Department of Electrical, Computer and Software Engineering
COMPSYS 305 – Digital Systems Design
Mini Project (30%)

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

Apart from a computer with QuestaSim/ModelSim and Quartus Prime 18.1 installed on it, you will need the following equipment during your project which can be obtained from the ECSE Component Store. Each group needs one set of the following equipment.

- A DE0-CV board (used as the game console), a USB cable and a power supply.
- A PS/2 mouse.
- A VGA to HDMI adapter.

Game Description

The game is Flappy Bird and is controlled and played using a PS/2 mouse, DIP switches, and push-buttons available on the DE0-CV board. The game is displayed on a VGA screen with a resolution of 640 x 480 pixels. It could be displayed on an ordinary computer monitor via the VGA interface. You may refer to the web link: http://flappybird.io/ for a possible game setting. The game is a side-scroller where the player controls a bird, attempting to fly between rows of pipes without hitting them. The game you will be designing should follow some preliminary rules:

1. The bird can move up and down (and backwards/forwards to some extent), controlled using a PS/2 mouse. If the bird is not flapping, it will free-fall towards the ground. The bird is dead if it falls on the ground. The bird must not touch anything when flying, otherwise, it will lose life points. When life points are depleted, the bird will die.
2. The game should consist of different types of obstacles (e.g. pipes) and gifts (e.g. dollars/medicine boxes/special flying abilities).
3. The screen must be kept in motion from the right-hand side to the left-hand side at a constant speed, which increases with the game level.
4. The level of difficulty can be controlled by various criteria, for example, the horizontal screen motion speed, the types and number of obstacles, etc.

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 doubt. You may need to use a pseudo-random number generator (implemented as a linear feedback shift register) for generating random types of obstacles and gifts. For practical reasons, you can assume a reasonable finite number of possible values. Although simple graphics for the bird and pipes may be sufficient, adding other graphical details may count in your favour.

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 bird's blood/life becomes zero. The game mode can be determined by using a DIP switch on the console (i.e., the DE0-CV 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. The start of the game can be indicated by pressing a push-

button provided on the console as another control input. Like 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.

In the GAME mode, a player should try to stay alive. The game will proceed to more advanced levels following certain criteria, such as time, distance, or the number of obstacles passed through. Each subsequent level will be more difficult, in terms of screen motion speed, route planning, 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-CV board. The board provides all necessary interfaces (PS/2 for mouse, VGA for the 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 and the user interfaces.
b) Study operations of the input and output devices and features of the DE0-CV board. You will be given some basic design blocks which can be used as a starting point in your project to speed up the design process.
c) Design and develop the game by decomposing the game into components that can be described in VHDL. Implement, simulate, and synthesise the components and identify the elements of the datapath and control unit. Information on the datapath and control unit will be covered during the second part lectures well ahead of the submission deadline.
d) Integrate all components into a full design and compose the game console.
e) Analyse your implemented design with regards to the resource utilisation and timing performance.

Project Groups

The project is done in groups with three students. Groups are expected to be formed by the end of the day on **Tuesday 8th April**. Final list of groups and their members will be published on Canvas afterwards. You are asked to provide the evidence of individual contributions (who has done what) and a confidential peer assessment in which you evaluate the contribution of your peers 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 case of special concerns regarding the performance and involvement of your project partners, **you may contact lecturers no later than two weeks before the project deadline.**

Assessment

The project counts for **30%** of your total mark and is assessed through your interim (5%) and final (25%) submissions and interviews. The interim interview will be held on **Week 9 (Friday, 16th May 2 – 4 pm)**. The final interview will be held on **Week 11 (Friday, 30th May 1 – 4 pm).**

Final Deliverables

The project final deliverables from each team are:

- A zipped folder including all project design files (VHDL codes, simulation/synthesis results), additional explanations, etc. This should be submitted on Canvas by **Friday, 30th May 1 pm** before the final interviews start.
- Final project group report, due on **Friday, 30th May 11:59 pm.**
- Soft copies of the individual peer assessment form. The individual peer assessment form should be filled and submitted on Canvas by **each member** of the group individually. These forms are also due on **Friday, 30th May 11:59 pm.**

Evaluation Criteria Guidelines

- Good understanding of the game (i.e. the system) requirements and functionalities, 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 a clear definition of relations/interfaces between functional blocks.
- The ability to understand the performance of the designed system (e.g. resource usage, operating frequency) by checking different reports generated by the synthesis tool (Quartus II).
- The ability to provide some comments for future improvements (or even perform reasonable optimisation in this project).

The emphasis during the **final interview (15%)** would be on:

- The quality of game implementation and its features.
- The quality of your demo and presentation.
- A clear understanding of your code and design (and whether the coding follows the design). This will be assessed individually.
- Design performance (resource usage and operating frequency). You should have some idea about the resources used in each component of your design.

  The items related to the overall quality of the project and its presentation are assessed per group submission. Understanding of the code and design performance are the items to be assessed individually.

The **final report (10%)** is expected to be detailed, but no longer than 6 pages. It should include:

- 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.
- The resource usage and performance (max. operating frequency) of your implementation to indicate the quality of your design and suggest possible improvements.
- The report should be 5-6 pages using the report template provided. Please note that **the final report should have proper formatting** and follow the structure of research papers.

Interim Progress Review and Feedback:

To help you with your project management and provide feedback to you on your progress, **interim interviews (5%)** will be held during the lab time of **Week 9 (Friday, 16th May 2 – 4 pm)**. During the interim interviews, each group is expected to demo their progress and provide their design plans.

Each group should submit a zipped folder including a brief design report (2-page max) and their codes demonstrating their progress and the ability to use all user interfaces (i.e. VGA display, mouse, DIP switches, push-buttons, and seven-segment display). Interim submissions are due by **Friday, 16th May 1 pm.**

The short report should include:

- The game strategy, and design specifications and plans.
- A Block diagram showing all the components of the game and their interfaces.
- The high-level state machine of the game.

Note that proper report structure is not required, however writing should have a logical flow.

Interim Stage Expectations

By the interim stage, groups are expected to have clear design plans and the ability to use all the interfaces on the board, confidently. The functionality of user interface devices could be shown through:

- Working mouse (you can use the data packet received from the mouse to control ball movement or display the packet on a seven-segment display).
- Evidence of working DIP switches, push-buttons, and seven-segment displays (you can think of a way to demonstrate their working).
- Display the moving ball on the VGA display and show some sort of control over the ball, showing the ball behaves differently than the provided design.
- Display different sizes of text on the VGA display.

Support

Additional information, documentation, useful notes and hints that can help in implementing this project will be provided on Canvas. For the purpose of getting feedbacks for your design decisions, TAs (Ross Porter, Ehsan Behravan, Mekal Covic, Jenny Nguyen, and Campbell Wright) will be available during the fixed weekly lab time (Thu/Fri 2-4 pm). You may consult with them within those 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 his or her 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.