How to read a code repository?

Read a repository: 3 passes

- 1st pass
  - read documents and filenames
- 2nd pass
  - track the execution: earth → grass → applications
- 3rd pass
  - read the details of a module, such as the SD card driver

Documents of egos-2000

- README.md
    - Explain why the project is important
- references/USAGES.md
    - Explain how to use this project
- references/README.md
    - Explain the internal design of the project

Read filenames: earth

- sd
- bus_gpio.c
- bus_uart.c
- ~~cpu_intr.c~~
- ~~cpu_mmu~~.c
- ~~dev_disk.c~~
- ~~dev_tty.c~~
- earth.S
- earth.c
- earth.lds

- From the documents:

Earth layer (hardware specific)

- `earth/dev_disk` : ROM and SD card (touched by P4)
- `earth/dev_tty` : keyboard input and tty output
- `earth/cpu_intr` : interrupt and exception handling (touched by P3)
- `earth/cpu_mmu` : memory paging and address translation (touched by P3)

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- earth.S
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- `cpu_intr`, `cpu_mmu`, `dev_disk`, `dev_tty` are explained in the documents
- `gpio` and `uart` are buses, just like `usb`; Search them on Wikipedia

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- sd
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- `cpu_intr`, `cpu_mmu`, `dev_disk`, `dev_tty` are explained in the documents
- `gpio` and `uart` are buses, just like `usb`; Search them on Wikipedia
- `earth.S` and `earth.c` are for initialization
- `earth.lds` specifies the memory layout

Read filenames: earth/sd

- sd.h
- sd_init.c
- sd_rw.c
- sd_utils.c

- `sd.h` provides basic definitions
- `sd_init.c` initializes the SD card
- `sd_rw.c` provides SD card read and write
- `sd_utils.c` provides helper functions
- We will read this module in details later

Read filenames: grass

- grass.S
- grass.c
- grass.lds
- ~~process.c~~
- ~~process.h~~
- ~~scheduler.c~~
- ~~syscall.c~~
- ~~syscall.h~~
- ~~timer.c~~

- From the documents:

Grass layer (hardware independent)

- `grass/timer` : timer control registers
- `grass/syscall` : system call interfaces to user applications
- `grass/process` : data structures for managing processes (touched by P1)
- `grass/scheduler` : preemptive scheduling and inter-process communication

Read filenames: grass

- ~~grass.S~~
- ~~grass.c~~
- ~~grass.lds~~
- ~~process.c~~
- ~~process.h~~
- ~~scheduler~~.c
- ~~syscall.c~~
- ~~syscall.h~~
- ~~timer.c~~

- `process`, `syscall`, `timer`, `scheduler` are explained in the documents
- `grass.S` and `grass.c` are for initialization
- `grass.lds` specifies the memory layout

Read a repository: 3 passes

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The Key:

Find `main()` functions

and track executions from there

`grep` is a useful command

```
> cd egos-2000
> grep "main(" -r *
```

Main functions in the repository

```
> cd egos-2000
> grep "main(" -r *
earth/earth.S:    /* Call main() of earth.c */
earth/earth.c:int main() {
grass/grass.S:    /* Call main() of grass.c */
grass/grass.c:int main() {
tools/mkrom.c:int main() {
tools/mkfs.c:int main() {

apps/*.c: /* Every application has a main() function */
```

Main function in earth

- Read earth.s and earth.c
  - Boot loader disable interrupt and call earth main()
  - Earth main()
    - Initialize memory for earth layer
    - Initialize dev_tty, dev_disk, cpu_intr, cpu_mmu
    - Load and enter the grass layer

Main function in grass

- Read grass.s and grass.c
  - Initialize PCB data structures
  - Initialize the timer and enable interrupt
  - Load and enter the first application: GPID_PROCESS
- Where is GPID_PROCESS defined?

Find GPID_PROCESS

```
> cd egos-2000
# Find which header file contains GPID_PROCESS
> grep "GPID_PROCESS" -r * | grep “\.h"

library/servers/servers.h:    GPID_PROCESS,
library/servers/servers.h:/* GPID_PROCESS */
```

Kernel Processes (aka. Daemon)

```
enum grass_servers {
    GPID_UNUSED,
    GPID_PROCESS,
    GPID_FILE,
    GPID_DIR,
    GPID_SHELL,
    GPID_USER_START
};
```

- `GPID_PROCESS`
  - spawn and kill processes
- `GPID_FILE & GPID_DIR`
  - something about file system
- `GPID_SHELL`
  - shell for entering commands

Control Flow Sketch

- During boot up
  - earth main() → grass main() → GPID_PROCESS
  - GPID_PROCESS → GPID_FILE
  - GPID_PROCESS → GPID_DIR
  - GPID_PROCESS → GPID_SHELL
- After boot up
  - GPID_SHELL → user applications

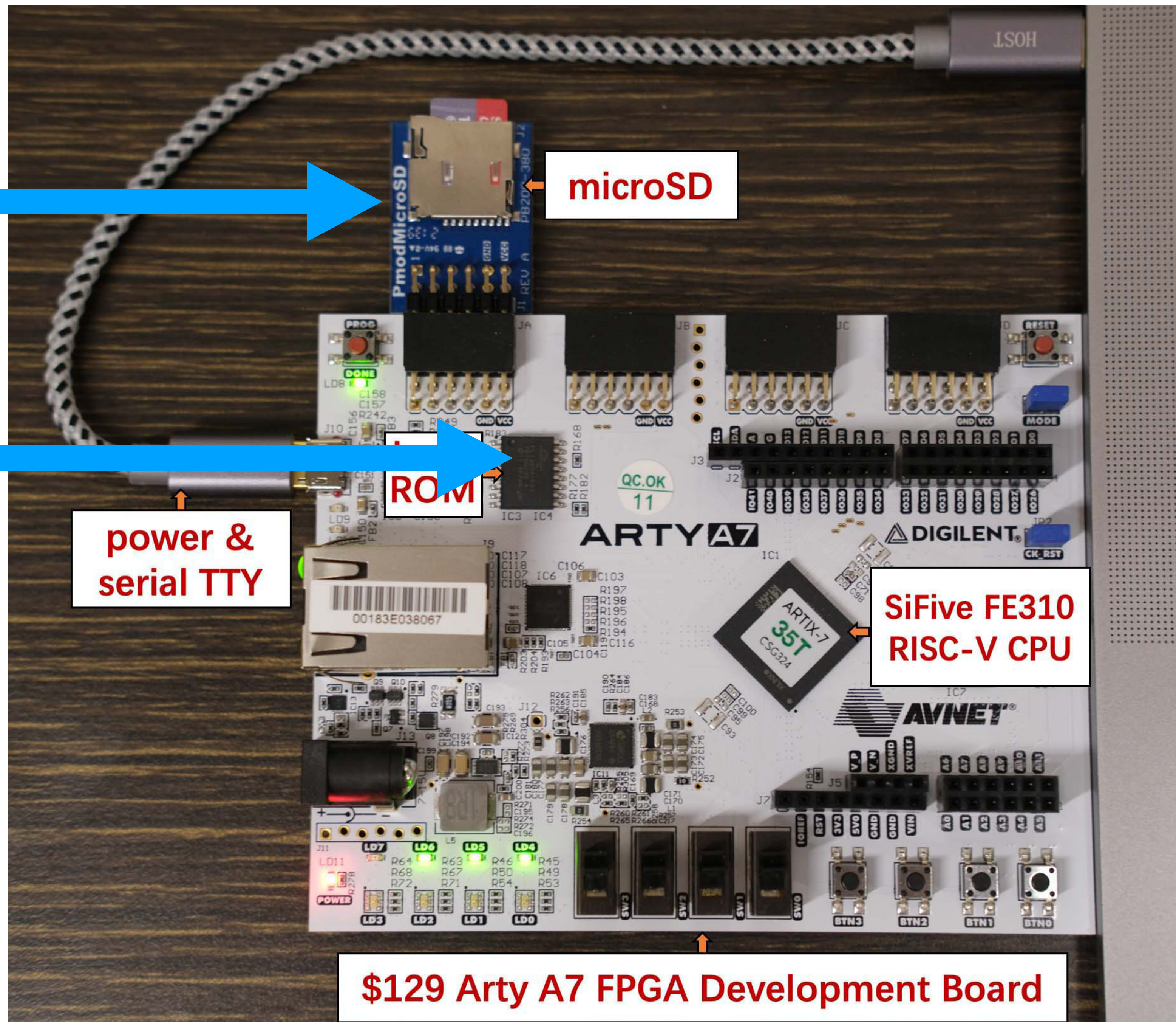
Two more main functions to read

```
> cd egos-2000
> grep "main(" -r *
~~earth/earth.S:      /* Call main() of earth.c */~~
~~earth/earth.c:int main() {~~
~~grass/grass.S:      /* Call main() of grass.c */~~
~~grass/grass.c:int main() {~~
tools/mkrom.c:int main() {
tools/mkfs.c:int main() {

apps/*.c: /* Every application has a main() function */
```

mkfs and mkrom

- During make, the RISC-V compiler compiles egos-2000
  - i.e., create everything under build/
- During make install,
  - mkfs creates disk.img
  - mkrom creates bootROM.bin



Reading `main()` provides a rough picture

```
> cd egos-2000
> grep "main(" -r *
```

~~earth/earth.S: /* Call main() of earth.c */~~
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~~grass/grass.c:int main() {~~
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~~tools/mkfs.c:int main() {~~

```
apps/*.c: /* Every application has a main() function */
```

Reading `main()` provides a rough picture

We know the **structure** of the work and **some details**.

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Now is a good time to read the SD driver

- CS4411 has 12 lectures:
    - Step #1: understand computer architecture
    - Step #2: understand interrupt and exception
    - Step #3: understand context-switch and multi-threading
    - Step #4: understand privilege levels
    - Step #5: understand i/o devices
    - Step #6: understand file systems

In your career:

Find and read the module that is

the most relevant to your assigned job

Part #1 of earth/sd.h

```
#define SPI1_BASE      0x10024000UL

#define SPI1_SCKDIV    0UL
#define SPI1_SCKMODE   4UL
#define SPI1_CSID      16UL
#define SPI1_CSDEF     20UL
#define SPI1_CSMODE    24UL
#define SPI1_FMT       64UL
#define SPI1_TXDATA    72UL
#define SPI1_RXDATA    76UL
#define SPI1_FCTRL     96UL
```

- `spi` is a bus, just like `usb`
- section19 of SiFive document
- The document is a dictionary for reference, instead of a textbook!
  - read only when necessary

Part #2 of earth/sd.h

Read and write disk blocks

```
void sdinit();
int sdread(int offset, int nblock, char* dst);
int sdwrite(int offset, int nblock, char* src);
```

Send commands to SD card

```
char sd_exec_cmd(char*);
char sd_exec_acmd(char*);
```

Send bytes to SD card

```
char recv_data_byte();
char send_data_byte(char);
```

Part #2 of earth/sd.h

Read and write disk blocks

calls

Send commands to SD card

calls

Send bytes to SD card

```
void sdinit();
int sdread(int offset, int nblock, char* dst);
int sdwrite(int offset, int nblock, char* src);

char sd_exec_cmd(char*);
char sd_exec_acmd(char*);
char recv_data_byte();
char send_data_byte(char);
```

What to understand in sd_utils.c

```
char send_data_byte(char byte) {
    while (REGW(SPI1_BASE, SPI1_TXDATA) & (1 << 31));
    REGB(SPI1_BASE, SPI1_TXDATA) = byte;

    long rxdata;
    while ((rxdata = REGW(SPI1_BASE, SPI1_RXDATA)) & (1 << 31));
    return (char)(rxdata & 0xFF);
}

inline char recv_data_byte() {
    return send_data_byte(0xFF);
}
```

How to send and receive bytes to/from the SD card?

What to understand in sd_utils.c

```
char sd_exec_cmd(char* cmd) {
    for (int i = 0; i < 6; i++) send_data_byte(cmd[i]);

    for (int reply, i = 0; i < 8000; i++)
        if ((reply = recv_data_byte()) != 0xFF) return reply;

    FATAL("SD card not responding cmd%d", cmd[0] ^ 0x40);
}
```

How to send commands to the SD card?

What to understand in sd_rw.c

```c
static void single_read(int offset, char* dst) {
    /* Wait until SD card is not busy */
    while (recv_data_byte() != 0xFF);

    /* Send read request with cmd17 */
    char *arg = (void*)&offset;
    char reply, cmd17[] = {0x51, arg[3], arg[2], arg[1], arg[0], 0xFF};

    if (reply = sd_exec_cmd(cmd17))
        FATAL("SD card replies cmd17 with status 0x%.2x", reply);

    /* Wait for the data packet and ignore the 2-byte checksum */
    while (recv_data_byte() != 0xFE);
    for (int i = 0; i < BLOCK_SIZE; i++) dst[i] = recv_data_byte();
    recv_data_byte();
    recv_data_byte();
}
```

How to read a block from the SD card?

Homework

- P4 will be released and is optional.
- P5 will be released and due on Dec 2.
- No class next week (Nov. 11)
    - switch to office hours in Gates 437 due to Veterans day
- Lecture on Nov. 18: file systems