

# Computer Systems and Architecture

## MIPS: Memory-Mapped I/O

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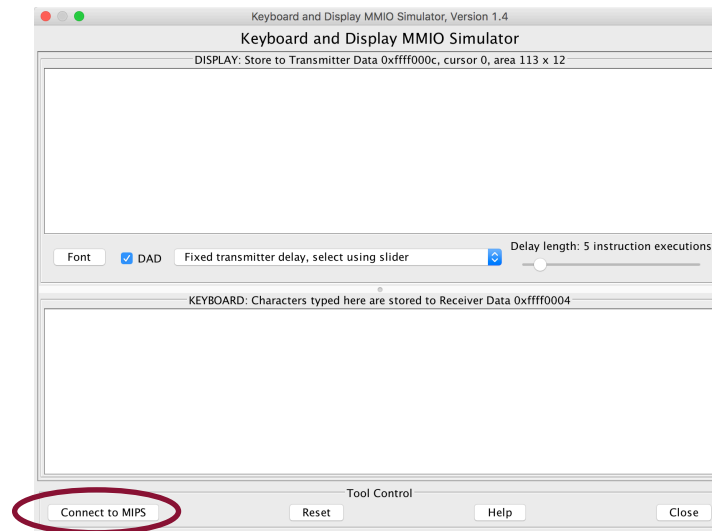
# Outline

- Keyboard inputs
- Bitmap outputs
- File handling
- Sleep



# Keyboard Inputs

- Menu > Tools > Keyboard and Display MMIO Simulator



- 0xffff0000: set to 1 when input available
- 0xffff0004: contains latest character in ASCII format
- After loading of content 0xffff0000 resets to 0

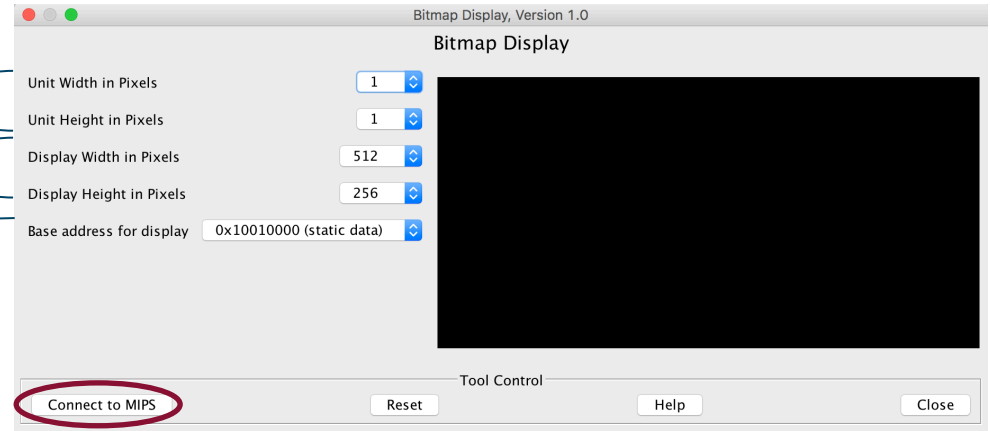
# Bitmap outputs

- Menu > Tools > Bitmap Display

Set display-width for one pixel: set to 16 x 16

Set size of display in pixels: set to 512 x 512

Set base address to `$gp`

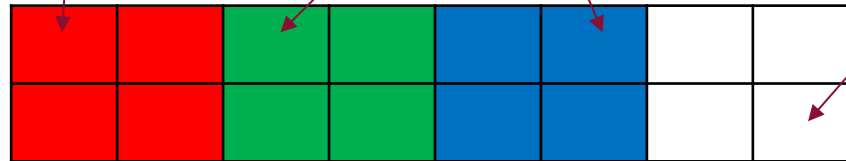


- Every memory location defines color for one pixel (aRGB in hexadecimal format)
- Row-major

# Bitmap - Voorbeeld

Memory	+0	+4	+8	+c
0x10008000	0x00ff0000	0x00ff0000	0x0000ff00	0x0000ff00
0x10008010	0x000000ff	0x000000ff	0x00ffffff	0x00ffffff
0x10008020	0x00ff0000	0x00ff0000	0x0000ff00	0x0000ff00
0x10008030	0x000000ff	0x000000ff	0x00ffffff	0x00ffffff

Bitmap:



# File Handling

- Read File Descriptor
  - Syscall with op-Code 13
  - `$a0`: address of null-terminated string (`.asciiz`) containing file location
  - `$a1`: flags (set to 0)
  - `$a2`: mode (set to 0)
- Load entire file into a buffer
  - Syscall with op-Code 14
  - `$a0`: file descriptor
  - `$a1`: address of the buffer
  - `$a2`: max number of characters to read



# Sleep

- Used to create 'visual' time steps in our game
- Syscall with op-Code 32
- `$a0`: time to sleep in milliseconds



# Example – File input

```
.data
fin:      .asciiz    "input.txt"          # filename for input
buffer:   .space    2048                 # space used as buffer

.text
#####
# Open (for reading) a file
li $v0, 13          # system call for open file
la $a0, fin         # output file name
li $a1, 0           # Open for writing (flags are 0: read, 1: write)
li $a2, 0           # mode is ignored
syscall            # open a file (file descriptor returned in $v0)

move $s6, $v0      # save the file descriptor

#####
# Read from file to buffer
li $v0, 14          # system call for read from file
move $a0, $s6       # file descriptor
la $a1, buffer      # address of buffer to which to load the contents
li $a2, 2048        # hardcoded max number of characters (equal to size of buffer)
syscall            # write to file, $v0 contains number of characters read

#####
# Close the file
li $v0, 16          # system call for close file
move $a0, $s6       # file descriptor to close
syscall            # close file
#####
```

