4.栈与队列

（b）栈与递归

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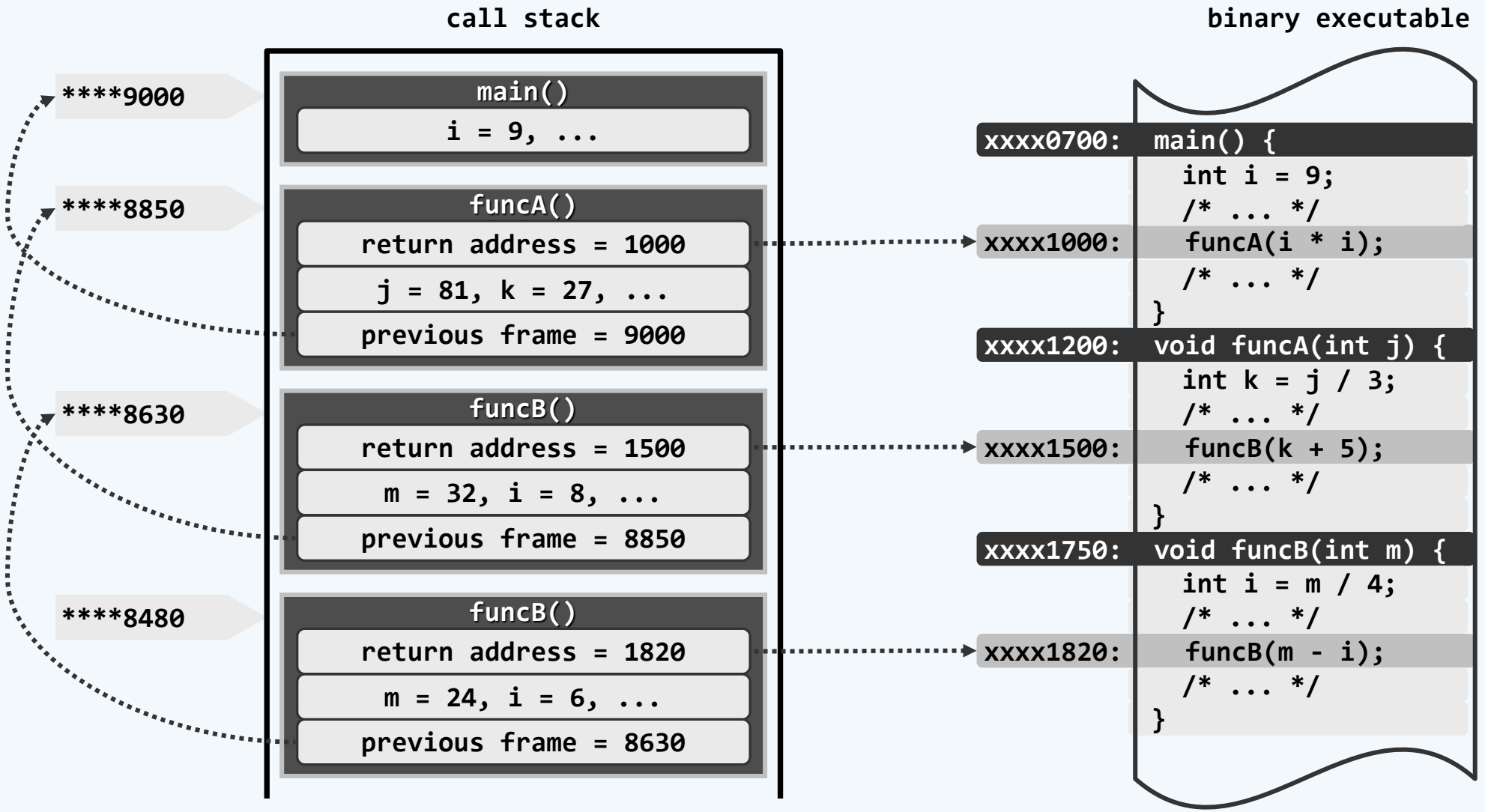
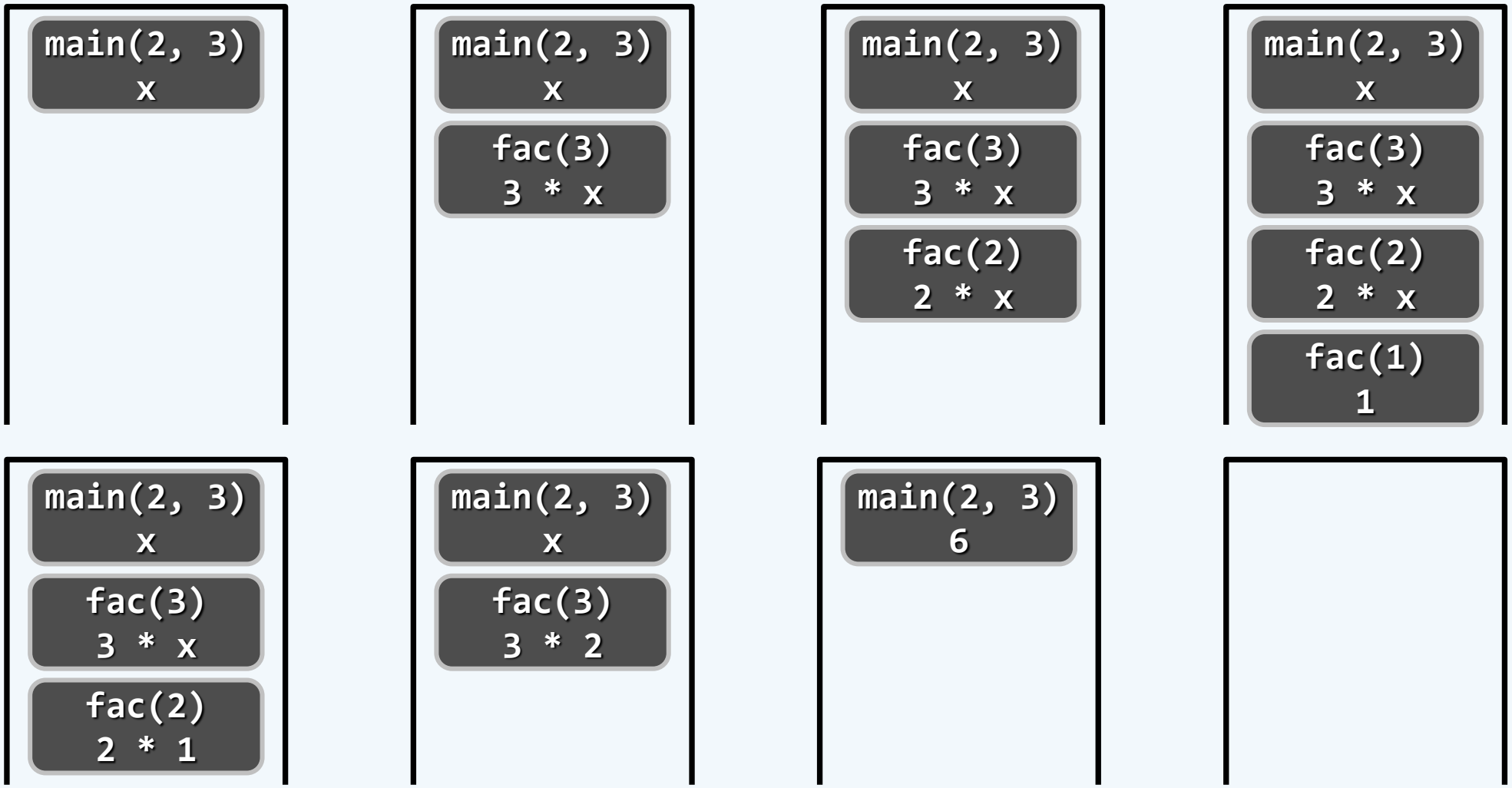
函数调用栈


call stack
binary executable
****9000
****8850
****8630
****8480
main()
i = 9, ...
funcA()
return address = 1000
j = 81, k = 27, ...
previous frame = 9000
funcB()
return address = 1500
m = 32, i = 8, ...
previous frame = 8850
funcB()
return address = 1820
m = 24, i = 6, ...
previous frame = 8630
xxxx0700: main() {
int i = 9;
/* ... */
xxxx1000: funcA(i * i);
/* ... */
}
xxxx1200: void funcA(int j) {
int k = j / 3;
/* ... */
xxxx1500: funcB(k + 5);
/* ... */
}
xxxx1750: void funcB(int m) {
int i = m / 4;
/* ... */
xxxx1820: funcB(m - i);
/* ... */
}

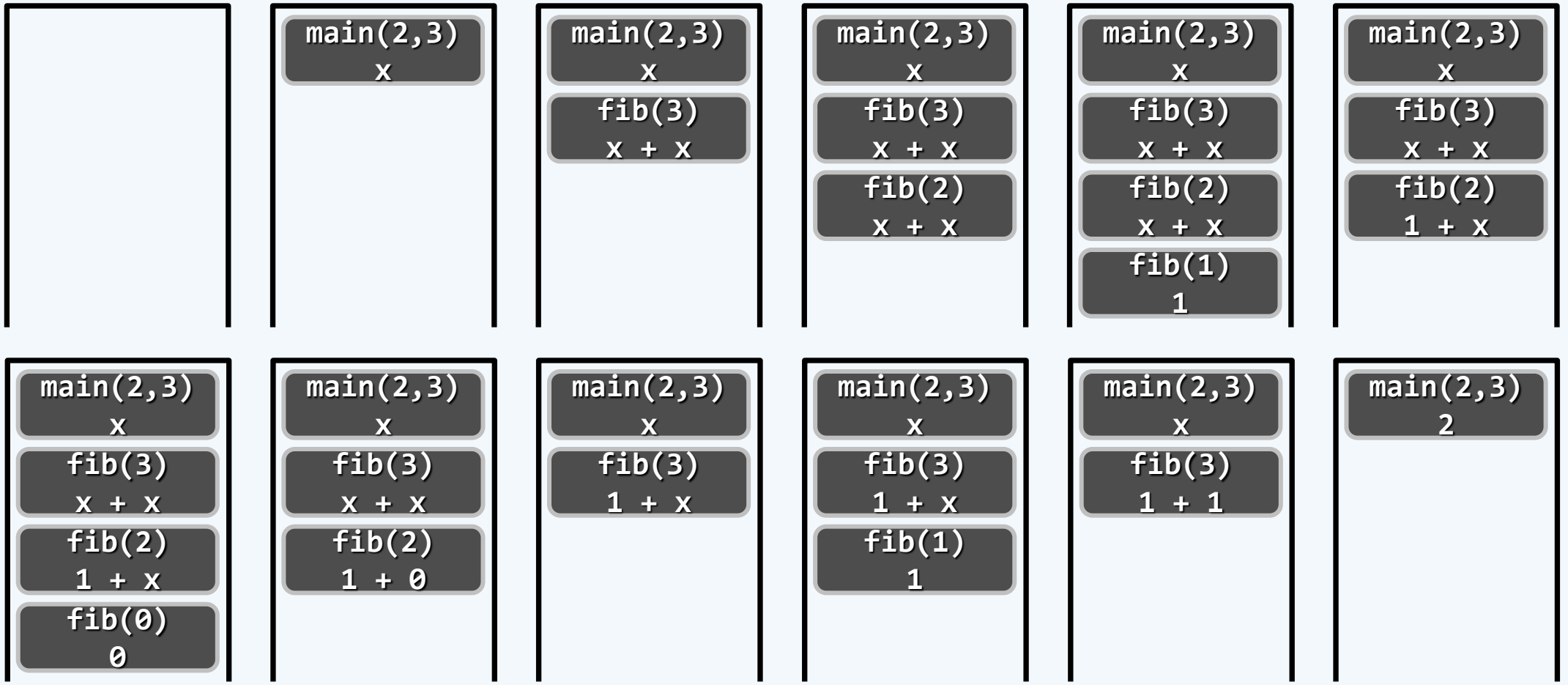
实例：fac()

❖ `int fac(int n) { return (n < 1) ? 1 : n * fac(n - 1); }`



实例：fib()

❖ `int fib( int n ) { return (n < 2) ? n : fib(n - 1) + fib(n - 2); }`



实例：hailstone()

```
❖hailstone(int n) {
    if ( 2 > n ) return;
    n % 2  ?  odd( n ): even( n );
  }

❖even( int n ) { hailstone( n / 2 ); }
  odd( int n ) { hailstone( 3*n + 1 ); }

❖main(int argc, char* argv[])
  { hailstone( atoi( argv[1] ) ); }
```

避免递归

- 动机： 递归函数的空间复杂度，主要取决于最大递归深度，而非递归实例总数

  为隐式地维护调用栈，需花费额外的处理时间

- 方法： 将递归算法改写为迭代版本...

- `int fac( int n ) { int f = 1; while ( n > 1 ) f *= n--; return f; } //O(1)空间`

- ```
  int fib( int n ) { //O(1)空间
     int f = 0, g = 1; while ( 0 < n-- ) { g += f; f = g - f; }
     return f;
  }
  ```

- `void hailstone( int n ) { while ( 1 < n ) n = n % 2 ? 3*n + 1 : n/2; } //O(1)空间`

- 更为复杂的算法，迭代版本往往需要显式地维护栈，空间（乃至时间）效率更低 //第五章
  ```