Introduction and Installation in RTEMS

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Outline

What is RTEMS?

- Real-Time Executive for Missile Systems? X
- The Real-Time Executive for Multiprocessor Systems (RTEMS) is an open source Real Time Operating System (RTOS) that supports open standard application programming interfaces (API) such as POSIX.
- It is used in space flight, medical, networking and many more embedded devices using processor architectures including ARM, PowerPC, Intel, Blackfin, MIPS, Microblaze and more.
- Commercial support is available from US and European companies, and free support comes via the active global community.

Features of RTEMS

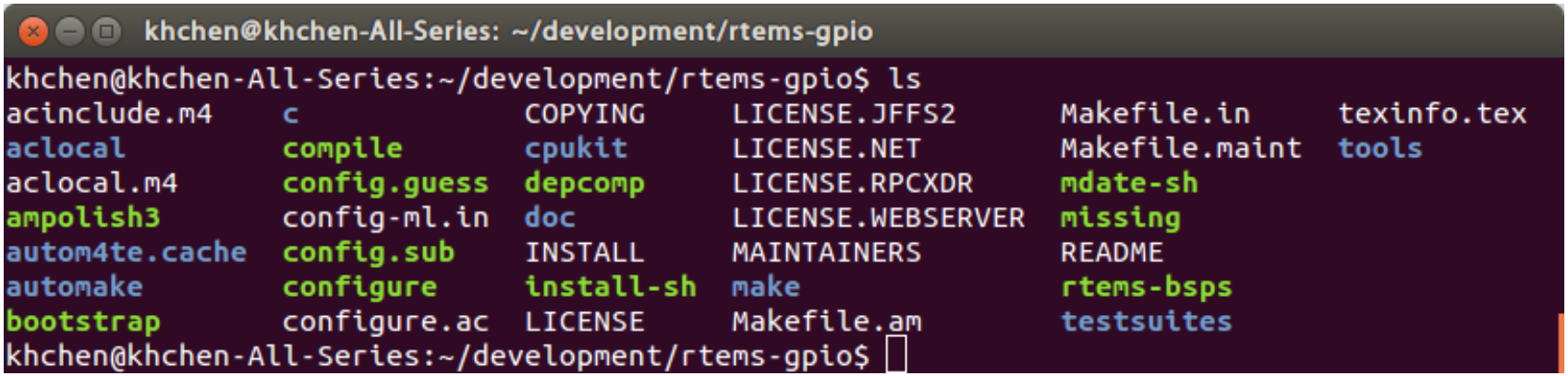
- The list of features:
  - multitasking capabilities
  - homogeneous and heterogeneous multiprocessor systems
  - event-driven, priority-based, preemptive scheduling
  - optional rate monotonic scheduling
  - intertask communication and synchronization
  - priority inheritance
  - responsive interrupt management
  - dynamic memory allocation
  - high level of user configurability
- Please check:
  `https://docs.rtems.org/doxygen/cpukit/html/modules.html`

How to install RTEMS? (1/5)

1. First of all, we have to build up the cross-compiling tool chains on your host-computer.
   - We have already prepared the environment for you to ease the complexity of installation.
   - If you want to implement on somewhere, please adopt RTEMS Source Builder `ftp://ftp.rtems.org/pub/rtems/people/chrisj/source-builder/source-builder.html` to aid you building packages.
2. Then, check out the repository from Github:

   ```
   git clone https://github.com/c0066c/rtems-gpio.git
   ```
3. Now you should have the source tree in your destination.

Look into the source tree (2/5)



- Some important directories to us:
  - cpukit/score/src: Provides services for all APIs (SuperCore).
  - cpukit/rtems/src: Provides RTEMS Classic APIs.
  - testsuites: Some testing programs released by RTEMS.
  - Please check the doxygen generated documentation: `https://docs.rtems.org/doxygen/cpukit/html/modules.html`

Hello world! (3/5)

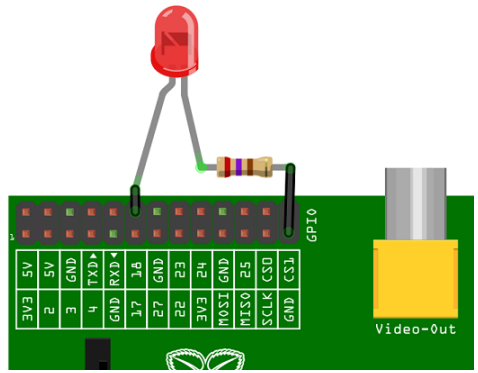
- The source code of hello world can be found in ./testsuites/samples/hello/init.c
- Init() is similar as the main() in the standard C program.
- In general, the init task is used to fork the multi tasks and set up the environment. Then call rtems_task_delete(RTEMS_SELF) to terminate itself after initializing the system.
- We recommend you to check the example of "Ticker" and see how to do the multitasking.
- C User's Guide
  `http://www.infres.enst.fr/~domas/astre/rtems_C_user.pdf`

Generating the kernel imaging (4/5)

1. Under the source directory, type the command:
   `./bootstrap`
   to run a self-sustaining process getting the configure files.
2. Trigger the configure under the building directory:
   ```
   ../rtems-gpio/configure --target=arm-rtems4.11 \
   --enable-rtemsbsp=raspberrypi \
   --enable-tests=samples \
   --enable-posix \
   --prefix=$HOME/development/rtems/4.11
   ```
   and
   `make install`
3. Find up the executable file under
   "arm-rtems4.11/c/raspberrypi/testsuites/samples/hello"
   ```
   make install
   arm-rtems4.11-objcopy -Obinary hello.exe kernel.img
   ```

Upload and execute the example on Raspberry Pi (5/5)

1. Connect Raspberry Pi with the host computer by USBtoTTL. Please note, the pin must be connected properly, i.e., GWD, TXD, RXD, otherwise the board might be damaged.



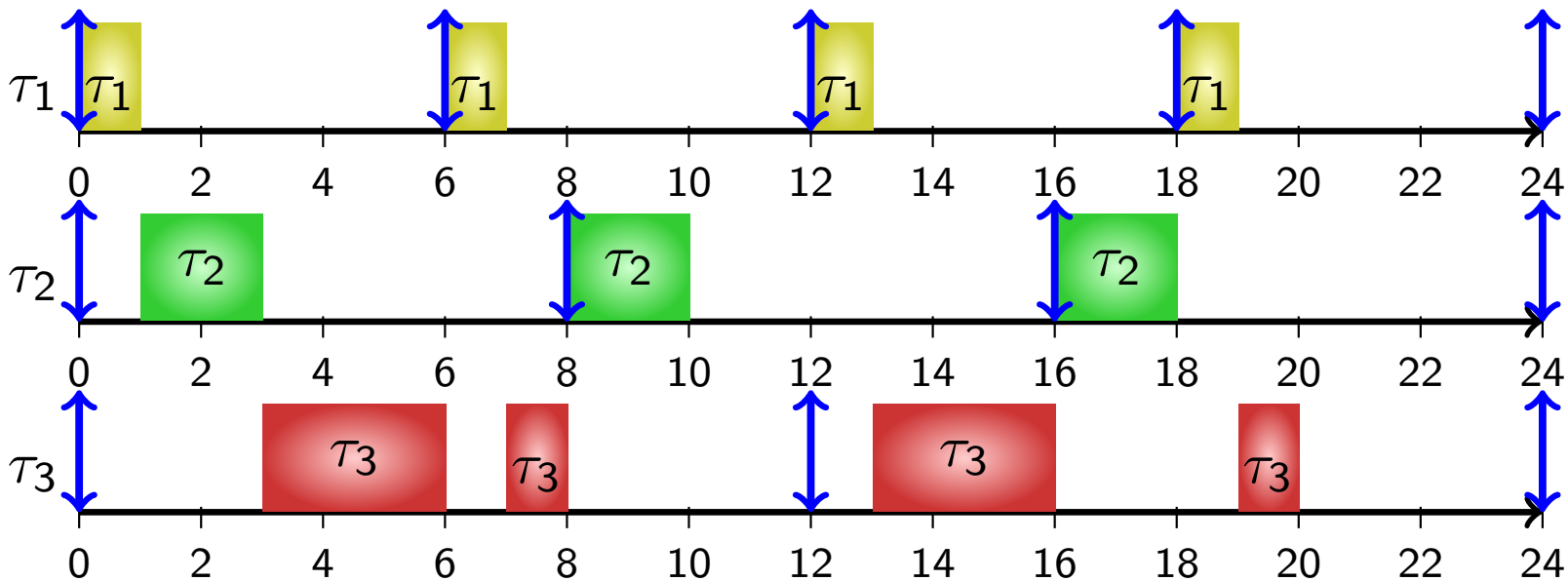
2. Copy kernel.img to "/sdcard/boot"
3. Before the power on, insert the SD-card. Please do not remove the SD-card when the power on!!
4. Open the terminal and use the following command to setup the serial debug terminal:

```
sudo screen /dev/ttyUSB0 115200
```

Rate-Monotonic Scheduling Example

Priority Definition: A task with a smaller period has higher priority, in which ties are broken arbitrarily. In RTEMS, the priorities of tasks need be defined when you create the tasks.

Example Schedule: $\tau_1 = (1, 6, 6)$, $\tau_2 = (2, 8, 8)$, $\tau_3 = (4, 12, 12)$. $[(C_i, T_i, D_i)]$



Exercises (10 points)

1. Please follow the tutorial and install RTEMS on your computer. Then upload the generated kernel on Raspberry Pi to execute. Please ensure that how to compile and program the executable example. (3 points)
2. Implement the example in slide 10 and display the corresponding behaviours on the debug terminal. Please note, you have to use rtems_clock_get_ticks_per_second() "properly" to mimic the execution time. (7 points)
3. Hint:printf(), rtems_clock_get_ticks_per_second().