Department of Electrical and Computer Engineering
COMPSYS 305 – Digital Systems Design
Mini project (25%)

Objective

The goal of the mini project is to design a simple game console with a built-in computer game using only digital logics and digital design.

Equipment provided in the project

Apart from computers available in the lab, you will need the following equipment for your project which can be obtained from the ECE Component Store. Each group should have access to only one set of the following equipment.

- A DE0-board (used as the game console), a USB cable and a power supply.
- A PS/2 Mouse (A USB Mouse + PS2 Adapter)
- A VGA cable

Game description

The game (Tank Hunting, a reduced version of Dual tank game) is controlled and played (or displayed) using a PS/2 mouse, a VGA screen (640 x 480 pixels), DIP switches and pushbuttons as the man-machine interfaces. The game should be displayed on an ordinary computer monitor via the VGA interface. The game comprises two tanks which are realized as square boxes on the VGA monitor, one at the top and the other at the bottom. The tank at the top keeps continuously moving on a horizontal line on the screen. The bottom tank can be controlled by using the mouse. When mouse is clicked, the bottom tank shoots a bullet (round ball); if it hits the top tank, it scores one point. Once a tank is hit, it vanishes and reappears at a random place. The score of the player is displayed on the screen. Once the game is finished, it can be resets by pressing the reset button.

The game you are going to design should follow some preliminary rules:

1. Two square shaped tanks facing each other on VGA screen with different colours (for example red and green). One tank appears on the top of the screen and the other appears on the bottom.
2. The tank at the top should continuously move on a horizontal line on the screen.
3. You should be able to show multiple tanks at the top in your final design (at least two).
4. The bottom tank's horizontal movement is controlled by using mouse.
5. The bottom tank is preloaded with bullet and shoots one bullet at a time; if it hits the opponent's tank, it scores one point.
6. Once top tank is hit, it vanishes and reappears at a random location at the top.
7. A tank can shoot the second bullet only when the previous bullet goes out of the screen or hits the opponent. The score should be displayed on screen. It could also be displayed on the seven segment display.
8. The top tank should be kept on moving at constant speed, which increases with the game level.
9. The students need to come up with a strategy for changing the level of the game. The level of difficulty can be controlled by various criteria, for example, the tank speed, bullet speed and time to hunt the tank and number of bullets loaded in the tank.

These preliminary rules can be used as general guidelines for your game specifications. **However, you are welcome to introduce changes in the game rules to make the game more interesting and challenging**. Please discuss with the TAs or lecturers regarding changing game rules if you are in doubts. You may need to use a pseudo random number generator (implemented as linear feedback shift register) for generating random tank position at the top. For practical reasons you can assume a reasonable finite number of possible values. Also remember that for your game simple square boxes for tanks and round ball shaped bullets are sufficient but adding other graphic details may count in your favour.

Optional:

- The top tank can also be provided with the capability of moving vertically downward or to fire back at the bottom tank. The game is over if the top tank moving downwards goes out from bottom part of screen without being hit or bottom tank gets hit. (1 bonus point)
- Use of graphics for tanks and background (No bonus point)
- Use of music (No bonus point)

Game modes

The game should have two operation modes:

1. TRAINING mode
2. Single-Player GAME mode

In TRAINING mode, the game allows the player to practice at the lowest game level until the hunting time is over. The game mode can be determined by using a DIP switch on the console (i.e. the DE0 board), provided as a control input. When the game console is powered up or reset, it should automatically go into an initial state with a proper graphical user interface, which requires the player to select a mode and start the game. Start of the game can be indicated by pressing a push-button provided on the console as another control input. Similar to other video games, you may need to provide simple textual messages on the user interface to a player (messages like start, end, mode, score = value, time = value). While playing the game, another push-button can be used to perform pause/resume functionality in the game. The training mode duration can be limited based on the time, number of movements of the top tank or the number of bullets fired.

In the GAME mode, a player should try to hunt required number of tanks in a given time. The game will proceed to more advanced levels following certain criterion, such as time or number of tanks hunted etc. Each subsequent level will be more difficult, in terms of screen motion speed, tanks hunted, reduced time for hunting or reduced number of bullets fired etc. The GAME mode should contain at least three levels.

In this mini project, the hardware platform that you will use for implementing the game console is Terasic DE0 board. The board provides all necessary interfaces (PS/2 for mouse, VGA for monitor, DIP switches and push-buttons) and a relatively large FPGA in which the game logic will be implemented.

Tasks

Your tasks are:

a) Understand and specify the full operations/functionalities of the game (logics) and man-machine interface.
b) Study operations of the input and output devices and features of the DE0 board. Also, you will be given some basic design blocks which you can use as a starting point in your project and speed up the design process.
c) Decompose the game into parts which can be described in VHDL and design those parts (specify/design, implement, simulate, synthesise). In this process identify the elements of datapath and control unit.
d) Implement all design parts and compose the game console by integrating individual parts into a full design.

Project Groups

The project is done in **groups** with **two students** who at the end have to produce the evidence of individual contributions (who has done what) and a confidential peer assessment in which each student evaluates the contribution of his/her peer in terms of design specification, implementation, testing and report writing (grades between 0-minimum and 5-maximum, and short comments and observations if

necessary). In the case of special concern regarding the performance and involvement of your project partner you can contact lecturers not later than two weeks before the project deadline.

Deliverables

The project final deliverables from each team are:

- A zip file including project report soft-copy, all project design files, additional explanations etc. Details about the submission process will be provided later.
- Soft-copies of individual peer assessment form. The individual peer assessment form should be emailed directly to the lecturer. (muhammad.nadeem@auckland.ac.nz).

Assessment

The project assessment is done in two stages:

Stage A (10%):

Interim progress review will be scheduled during the lab time of **week 9**, where each group will present their progress.

Evaluation criteria guidelines

Interim report (5%) with at least the following two items (2-page max, design ideas can be reused in final report, proper report structure is not required but writing should have a logical flow).

- Design specification: Providing a definition and requirements of the system that you are designing (definitely not a copy of the given project description).
- Block diagram with clear explanation of each block's functionalities and interface between connected blocks.
- Clearly outline the game strategy

Interim Interview (5%) will generally be evaluated based on:

- Functionality of man-machine interface devices
    - Display at least one tank on the VGA display (should it be a moving object or just a still one is enough?)
    - Working mouse (you can use the data packet received from the mouse to control tank movement or display the packet on seven segment display)
    - Evidence of working DIP switches, push-buttons or even seven-segment display (you can think of a way to demonstrate their working).
    - Display the text on the VGA display
- Familiarity with the design resources
- Explanation of your design and design plan
- Quality of the design plan and initial implementations

Stage B (15%):

1. The final report (5%) and other deliverables should be zipped in a file before **Tuesday 30th May 10 am**. The report should be no longer than 6 pages, following the template provided on Canvas.

2. Final demonstration and interview (10%) will be held during the lab time of **week 11 (Tuesday 30th May)**.

The final demonstration presented should be based entirely on the submitted deliverable and you are not allowed to change the code after that.

Evaluation criteria guidelines:

- Good understanding of the game (i.e. the system) requirements and functionalities that "you are designing" and the provided development board features in order to implement the game.
- The ability to decompose the problem (i.e. the game, the system) to small functional blocks by providing a block diagram with clear definition of relations/interfaces between functional blocks.
- Go through different reports generated by the synthesis tool (Quartus) to understand the performance of the designed system (e.g. resource usage, operating frequency) and give some comments for future improvements (or even perform reasonable optimisation in this project).

The **final report** (5%) is expected to be more detailed especially with regard to:

- The final system design and implementation. It should also provide information about the FSM for controlling the overall operations of the system.
- Explaining your design decisions/trade-offs and the merits of your design specification/decomposition.
- The resource usage and performance (max. operating frequency etc.) of your implementation. To indicate the quality of your design and suggest possible improvements.
- Provide reference if needed.
- The report should be 4-6 pages using the report template provided.

The emphasis during **final interview** (10%) would be on:

- The quality of the game and its features
- Clear understanding of your codes and design (and whether the coding follows the design)
- Design performance
- Presentation quality (you might prepare a few slides to explain your design)

Support

Additional information, documentations, useful notes and hints that can help implementing this project will be provided on Canvas. For the purpose of getting feedbacks for your design decisions, TAs (Nicholas Harvey and Maryam Hemmati) will be available during the fixed weekly lab time (Tue/Thu 4-6pm). You can consult with them within those given hours.

Academic integrity notice

The University of Auckland will not tolerate cheating, or assisting others to cheat, and views cheating in coursework as a serious offence. The work that a student submits for grading must be the student's own work, reflecting her or his learning. Where work from other sources is used, it must be properly acknowledged and referenced. This requirement also applies to sources on the world-wide web.