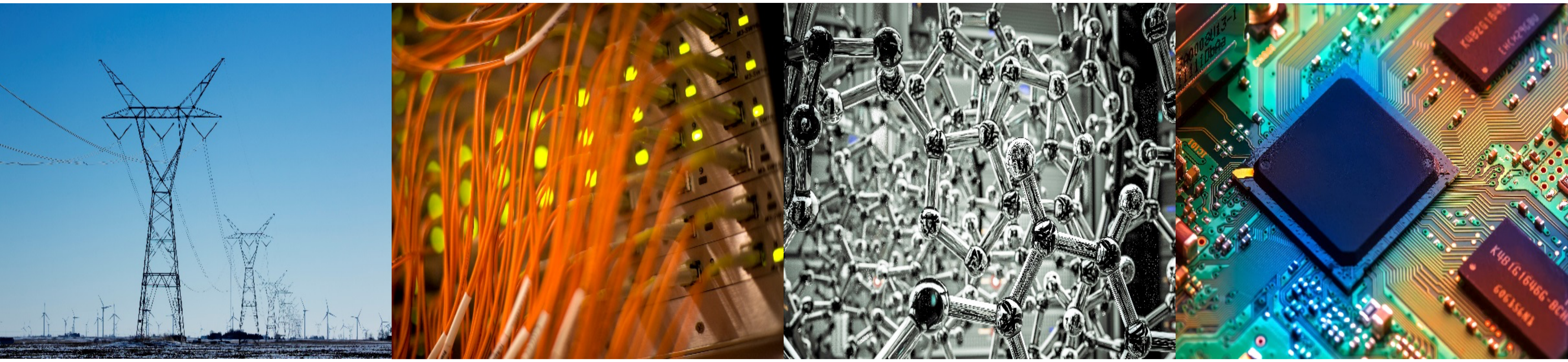
ECE 220 Computer Systems & Programming

Lecture 10 – Run-Time Stack

February 25, 2021



- MT1: 7pm CT on Thursday, 3/4
- Conflict: 8am CT on Friday, 3/5
- Submit conflict request through CBTF

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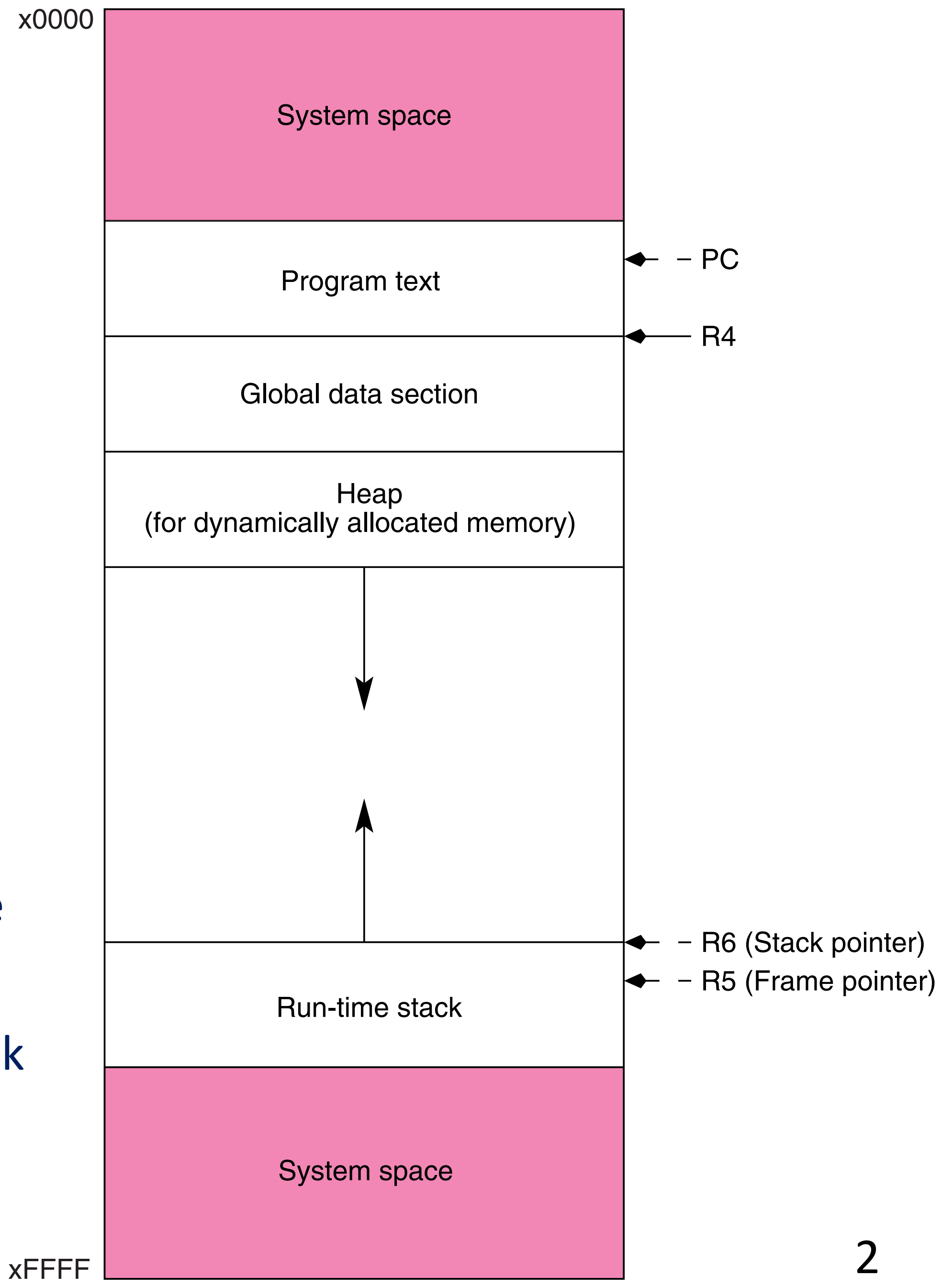
Space for Variables

1. **Global data section**
   (global variables)
2. **Run-time stack**
   (local variables)
3. **Heap**
   (dynamically allocated variables)

R4 (global pointer) points to the first global variable

R5 (frame pointer) points to first local variable

R6 (stack pointer) points to the top of run-time stack



Symbol Table

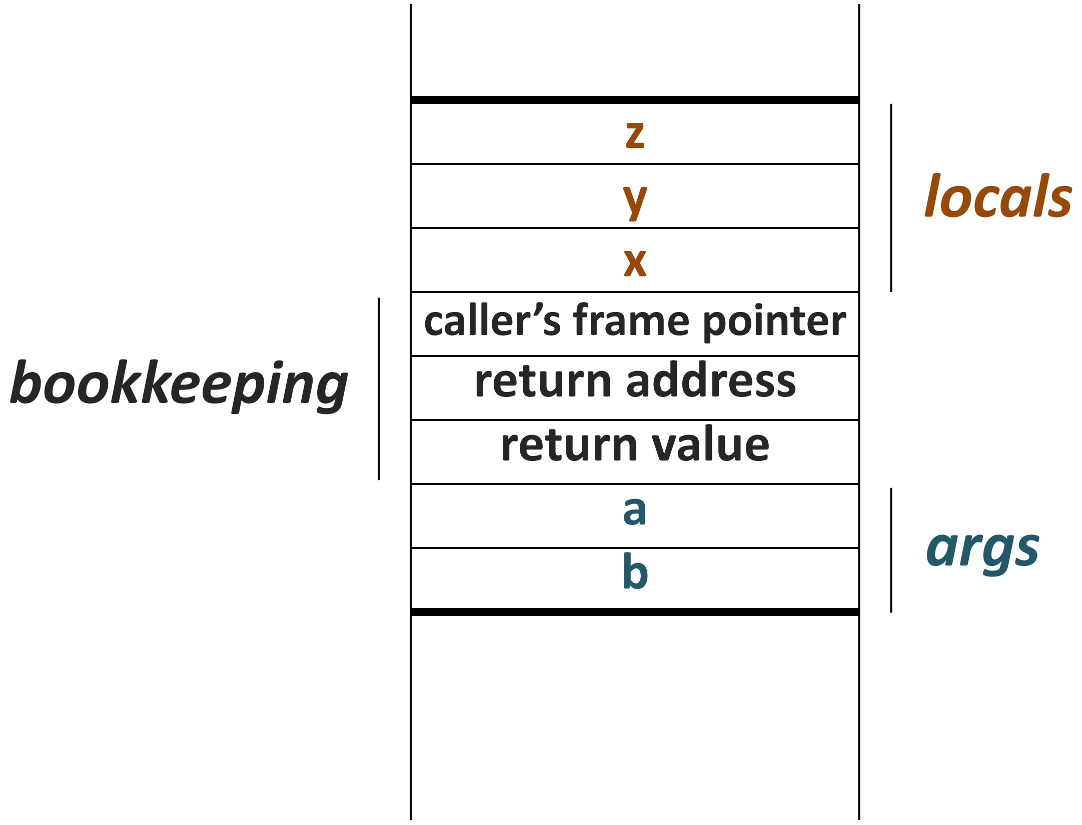
- It contains name, type, location (as an offset), and scope.

```
int inGlobal;
int outGlobal;

int dummy(int in1, int in2);

int main(){
    int x,y,z;
    …

}

int dummy(int in1, int in2){
    int a,b,c;
    …
}
```

Name	Type	Location (as an offset)	Scope
inGlobal	int	0	global
outGlobal	int	1	global
x	int	0	main
y	int	-1	main
z	int	-2	main
a	int	0	dummy
b	int	-1	dummy
c	int	-2	dummy

Activation Record

```
int func(int a, int b){
  int x, y, z;
  .
  .
  .
  return y;
}
```



Stack Built-up and Tear-down

Caller function	**1. caller setup** (push callee’s arguments onto stack) **2. pass control to callee** (invoke function)
Callee function	**3. callee setup** (push bookkeeping info and local variables onto stack) **4. execute function** **5. callee teardown** (pop local variables, caller’s frame pointer, and return address from stack) **6. return to caller**
Caller function	**7. caller teardown** (pop callee’s return value and arguments from stack)

Run-Time Stack Example

```
#include <stdio.h>
int Factorial(int n);

int main() {
   int number;
   int answer;
   …
   answer = Factorial(number);
   …
   return 0;
}

int Factorial(int n) {
   int i, result = 1;

   for(i=1; i<=n; i++){
      result = result*i;
   }
   return result;
}
```

x3FF7	
x3FF8	
x3FF9	
x3FFA	
x3FFB	
x3FFC	
x3FFD	
x3FFE	
x3FFF	answer
x4000	number

C to LC-3 Conversion with Run-Time Stack (RTS)

```
;; main prog
    ; main code omitted here for simplicity
    ; assume R6 pointing to answer and R5 pointing to number on the RTS at this moment

    ; 1. Caller setup (push callee's argument onto the RTS)
    ; push number



    ; 2. Caller pass control to callee



    ; 7. Caller teardown (pop callee's return value and argument from the RTS)
    ; load return value at top of stack (R6)

    ; perform assignment: answer = Fact(number)

    ; pop return value and argument
```

```
FACTORIAL
        ; 3. Callee setup (push bookkeeping info & local variables onto the RTS)
        ; leave space for return value

        ; push return address (R7)


        ; push caller's frame pointer (R5)


        ; set new frame pointer

        ; push local variables




        ; 4. Execute function (function logic omitted here for simplicity)
        …
```

; 5. Callee teardown *(pop local variables, C.F.P., and return addr from the RTS)*

```
; copy result into return value


; pop local variables

; pop caller's frame pointer (into R5)


; pop return address (into R7)
```

;6. Return to caller *(R6 should be pointing to return value when returning to caller)*

Another Run-Time Stack Example

The call: **w = Volta(w, 10);**

Caller:

```
int main(){
        int a;
        int b;
        …
        b = Watt(a);
        b = Volta(a,b);
        return 0;
}

int Watt(int a){
        int w;
        …
        w = Volta(w,10);
        return w;
}

int Volta(int q, int r){
        int k;
        int m;
        …
        return k;
}
```

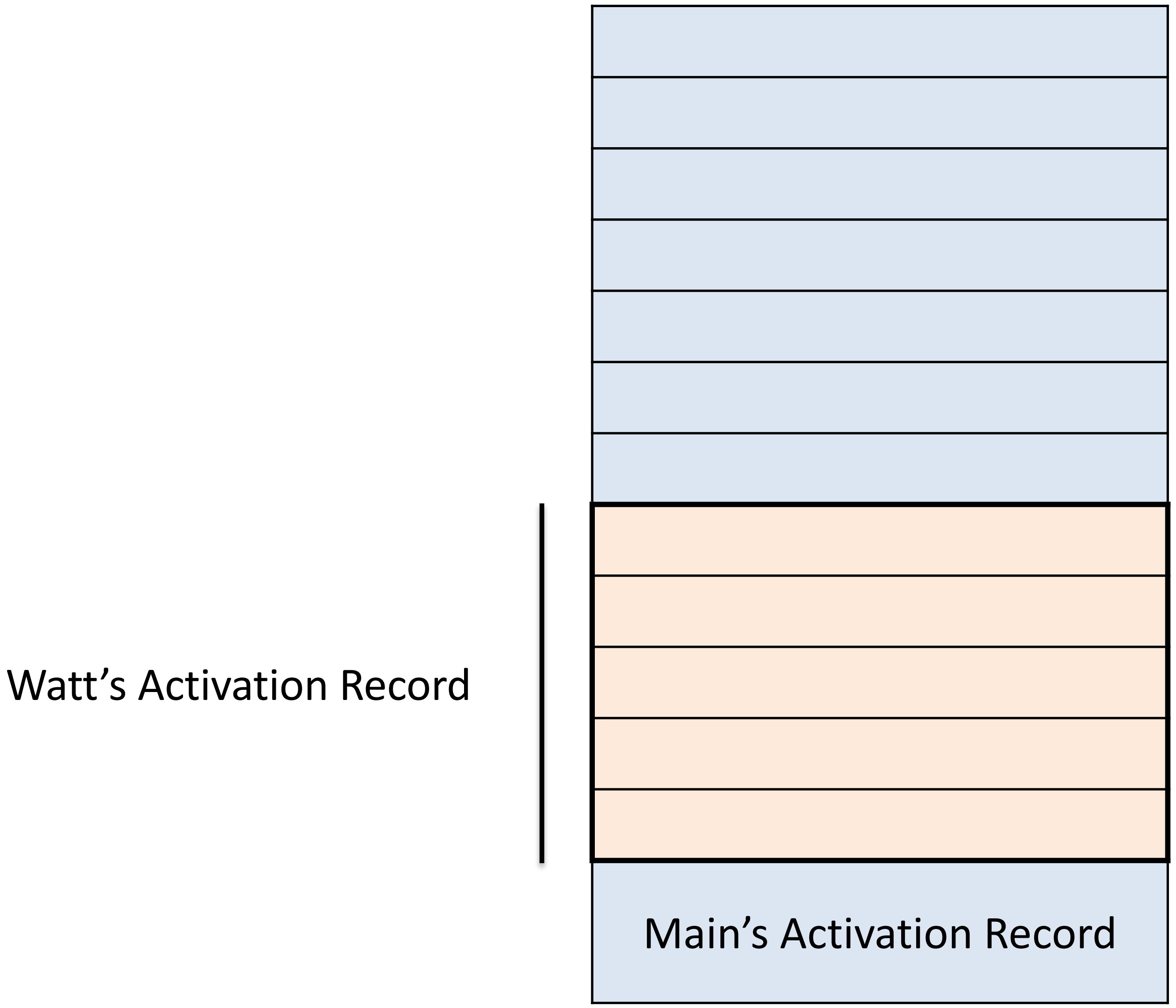
Another Run-Time Stack Example

The call: **w = Volta(w, 10);**

Callee:

```
int main(){
        int a;
        int b;
        …
        b = Watt(a);
        b = Volta(a,b);
        return 0;
}

int Watt(int a){
        int w;
        …
        w = Volta(w,10);
        return w;
}

int Volta(int q, int r){
        int k;
        int m;
        …
        return k;
}
```

Stack Built-Up & Tear-Down



Swap Function

- Analyze the given code below using what we've learned so far about the Run-Time Stack. Will x and y be swapped in main after calling Swap?

```
void Swap(int x, int y);

int main(){
        int x = 2;
        int y = 3;
        Swap(x,y);
        return 0;
}

void Swap(int x, int y){
        int temp;
        temp = x;
        x = y;
        y = temp;
}
```