



# Secure Timeout System NXP S32K3X8EVB

Beamer for the CAOS Project

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# Project Overview

## 1 Project Overview

- The assignment consists of FOUR parts:
  - **Part 1: QEMU board emulation**
    - Generating a custom QEMU version to emulate the NXP S32K3X8EVB board.
    - Ensuring that QEMU emulates the proper CPU, memory map, and the peripherals assigned.
  - **Part 2: FreeRTOS porting**
    - Ensuring that FreeRTOS runs on the emulated board.
  - **Part 3: Writing a simple application**
    - Writing a simple application implementing different tasks to test the setup.



# Project Overview

## 1 Project Overview

- The assignment consists of FOUR parts:
  - **Part 4: Documentation and presentation**
    - Creating a tutorial to run and test your code.
    - Documentation of the code.
- What we've actually done:
  - *Secure Timeout System* application on the **NXP S32K3X8EVB board** using **FreeRTOS**, emulated with **QEMU**.
  - Refer to the dedicated markdown files in the repository: `README.md` and `GUIDE.md`. These files contain all the implementation details and the tutorial to replicate the project.



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## 2 Part 1 - QEMU Board Emulation

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# Custom QEMU Version

## 2 Part 1 - QEMU Board Emulation

- Emulate the NXP S32K3X8EVB board, which is not natively supported by QEMU.
- Ensure proper emulation of the CPU, memory map, and peripherals.



## Resources Used

### 2 Part 1 - QEMU Board Emulation

- Adding a new architecture to QEMU.
- Previous projects and repositories for reference.



# Implementation Details

## 2 Part 1 - QEMU Board Emulation

- Board Initialization and Configuration:
  - Implement functions to load firmware, initialize memory regions, and handle hardware components.
  - Set up and configure hardware components like NVIC, LPUART, and PIT timers.
  - Manage system clocks and interrupts.





# Memory Regions Initialization

## 2 Part 1 - QEMU Board Emulation

- Flash Memory:
  - Block0: Base Address: 0x00400000, Size: 2 MB
  - Block1: Base Address: 0x00600000, Size: 2 MB
  - Block2: Base Address: 0x00800000, Size: 2 MB
  - Block3: Base Address: 0x00AD0000, Size: 2 MB
  - Block4: Base Address: 0x10000000, Size: 128 KB
  - Utest: Base Address: 0x18000000, Size: 8 KB
- SRAM Memory:
  - Block0: Base Address: 0x20400000, Size: 256 KB
  - Block1: Base Address: 0x20440000, Size: 256 KB
  - Block2: Base Address: 0x20480000, Size: 256 KB
- DRAM Memory:
  - Base Address: 0x30000000, Size: 1 MB



# Hardware Components Setup

## 2 Part 1 - QEMU Board Emulation

- NVIC (Nested Vectored Interrupt Controller):
  - Configured with 32 IRQs and 4 priority bits.
  - Connected to system clock and reference clock.
- LPUART (Low Power UART):
  - Base Address: 0x4006A000
  - Connected to NVIC and system clock.
- PIT Timers (Periodic Interrupt Timer):
  - Timer1: Base Address: 0x40037000
  - Timer2: Base Address: 0x40038000
  - Connected to NVIC and system clock.



# System Clocks and Interrupts

## 2 Part 1 - QEMU Board Emulation

- System Clock:
  - Created clock object with 7.14ns period (140MHz frequency).
- Interrupt Handling:
  - Configured NVIC to handle interrupts.
  - Linked NVIC's memory access to system memory.



# Firmware Loading

## 2 Part 1 - QEMU Board Emulation

- Function: `s32k3x8_load_firmware`
- Parameters:
  - `cpu`: The ARM CPU instance.
  - `ms`: The machine state.
  - `flash`: The memory region representing the flash memory.
  - `firmware_filename`: The filename of the firmware to be loaded.
- Functionality:
  - Reads the firmware file and loads its contents into the specified flash memory region.



# Initialization Functions

## 2 Part 1 - QEMU Board Emulation

- `s32k3x8_initialize_memory_regions`:
  - Initializes flash, SRAM, and DRAM memory regions.
- `s32k3x8_init`:
  - Initializes the system, including memory regions, NVIC, LPUART, and PIT timers.



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# FreeRTOS on Emulated Board

## 3 Part 2 - FreeRTOS Porting

- Port FreeRTOS to run on the emulated NXP S32K3X8EVB board.
- Ensure compatibility and functionality of FreeRTOS on the emulated hardware.



# Implementation Details

## 3 Part 2 - FreeRTOS Porting

- Kernel Configuration:
  - Configure FreeRTOS kernel settings in FreeRTOSConfig.h.
  - Define task priorities, stack sizes, and heap sizes.
  - Enable necessary FreeRTOS features like mutexes, semaphores, and task notifications.





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## 4 Part 3 - Write a Simple Application

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# Secure Timeout System Application

## 4 Part 3 - Write a Simple Application

- The application is a simple implementation of a *Secure Timeout System*.
- It consists of **multiple tasks** that simulate events, monitor activities, and handle alerts.
- **Hardware timers** are used to generate **periodic interrupts** for activity detection.



# Task Implementation

## 4 Part 3 - Write a Simple Application

- **Event Task:**

- Periodically generates events that can be either user activities or suspicious activities.
- Uses a pseudo-random number generator to decide the type of event.
- Logs the generated event and updates the respective counters.

```
[EVENT SIMULATOR] ——— New Cycle Started —————  
[EVENT SIMULATOR] Generated: User Activity      | Count: 1
```

```
[EVENT SIMULATOR] ——— New Cycle Started —————  
[EVENT SIMULATOR] Generated: Security Event    | Count: 1
```

**Figure:** Generation of a user activity and a suspicious activity.



# Hardware Timer Initialization

## 4 Part 3 - Write a Simple Application

- **Timer 0:**
  - Configured to generate periodic interrupts.
  - Interrupt handler checks for **user activities** and sets the user activity detection flag.
- **Timer 1:**
  - Configured to generate periodic interrupts.
  - Interrupt handler checks for **suspicious activities** and sets the suspicious activity detection flag.



# Task Implementation

## 4 Part 3 - Write a Simple Application

- **Monitor Task:**

- Checks for user activity detection.
- Logs the status of user activity.
- Resets the user activity detection flag after logging.

- **Alert Task:**

- Checks for suspicious activity detection.
- Logs the status of the system security.
- Initiates security protocols if suspicious activity is detected.
- Resets the suspicious activity detection flag after logging.



# Implementation Details

## 4 Part 3 - Write a Simple Application

- **Global Variables:**

- Four main flags:
  - `userActivity`, `userActivityDetection`,  
`suspiciousActivity`, `suspiciousActivityDetection`

- **Task Priorities:**

- Event Task has the highest priority to ensure timely event generation.
- Monitor Task and Alert Task have lower priorities.

- **Timer Frequency:**

- Timer 0 and Timer 1 are configured to generate periodic interrupts at a frequency of 2 Hz.



# Implementation Details

## 4 Part 3 - Write a Simple Application

- **Task Priorities:**

```
// filepath: /App/SecureTimeoutSystem/secure_timeout_system.c
#define MONITOR_TASK_PRIORITY (tskIDLE_PRIORITY + 2)
#define ALERT_TASK_PRIORITY   (tskIDLE_PRIORITY + 3)
#define EVENT_TASK_PRIORITY   (tskIDLE_PRIORITY + 4)
```

- **Timer Frequency:**

```
// filepath: /App/Peripherals/IntTimer.c
#define tmrTIMER_0_FREQUENCY (2UL)
#define tmrTIMER_1_FREQUENCY (2UL)
```



# Run Example

## 4 Part 3 - Write a Simple Application

```
[EVENT SIMULATOR] ----- New Cycle Started -----  
[EVENT SIMULATOR] Generated: Security Event | Count: 1  
  
Timer 0 Interrupt: looking for user activities ...  
Timer 1 Interrupt: looking for suspicious activities ...  
[SECURITY ALERT] Suspicious activity detected | Status: ALARM  
[SECURITY ALERT] Initiating security protocols ...  
[USER MONITOR] No activity | Status: IDLE  
Timer 0 Interrupt: looking for user activities ...  
Timer 1 Interrupt: looking for suspicious activities ...  
Timer 0 Interrupt: looking for user activities ...  
Timer 1 Interrupt: looking for suspicious activities ...  
[SECURITY ALERT] Suspicious activity detected | Status: ALARM  
[SECURITY ALERT] Initiating security protocols ...  
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Timer 1 Interrupt: looking for suspicious activities ...  
Timer 0 Interrupt: looking for user activities ...  
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[SECURITY ALERT] Initiating security protocols ...  
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```

Alt+F2 to open the terminal

How can I view the output of the terminal with xterm?

How can I view the output of the terminal with xterm?

Alt+F2 to open the terminal

How can I view the output of the terminal with xterm?

To take a screenshot of the terminal in the terminal, you can use the `Alt+F2` key combination.

1. Open the Terminal. Open the terminal window that you want to take a screenshot of.

2. Using Keyboard Shortcut. Press `Alt+F2` to take a screenshot of the terminal.

3. Using the Screenshot Tool. Open the Screenshot Tool.

4. Select the terminal window that you want to take a screenshot of.

5. Click the Screenshot button to take a screenshot of the terminal.

6. Save the screenshot. Save the screenshot to a location of your choice.

7. Include the screenshot in your LaTeX Document. Use the `\includegraphics` command to include the screenshot in your LaTeX document.

8. Compile the document. Compile the document to generate the PDF file.

9. View the screenshot. View the screenshot in the PDF file.

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# Conclusion

## 5 Conclusion

- The `s32k3x8evb_board.c` file plays a crucial role in the emulation of the **NXP S32K3X8EVB board** within **QEMU**.
- It provides the necessary functions to load firmware, initialize memory regions, set up hardware components, and manage system clocks and interrupts.
- All the implementations and detailed information about the project are contained in the repository.
- Repository link: <https://baltig.polito.it/caos2024/group2.git>



*Thank you for listening!*  
*Any questions?*