Files

Systems Programming

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From the lecture part…

System calls for file manipulation

System call	RAX (cmd.)	RDI (parameter 1)	RSI (parameter 2)	RDX (parameter 3)	RAX (return value)
SYS_OPEN	2	Pointer to filename	Flags (O_RDONLY, …)	Create mode (e.g. 0666)	File descriptor or error number
SYS_READ	0	File descriptor	Pointer to data buffer	Max. number of bytes to read	Actual number of bytes read or error number
SYS_WRITE	1	File descriptor	Pointer to data buffer	Number of bytes to write	Actual number of bytes written or error number
SYS_CLOSE	3	File descriptor	---	---	0 (success) or error number

Example: toupper.s – Helper constants

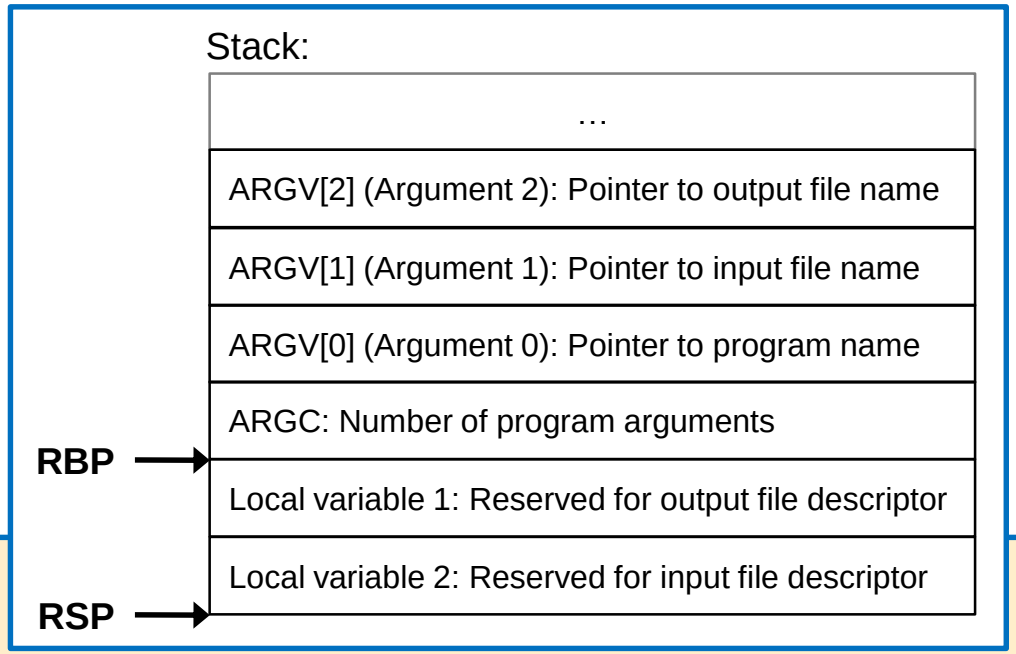
```
# System call numbers
.equ SYS_OPEN, 2
.equ SYS_READ, 0
.equ SYS_WRITE, 1
.equ SYS_CLOSE, 3
.equ SYS_EXIT, 60

.equ O_RDONLY, 0                      # Open file options - read-only
.equ O_CREAT_WRONLY_TRUNC, 03101      # Open file options - these are:
                                      # CREAT  - create file if not exising
                                      # WRONLY - only write to this file
                                      # TRUNC  - destroy current contents

.equ O_PERMS, 0666                    # Read & Write perms. for everyone

# End-of-file result status
.equ END_OF_FILE, 0     # This is the return value of read()
                        # which means we've hit the end of
                        # the file
```

Example: toupper.s – Data buffer

```
.section .bss
# This is where the data is loaded
# into from the data file and written
# from into the output file. It should
# never exceed 16,000 for various
# reasons.
.equ BUFFER_SIZE, 500
.lcomm BUFFER_DATA, BUFFER_SIZE
```

Example: toupper.s – Helper constants

Remember: OS puts command line arguments (actually only pointers to those strings) on stack




```
    .section .text

    # STACK POSITIONS
    .equ ST_SIZE_RESERVE, 16 # Space for local variables
    # Note: Offsets are RBP-based, which is set immediately at program start
    .equ ST_FD_IN, -16       # Local variable for input file descriptor
    .equ ST_FD_OUT, -8       # Local variable for output file descriptor
    .equ ST_ARGC,    0       # Number of arguments (integer)
    .equ ST_ARGV_0,  8       # Name of program (address = pointer to string)
    .equ ST_ARGV_1, 16       # Input file name (address = pointer to string)
    .equ ST_ARGV_2, 24       # Output file name (address = pointer to string)
```

Example: toupper.s (4)

```
_start:
    ###INITIALIZE PROGRAM###
    movq %rsp, %rbp              # Create new stack frame
    subq $ST_SIZE_RESERVE, %rsp # Allocate file descriptor space on stack

    ###CHECK PARAMETER COUNT###
    cmpq $3, ST_ARGC(%rbp)
    je open_files

    movq $-1, %rdi               # Our return value for parameter problems
    movq $SYS_EXIT, %rax
    syscall
```

Example: toupper.s (5)

```
open_files:
open_fd_in:
    ###OPEN INPUT FILE###
    movq ST_ARGV_1(%rbp), %rdi   # Input filename into %rdi
    movq $O_RDONLY, %rsi         # Read-only flag
    movq $O_PERMS, %rdx          # This doesn't really matter for reading
    movq $SYS_OPEN, %rax         # Specify "open"
    syscall                      # Call Linux

    cmpq $0, %rax                # Check success
    jl exit                      # In case of error simply terminate
store_fd_in:
    movq  %rax, ST_FD_IN(%rbp)   # Save the returned file descriptor
```

Example: toupper.s (6)

```
open_fd_out:
    ###OPEN OUTPUT FILE###
    movq ST_ARGV_2(%rbp), %rdi          # Output filename into %rdi
    movq $O_CREAT_WRONLY_TRUNC, %rsi    # Flags for writing to the file
    movq $O_PERMS, %rdx                 # Permissions for new file (if created)
    movq $SYS_OPEN, %rax                # Open the file
    syscall                             # Call Linux

    cmpq $0, %rax                       # Check success
    jl close_input                      # In case of error close input file
                                        # (already open!)
store_fd_out:
    movq %rax, ST_FD_OUT(%rbp)          # Store the file descriptor
```

Example: toupper.s (7)

```
read_loop_begin:
    ###READ IN A BLOCK FROM THE INPUT FILE###
    movq ST_FD_IN(%rbp), %rdi      # Get the input file descriptor
    movq $BUFFER_DATA, %rsi        # The location to read into
    movq $BUFFER_SIZE, %rdx        # The size of the buffer
    movq $SYS_READ, %rax
    syscall                        # Size of buffer read is returned in %rax
    ###EXIT IF WE'VE REACHED THE END###
    cmpq $END_OF_FILE, %rax        # Check for end of file marker (or error)
    je end_loop                    # If found, go to the end
    jl close_output                # On error just terminate

continue_read_loop:
    ###CONVERT THE BLOCK TO UPPER CASE###
    movq $BUFFER_DATA, %rdi        # Location of the buffer
    movq %rax, %rsi                # Size of the buffer
    pushq $-1                      # Dummy value for stack alignment
    pushq %rax                     # Store bytes read for write check
    call convert_to_upper
```

Example: toupper.s (8)

```
write_out_begin:
    ###WRITE THE BLOCK OUT TO THE OUTPUT FILE###
    movq ST_FD_OUT(%rbp), %rdi      # File to use
    movq $BUFFER_DATA, %rsi         # Location of  buffer
    movq %rax, %rdx                 # Buffer size (=number of bytes read)
    movq $SYS_WRITE, %rax
    syscall                         # Note: Check how much was written!

    ###CHECK WRITE SUCCESS###
    popq %rbx                       # Retrieve number of bytes read
    addq $8, %rsp                   # Remove stack alignment space
    cmpq %rax, %rbx                 # Compare number read to written
    jne close_output                # If not the same, terminate program

    ###CONTINUE THE LOOP###
    jmp read_loop_begin
```

Example: toupper.s (9)

```
end_loop:                   # No special error handling, so success and error
close_output:               # are the same: we just close both files
    ###CLOSE THE FILES###
    # NOTE - we don't need to do error checking on these, because
    #        error conditions don't signify anything special here
    movq ST_FD_OUT(%rbp), %rdi
    movq $SYS_CLOSE, %rax
    syscall

close_input:
    movq ST_FD_IN(%rbp), %rdi
    movq $SYS_CLOSE, %rax
    syscall

exit:
    ###EXIT###
    movq $0, %rdi
    movq $SYS_EXIT, %rax
    syscall
```

Example: toupper.s (10)

```
#####FUNCTION convert_to_upper
#PURPOSE:    This function actually does the conversion to upper case for a block
#INPUT:      The first parameter (rdi) is the location of the block of memory to convert
#            The second parameter (rsi) is the length of that buffer
#OUTPUT:     This function overwrites the current buffer with the upper-casified version.
#VARIABLES:
#            %rax  - beginning of buffer
#            %rbx  - length of buffer (old value must be saved!)
#            %rdi  - current buffer offset
#            %r10b - current byte being examined (%r10b is the first byte of %r10)
# Note: This variable assignment is for exemplary purposes only and very suboptimal!

    .equ  LOWERCASE_A, 'a'          # The lower boundary of our search
    .equ  LOWERCASE_Z, 'z'          # The upper boundary of our search
    .equ  UPPER_CONVERSION, 'A' - 'a'
                                    # Conversion: Difference upper/lower case
convert_to_upper:
    pushq %rbp                      # Prepare stack
    movq  %rsp, %rbp
    pushq %rbx                      # Save RBX
    ###SET UP VARIABLES###
    movq  %rdi, %rax
    movq  %rsi, %rbx
    movq  $0, %rdi
```

Example: toupper.s (11)

```
    # If a buffer with zero length was given us, just leave
    cmpq $0, %rbx
    je end_convert_loop
convert_loop:
    movb (%rax,%rdi,1), %r10b     # Get the current byte
    # Go to the next byte unless it is between 'a' and 'z'
    cmpb $LOWERCASE_A, %r10b
    jl next_byte
    cmpb $LOWERCASE_Z, %r10b
    jg next_byte
    # Otherwise convert the byte to uppercase
    addb $UPPER_CONVERSION, %r10b
    movb %r10b, (%rax,%rdi,1)     # And store it back
next_byte:
    incq %rdi                     # Next byte
    cmpq %rdi, %rbx               # Continue unless we've reached the end
    jne convert_loop
end_convert_loop:
    movq %rdi, %rax         # Store number of chars converted as return value
    popq %rbx
    movq %rbp, %rsp
    popq %rbp
    ret
```

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THANK YOU FOR YOUR ATTENTION!

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