Advanced pointer

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Contents

- String manipulations.
- Pointer of pointer.
- Other types of pointers.

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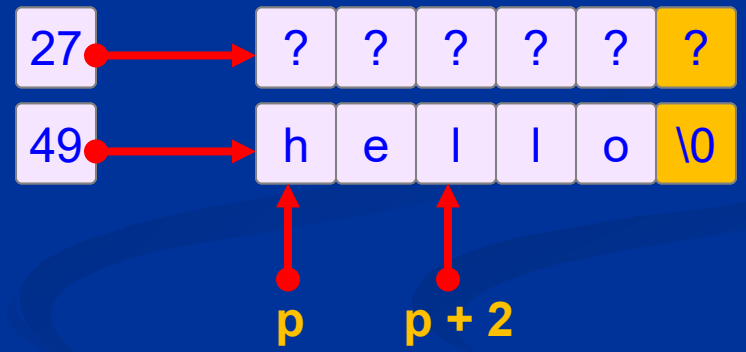
- **String manipulations.**
- Pointer of pointer.
- Other types of pointers.

String manipulations

- Dynamic C string:
  - Array of chars + '\0'.
  - Dynamic string = pointer + memory management.

```
char  *s1 = new char[6];
char  *s2 = new char[ ] { "hello" };
char  *p = s2;
int  len1 = strlen( p );       // len1 = 5
int  len2 = strlen( p + 2 ); // len2 = 3
//…
delete [ ]s1;
delete [ ]s2;
```



String manipulations

- Iterate C string:
  - Use index:

```
for ( int i = 0; s[ i ] != '\0'; ++i )
{
        // Process character s[ i ].
}
```

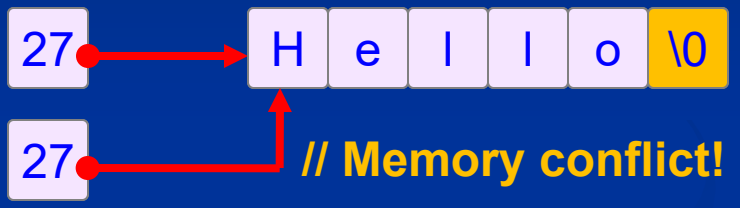
  - Use pointer:

```
for ( char *p = s; *p != '\0'; ++p )
{
        // Process character *p.
}
```

String manipulations

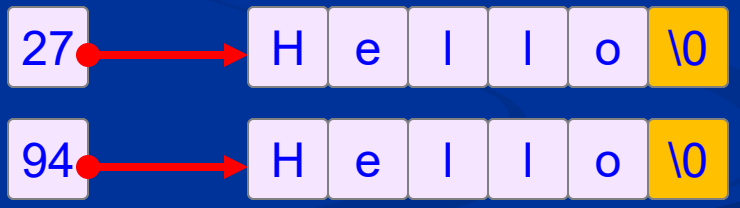
- Copy string:
  - Do not use “=“.

```
char  s1[ ] { “Hello” };
char  *s2 = s1;
```



  - Two-step copy: **strcpy**(<dest>, <source>).
    - Step 1: allocate new string.
    - Step 2: copy string content.

```
char  s1[ ] = “Hello”;
char  *s2 = new char[ strlen(s1) + 1 ];
strcpy( s2, s1 );
```



String manipulations

- Copy string:
  - One-step copy:
    - **strdup**(<source string>).
    - Return: new string copied from source string.
    - New string must be de-allocated by **free**().

```
char  s1[ ] { “Hello” };
char  *s2 = strdup( s1 );

// Same as….
// char *s2 = new char[ strlen( s1 ) + 1 ];
// strcpy( s2, s1 );

free( s2 );
```

String manipulations

- Compare string:
  - **strcmp**(<string 1>, <string 2>).
  - Return: 0 (equal), 1 (greater), -1 (less).
  - Compare based on dictionary order.

```
char  s1[ ] { “abc” };
char  s2[ ] { “abaab” };
char  s3[ ] { “Abc” };

int   r1 = strcmp( s1, s2 );        // r1 = 1.
int   r2 = strcmp( s3, s1 );        // r2 = -1.
int   r3 = strcasecmp( s3, s1 );    // r3 = 0, GCC compiler.
int   r4 = stricmp( s3, s1 );       // r4 = 0, MSVC compiler.
```

String manipulations

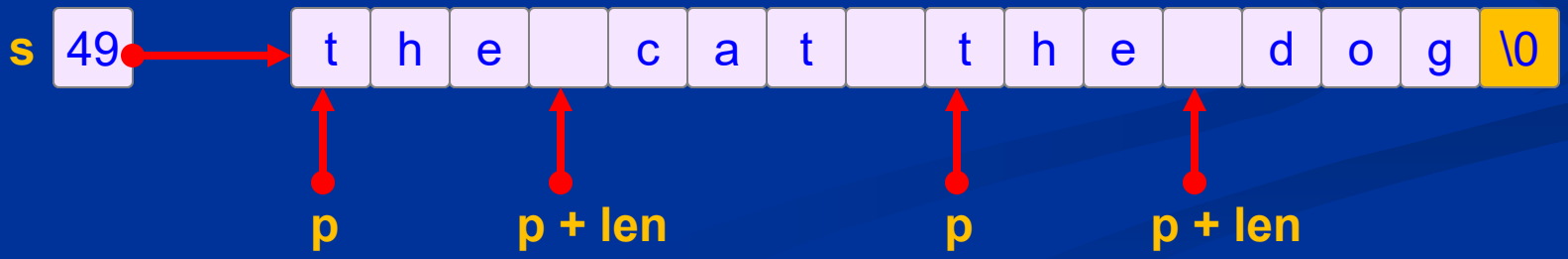
- Join string:
  - **strcat**(<dest>, <source>).
  - Copy source to the end of dest.
  - Dest string must have enough memory!!

```
char  s1[ ] { “Hello” };
char  s2[ ] { “World” };
int  len1 = strlen( s1 );
int  len2 = strlen( s2 );
char  *s3 = new char[ len1 + len2 + 1 ];

strcat( s3, s1 );          // Join s1 to s3.
strcat( s3, s2 );          // Then, join s2 to s3.
// More efficient way…
strcpy( s3, s1 );
strcpy( s3 + len1, s2 );
```

String manipulations

- Find sub char/string:
  - **strchr**(<source>, <sub>).
  - **strstr**(<source>, <sub>).
  - Return: pointer to sub in source or NULL (not found).

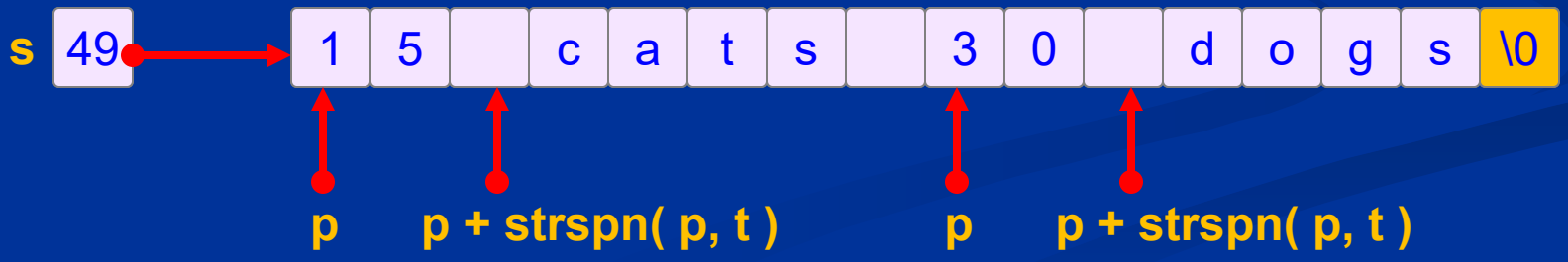
```
// Find and skip to find all t in s.
char  s[ ] { “the cat the dog” };
char  t [ ] { “the” };

int  len = strlen( t );
for ( char *p = s; (p = strstr( p, t ) ); p += len )
      printf( “Found at %d\n”, p – s );
```



String manipulations

- Find any of char in/not in set:
  - **strpbrk**(<source>, <set>).
    - Return: pointer to first source char in set or NULL (not found).
  - **strspn**(<source>, <set>).
    - Return: distance to first source char not in set.

```
// Find and skip to find all any of t in s.
char  s[ ] { “15 cats 30 dogs” };
char  t [ ] { “0123456789” };

for ( char *p = s; (p = strpbrk( p, t ) ); p += strspn( p, t ) )
      printf( “Found at %d\n”, p – s );
```



String manipulations

- Convert string to number:
  - To integer:
    - **atoi**(<string>)
    - **strtoll**(<string>, <end pointer>, <base>).
  - To float:
    - **atof**(<string>).
    - **strtod**(<string>, <end pointer>).

```
char  s1[ ]  { “123abc” };
char  s2[ ]  { “xyz” };
int  x1 = atoi( s1 );                  // x1 = 123
int  x2 = atoi( s2 );                  // x2 = 0
char *p;
int  y1 = strtoll( s1, &p, 10 );     // y1 = 123, p = “xyz”
int  y2 = strtoll( s2, &p, 10 );     // y2 = 0,     p = “xyz”
```

String manipulations

- Input dynamic string:
  - Declare struct Student:
    - Id: fix-sized 8 chars.
    - Name: variable-sized 50 chars.
    - GPA: float.
  - Write function to input a student from keyboard.

Contents

- String manipulations.
- **Pointer of pointer.**
- Other types of pointers.

Pointer of pointer

- Address of pointer:
  - Variable has an address.
    - int has address int *.
  - Pointer also has an address.
    - int * has address type?
  - Pointer of pointer:
    - A variable stores address of another pointer.
    - Declaration: **<pointer type> *** <pointer name>;

Pointer of pointer

- Pointer of pointer in C:
  - Declaration:
    - Method 1: use *.
    - Method 2: use **typedef**.
  - Initialization:
    - Use **NULL**.
    - Use **&** operator.

```
int  x = 257;
int  *p = NULL;
int  **q = NULL;

p = &x;
q = &p;
```

Pointer of pointer

- Pointer of pointer in C:
  - Access memory content:
    - 1-level access: operator *.
    - 2-level access: operator **.
  - Passing argument:
    - Pass-by-value.
    - Pass-by-reference.

➔ Which values are changed in foo() ?

```
void foo(int **g, int **&h)
{
        (**g)++; (*g)++; g++;
        (**h)++; (*h)++; h++;
}

int main()
{
        int  a[10];
        int  *p = a;
        int  **q = &p;
        int  **r = &p;

        foo(q, r);
}
```

Pointer of pointer

- Dynamic matrix:
  - Array of pointers:
    - Level-1 pointer is 1-dimensional dynamic array.
    - Level-2 pointer is 2-dimensional dynamic array.

```
void inputMatrix(int **&m, int &rows, int &cols) {
        printf( "Enter rows and cols = ");
        scanf("%d %d", &rows, &cols);

        m = new int * [ rows ];
        for (int i = 0; i < rows; i++) {
              m[ i ] = new int [ cols ];
              for (int j = 0; j < cols; j++)
                    scanf("%d", &m[ i ][ j ]);
        }
}
```

```
int main()
{
        int  **m;
        int  rows, cols;

        inputMatrix(m, rows, cols);
        delete [ ]m;
        // Error!! How to fix?!
}
```

Contents

- String manipulations.
- Pointer of pointer.
- **Other types of pointers.**

Other types of pointers

- Constant pointer:
  - Pointer points to only 1 address “for life”.
  - Declaration: <type> * **const** <pointer name>;

```
int  x = 5, y = 6;
int * const p = &x;
p = &y;        // Wrong.
```

  - All static arrays in C are constant pointers.
- Pointer to constant:
  - Memory content pointer points to cannot be changed.
  - Declaration: **const** <type> * <pointer name>;

```
int  x = 5;
const int *p = &x;
*p = 6;        // Wrong.
```

Other types of pointers

- void pointer:
  - Pointer can store address of any types.
  - Declaration: **void *** <pointer name>.
  - Cast to specific type when accessing content.

```
void printBytes(void *p, int size)
{
        char *q = ( unsigned char * ) p;
        for ( int i = 0; i < size; i++ )
                printf( "%d ", q[ i ] );
}
```

```
int main()
{
        int    x = 1057;
        double y = 1.25;

        printBytes(&x, 4);
        printBytes(&y, 8);
}
```

Other types of pointers

- Function pointer:
  - Function address:
    - Functions are also stored in memory.
    - Each function has an address.
  - Function pointer stores address of function.
  - Declaration:

    <return type> (* <pointer name>**) (<arguments>)**;
    typedef <return type> (* <alias>**) (<arguments>)**;
    <alias> <pointer name>;
  - Functions have same address type if:
    - Same return type.
    - Same arguments.

Other types of pointers

- Function pointer:

```
typedef  int  (*Operator)(int a, int b);

int add(int u, int v)
{
        return u + v;
}
int mul(int u, int v)
{
        return u * v;
}
int calculate(int u, int v, Operator p)
{       // u^3 operator v^2.
        return p(u*u*u, v*v);
}
```

```
int main()
{
        int  x = 5;
        int  y = 6;

        Operator  p = add;
        int r1 = p(x, y);

        p = mul;
        int r2 = p(x, y);

        int r3 = calculate(x, y, add);
}
```

Other types of pointers

- Pointer to fix-sized memory:
  - Address of static array:
    - What address type of static array?

```
int   a[ 10 ];
int   *p = a          // p and a store address of a[ 0 ].
???   q = &a;
```

  - Pointer to fix-sized memory:
    - Pointer stores address of static array.
    - Declaration:

<array type> **(***<pointer name>**)[**<array size>**]**;

```
int  a[ 10 ];
int  ( *p )[ 10 ] = &a;   // p points to 10-element array.
```

Other types of pointers

- Pointer to fix-sized memory:
  - Static 2-D array in C:
    - Is pointer to fix-sized 1-D array.
    - Stores address of the first row.

```
int  a[ 2 ] [ 3 ] = { { 1, 2, 3 }, { 4, 5, 6 } };
int ( *p )[ 3 ] = a;    // a = &a[ 0 ].
printf("%d\n", *( *(p + 1) + 1 ) );
```

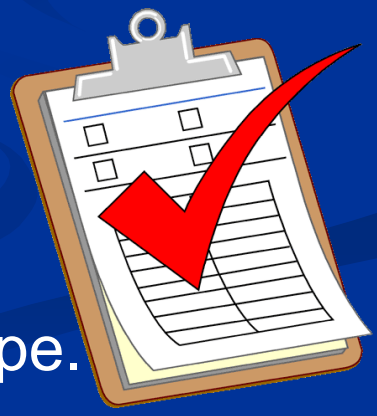
Other types of pointers

- Pointer to fix-sized memory:
  - Passing static 2-D array to function:
    - Not passing whole array.
    - Only passing address of first row.

```
void printMatrix(int a[ ][20], int rows, int cols)  {  // pass &a[ 0 ].
        for (int i = 0; i < rows; i++) {
                for (int j = 0; j < cols; j++)
                        printf("%d ", a[ i ][ j ] );
                printf("\n");
        }
}
int main() {
        int  a[10][20];
        printMatrix(a, 10, 20);
}
```

Summary

- String manipulations:
  - Dynamic string = pointer + memory management.
  - Copy string: strcpy, strncpy.
  - Join string: strcat (not efficient).
  - Compare string: strcmp, strcasecmp, stricmp.
  - Find sub char/string: strchr, strstr.
  - Find any of char in/not in set: strpbrk, strspn.
  - Convert to number: atoi, strtoll, atof, strtof.
- Types of pointers:
  - Different types → different address types.
  - Each address type stored by one pointer type.



Summary

- Types of pointers:
  - Pointer of pointer → stores address of pointer.
  - Constant pointer → stores constant address.
  - Pointer to constant → stores address of constant.
  - void pointer → stores address of any types.
  - Function pointer → stores address of function.
  - Pointer to fix-sized memory → stores address of static array.

Practice

- Practice 8.1:

  Write C/C++ program to find and replace all as follow:

  - Enter a sentence of words S.
  - Enter word to find F, and replacing word R.
  - Find and replace all F in S with R.
  - Print the result sentence.

  Input format:

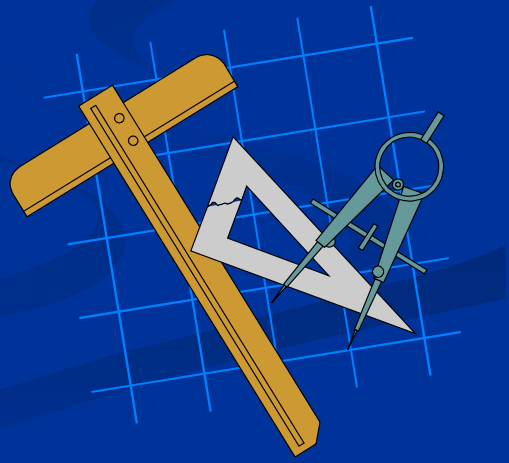
  Enter a sentence = the good, the bad, the ugly

  Enter find word = the

  Enter replacing word = (a very)

  Output format:

  (a very) good, (a very) bad, (a very) ugly



Practice

- Practice 8.2:

Write C/C++ program to increase numbers in sentence as follow:

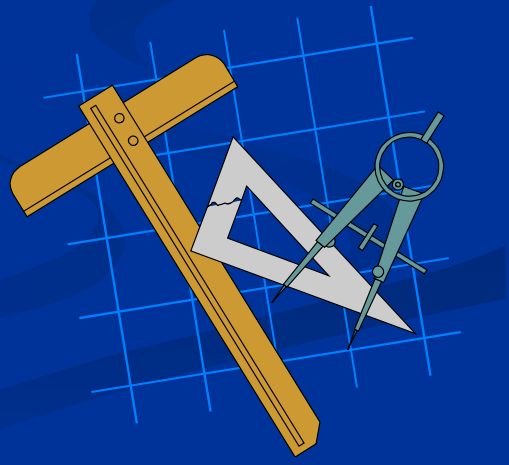
- Enter a sentence.
- Find all numbers in the sentence and increase each one to 1.
- Print the result sentence.

Input format:

Enter a sentence = there are 9 cats and 19 dogs.

Output format:

there are 10 cats and 20 dogs.



Practice

- Practice 8.3:

  Write C/C++ program to input a paragraph with arbitrary length:

  - Enter a long paragraph until input '.' and new line.
  - Print the paragraph.

  Note: use dynamic string.

Practice

- Practice 8.4:

Given static 2-D array as follow:

```
int  m[4][6];
```

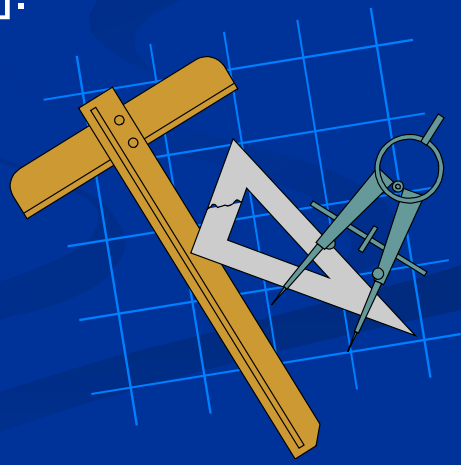
What types of addresses of the following variables?

a) m[1][3].

b) m[0].

c) m.

Write code to access m[2][4] without using operator [ ].



Practice

- Practice 8.5:

Given the following C code:

```
void initialize(double **p)
{
        for (int i = 0; i < 5; i++)
                *(p + i) = new double[ i + 1 ];
}
```

```
int main()
{
        double *p[10];
        initialize(p + 3);
        release(p);
}
```

Answer the following questions:

a) How many bytes are allocated at each line of main( ) ?

b) How memory are allocated by initialize( ) function in main( ) ?

c) Write release( ) function to avoid memory leak.