 ) = 9
hash ( 58, 10 ) = 8
hash (  9, 10 ) = 9
```

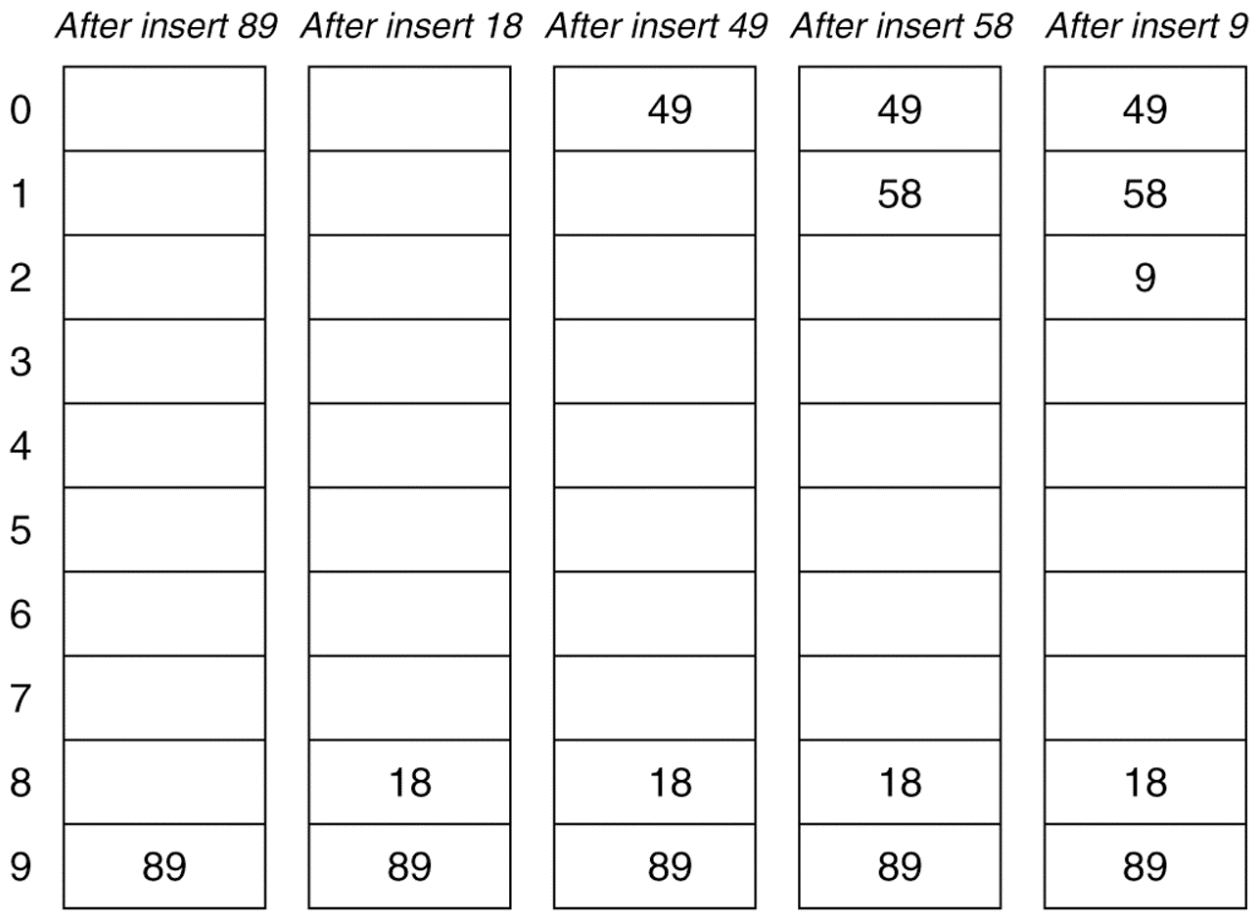


Figure 20.5

Illustration of primary clustering in linear probing (b) versus no clustering (a) and the less significant secondary clustering in quadratic probing (c). Long lines represent occupied cells, and the load factor is 0.7.

Figure 20.6

A quadratic probing hash table after each insertion (note that the table size was poorly chosen because it is not a prime number).

```
hash ( 89, 10 ) = 9
hash ( 18, 10 ) = 8
hash ( 49, 10 ) = 9
hash ( 58, 10 ) = 8
hash (  9, 10 ) = 9
```