A New Aspect of Coarse-Grained Re-configurable Architectures

"Can You Untangle It?"

Candace Calhoun

Johnson C. Smith University Class of 2012

Information Systems Engineering

Mentor: Gayatri Mehta, Ph.D.

Computer Aided Design Lab

Department of Electrical Engineering

University of North Texas, at Denton

Denton, Texas

1. Introduction

The main focus of this research was to develop a scientific, mapping game to discover faster and better algorithms. An algorithm is a sequence of unambiguous instructions for solving a computational problem. To discover these algorithms we made use of human intuition and their ability to recognize patterns and opportunities even in complex problems. Whether we as human beings realize it or not we are great at observing configurations. The players are presented with successively more difficult mapping problems that are in a game environment. The vast dataset of players' moves are analyzed to identify common patterns used by successful game players. The insights gained from strategic moves the players have made while solving the game based on their visual perception and experience will be used to discover new mapping approaches. These new mappings are beyond what can be conceived with traditional algorithms.

2. Background

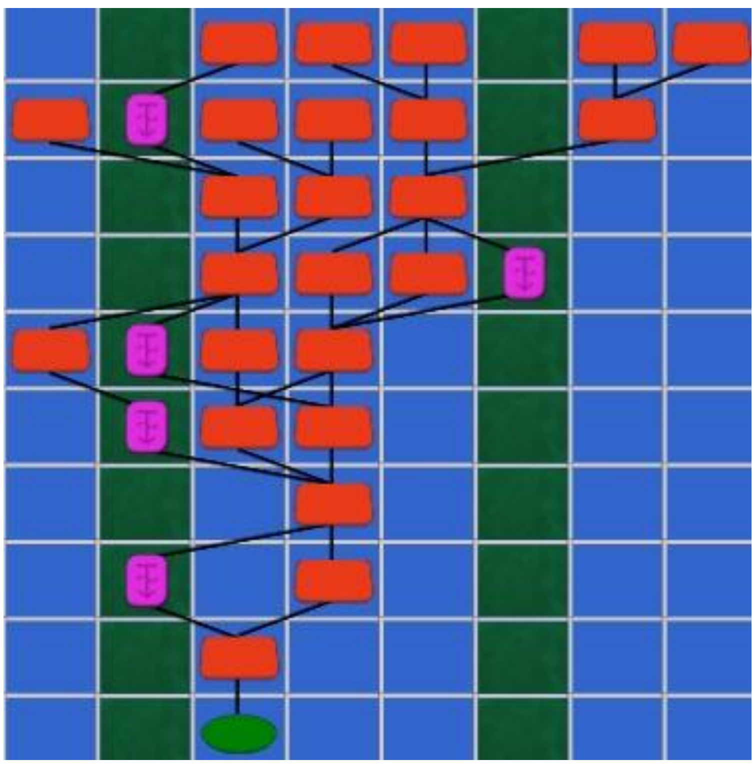
Coarse-Grained Reconfigurable Architectures (CGRA's) are becoming more promising than Application Specific Integrated Circuits (ASIC's) in todays society. One of the reasons for this turns out to be because various people are starting to realize CGRA's flexibility. An ASIC is a microchip designed for a special application, such as a particular kind of transmission protocol or a PDA. While on the other hand a CGRA is an integrated circuit with an assortment of Processing Elements (PE's) such as Arithmetic Logic Units (ALU's). ALU's are one of the vital components in the Central Processing Unit. PE's are linked to each other by routing buses. CGRA's are suitable for any applications that have a need of high throughput. One of several reasons for ASIC's going out of style is because they are high-priced in production cost. A benefit of using CGRA is it will be considerably cheaper in production cost and a lot faster than the traditional ASIC.

Our team figured that since so many individuals spend hours a day playing video games, why not come up with a game that will help humans in the long run. I am referring to making algorithms quicker because as of now they are typically slow. Therefore, we optimize the graphs made from playing the game and observe the patterns. My research team has developed "Untangled". This is a game that any and everybody can play. It does not matter if you're a college student or in high school. Our target audience is people that do not have any prior knowledge of Engineering, Electric or Computer Engineering to be specific.

3. Project

a. Gameplay

Our players are presented with graphs and are to attempt to minimize. While minimizing players also have to decrease the length of the connection between nodes which is turn increases their scores. Now playing to the constraints of each level is what makes this game a little challenging. Constraints are conditions that we need to happen or would like to happen with architecture. Hence, in the particular case it would be the rules and violations. To help make sense of this a little more a node is, in simple terms, a connection point. In order to complete each level the player is responsible for having a finished graph with no violations. I have placed an example of a finished graph below.

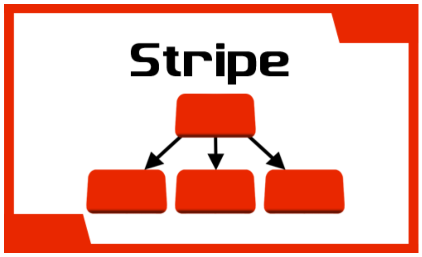


b. Architectures and Sub-Levels

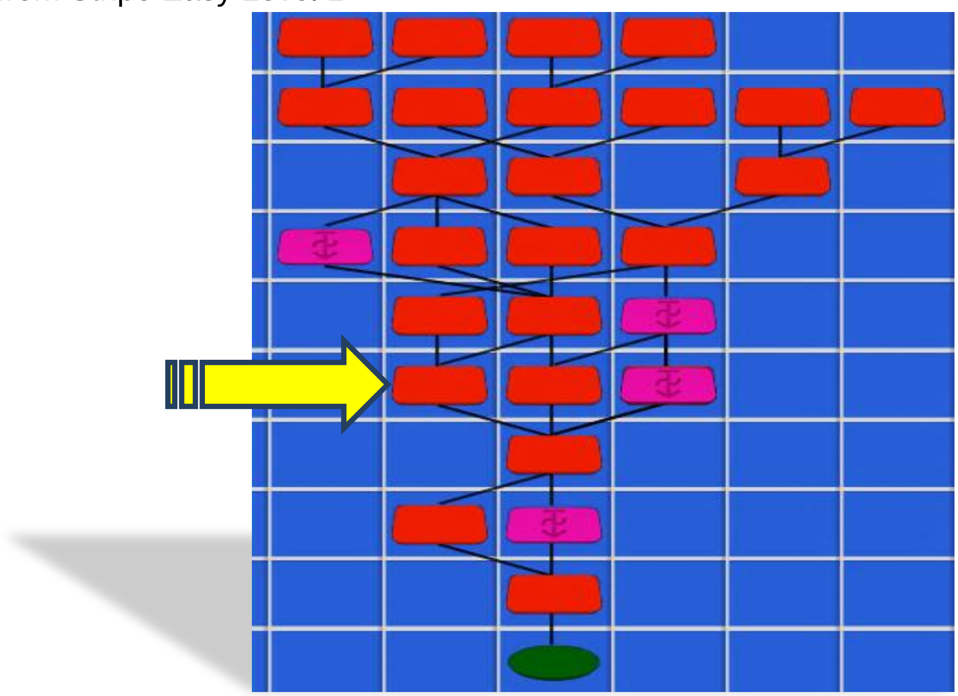
Untangled features six sub-levels that fall under two main architectures: Stripe and Mesh. In the Stripe architecture are sub levels Stripe and Dedicated Pass Gate Route. In the Stripe family the nodes are linked through multiplexors. In the Mesh architecture the graphs are construed as 2D mesh structures. The Mesh family sub levels are 4Way-

2Hops, 4Way-1Hop, 8Way, and 4Way. Each sub level has seven levels within it. There are three easy, two medium, and two hard levels.

1.



Stripe is a unidirectional data flow graph that does have a strict parent-child relationship with its nodes. Meaning the child has to be exactly one row below its parenting node. (For example see picture below)
You see where the yellow arrow is pointing at on the graph that is a child node and the node directly above it is the parent. This is a screenshot from Stripe Easy Level 1.



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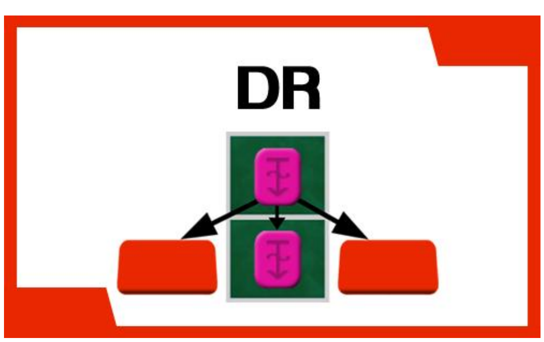
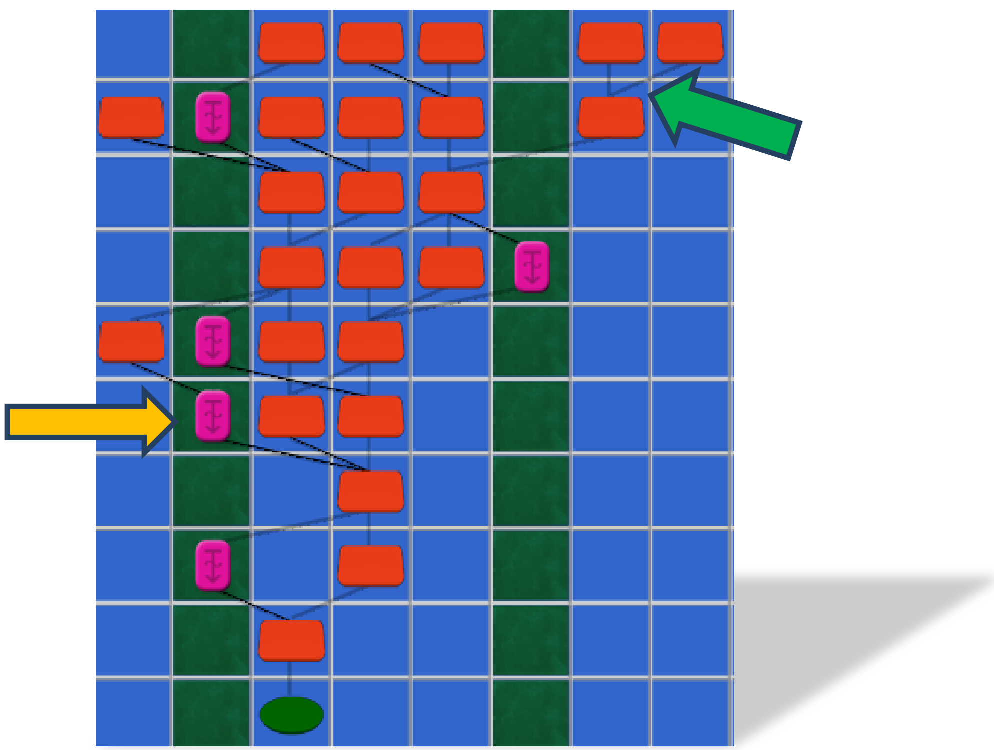
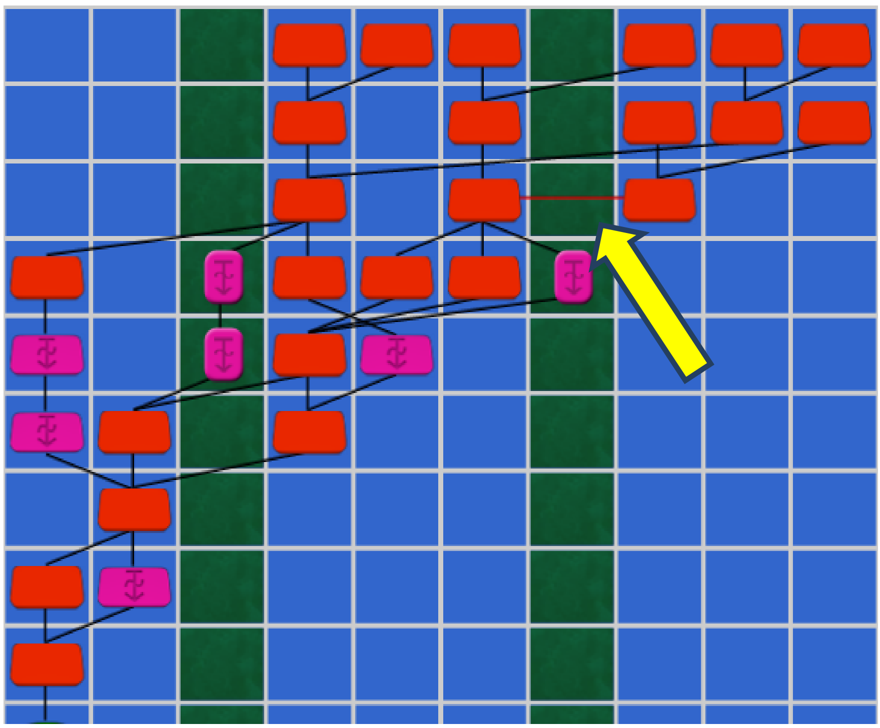


The Dedicated Pass Gate Route is also known as “DR” for short. When comparing the two sub levels there is only one difference between the two. In DR, unlike in Stripe, you actually have direct routes on the grid that are marked in the color dark green. In these areas you can place pass gates only. Pass gates are the pink nodes on the graph that has a “squiggly” line in the middle, in which I will talk about later.

Here is a screenshot of my actual graph playing Easy 1 in DR. Looking at the yellow arrow it is pointing at is a pass gate. As you see the pass gate is in its designated area on the grid. Drawing your attention to the green arrow you will be able to see that the parent-child relationship is still present.

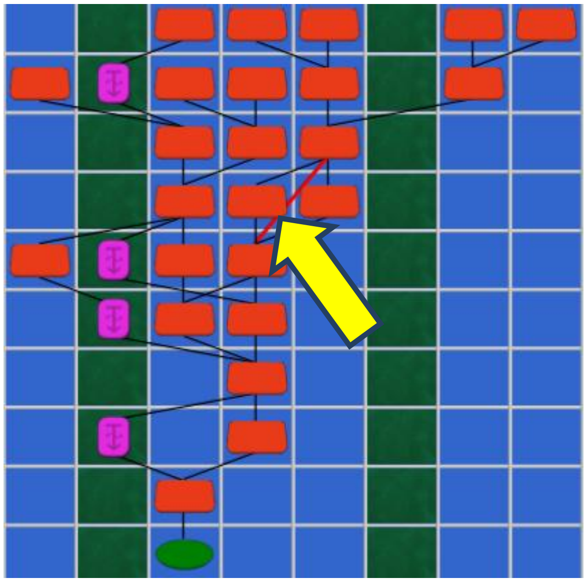


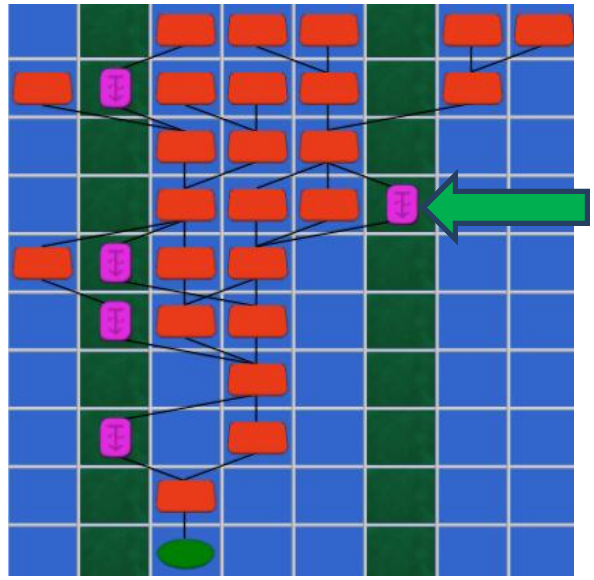
Before I move on to the Mesh Family of Architectures let me explain what some of these nodes are on the grid. The red nodes are ALU's, which I previously explained in section 2. The green ovals are called output nodes, the reason being because they are the end of the Algorithm and nothing can be placed underneath them or you will end up with a violation. Violations are simply a red line between two nodes, which appears when you have made an illegal move, broke a constraint in the level. The arrow below is pointing to one violation in DR level.



Furthermore, this is also where pass gates are imperative to the completion of your graph in the Stripe architecture. Pass gates are used to connect a child to its parent or vice versa. Directing your attention to the screenshot on the left, you have a violation because the child node is more than one row away from the parent and that is an illegal move in this sub level. Therefore, I have to add a pass gate to connect the two nodes in order to remove the violation referring to the graph on the right side.

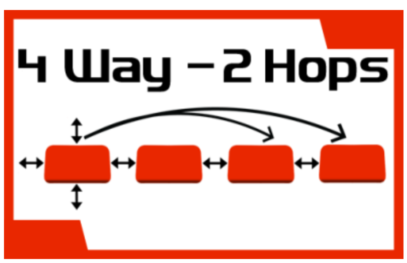
(Before Pass Gate: 1Violation) (After Pass Gates 0Violation)



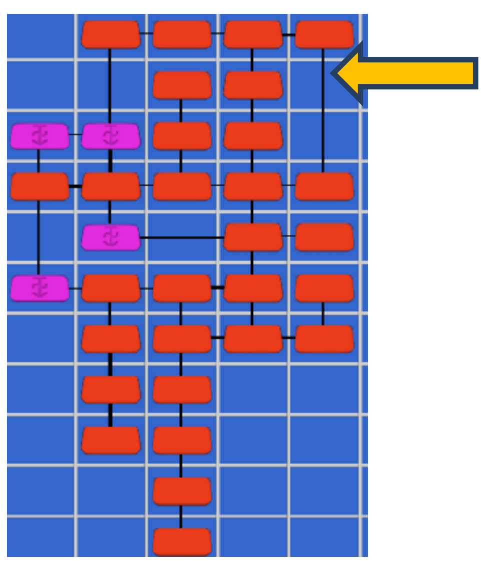


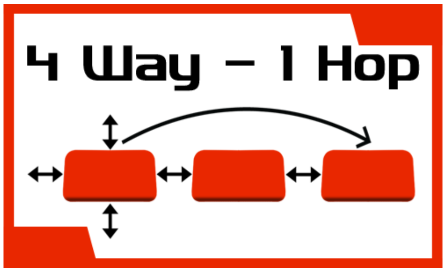
The second architecture family in “Untangled” is Mesh. Mesh has four sub levels. The four sub levels are: 4Way-2Hops, 4Way-1Hop, 4Way and 8Way. The “four way” family is based on bi-directional data flow and 8Way is not. 8Way can be placed anywhere on the graph near the parent even diagonal. Unlike 8Way the “four way” can only be placed on the sides, above, or beneath the parent node. The names of these four sub levels are very self-explanatory.

3.

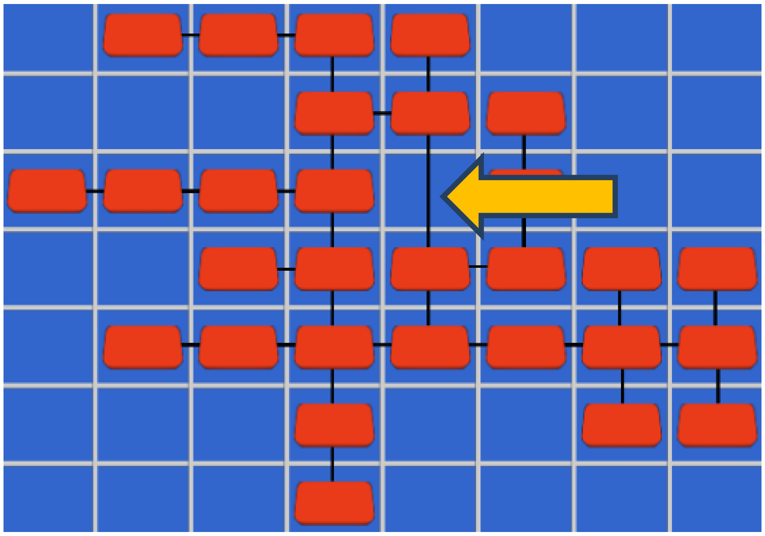


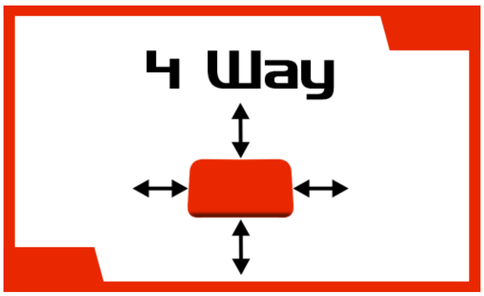
For 4Way-2Hops it is not mandatory for the nodes to be right next to the parent but can have a maximum of two spaces between each other. In the picture notice the arrow pointing to the two spaces separating the two nodes on the grid.



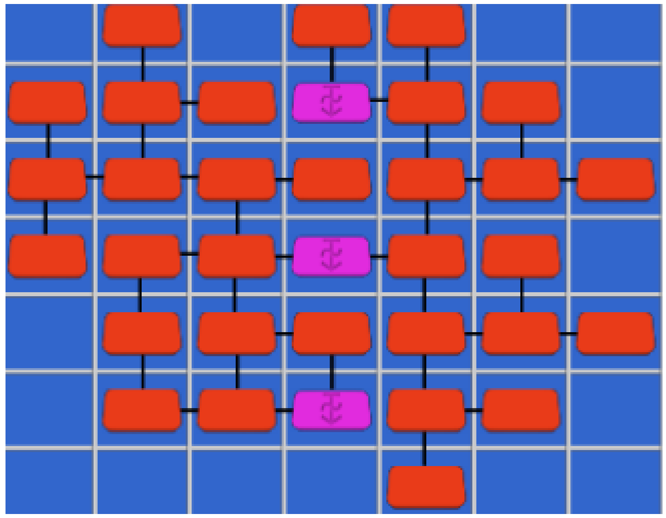
5. 

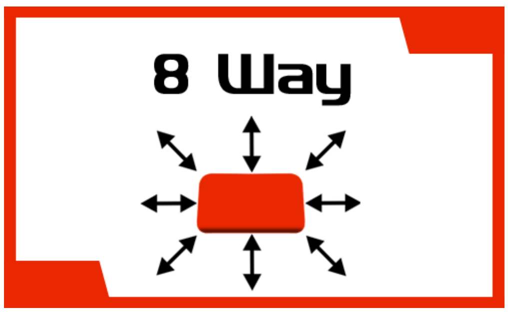
4Way-1Hop ultimately has the same concept as 2Hops except the nodes can only be positioned one space away from each other. Observe the yellow arrow only allowing one space between the two nodes.



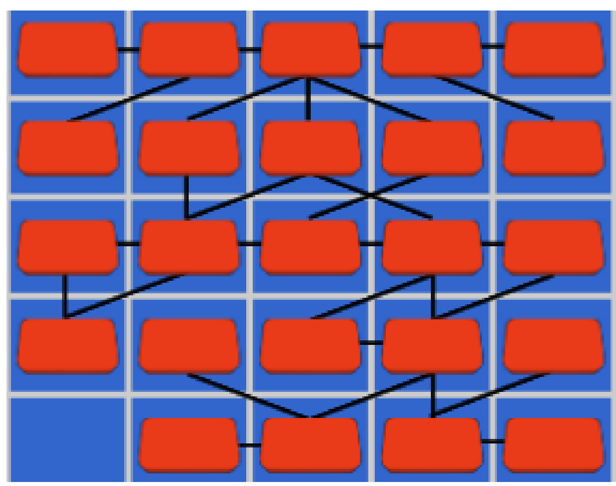
6. 

At this present time according to statistics 4Way is by far the most perplexing sub level of this game. In 4Way you cannot have any spaces between your nodes. They have to be side by side or top to bottom period. You can have more than 4 nodes that are connected to a parent but you also know a square only has four sides so how will it be possible to connect the fifth or sixth node. With that being said you have to be on your “A GAME” when playing this level because it definitely gives you a challenge. The image below is a screenshot of a completed 4Way graph, notices there are no spaces.



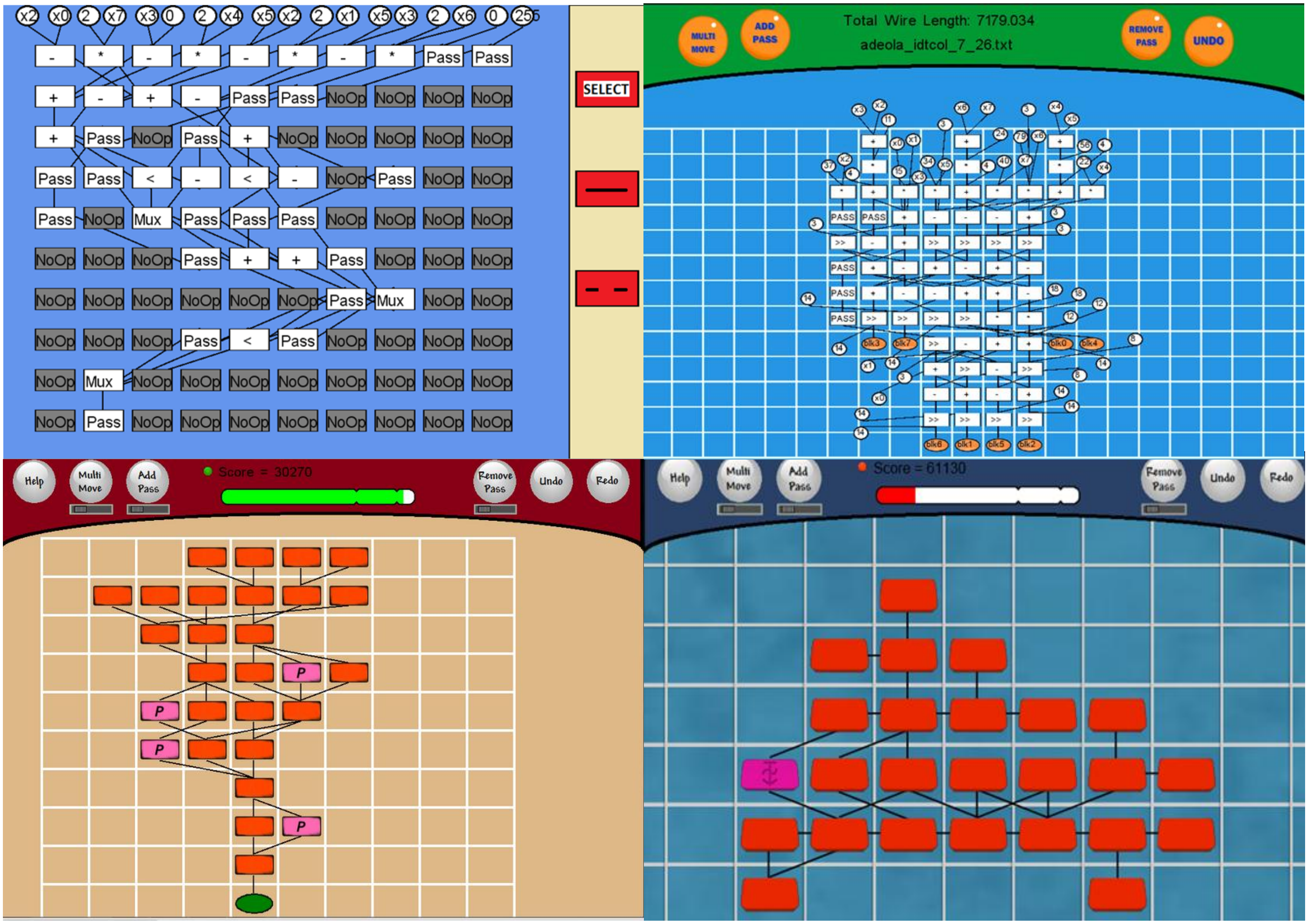
7. 

To conclude the sub levels is 8Way, which in my opinion, is supremely the greatest to play. It is a lot of fun because you have eight different ways to organize the nodes together. The main problem you worry about is just shortening connections to make your score higher.



4. Evolution

"Untangled" is still being improved today to help enhance the playing experience. Before I joined the team it had already went through four prototypes (pictures below going from left to right starting with prototype1).



It evolved from being just nodes and long connections with very poor graphics to an incredibly colorful, appealing game. I came in on prototype five and we worked vigorously to fix bugs and change the appearance of the game a little more. Within the first week we saw that some people would not or could not play the game because they did not comprehend the tutorials. Members of the research team worked very hard to create new tutorials after we looked over the feedback from players.

5. <u>Analyzing</u>

I worked with a team full of undergraduates and graduate students under the supervision of Dr. Mehta. Considering other research teams that were there, we were a nice size group of ten students. We were broken into teams of programmers, graphics, buggers, and analyst. I was chiefly an analyst for the game but also played a part in finding bugs. My job was to keep a book of records for the leader boards every day. I had to keep track of what players were in the top three and bottom three in some cases. Moreover, I examined their graphs to see if there was a common factor between them. Or why some graphs were better than other players on the leaderboard. I kept my records on spreadsheets in Microsoft Excel and made my graphs in Microsoft Word.

As I was comparing the graphs I did find out something interesting about the top three. I realized that their final graphs were similar to each other in terms of node placement and sizes. For example look at the spreadsheet below and check out 8Way-Easy 1 and 2. Do you see how relatively close the three graphs are in terms of score, pass gates, and size?

8Way Easy 1	Score	Size	Pass Gates
Velja73	78,560	5x5	0
Kpat	76,560	6x5	0
Npar	76,560	6x5	0
8Way Easy 2			
Kbur	41,100	5x6	0
Velja73	41,100	5x6	0
Npar	40,700	6x5	0
8Way Easy 3			
Velja73	26,250	6x5	0
Kpat	25,450	10x3	0
Npar	25,450	10x3	0
8 Way Medium 1			
Velja73	29,100	8x4	0
Aedwards	28,300	7x5	0
Npar	28,300	7x5	0
8 Way Medium 2			
Velja73	76,180	8x8	19
Kbur	65,380	10x9	21
Npar	39,520	N/A	N/A
8Way Hard1			
Velja73	95,020	11x7	14
Kbur	70,220	10x12	34
Brod	11,820	18x12	82
8 Way Hard 2			
Brod	162,540	N/A	N/A
Velja73	82,590	11x8	8
Kbur	66,190	12x9	31

During my weeks here I was also asked by Dr. Mehta to write up an analysis, for the week of June 29th. I was to investigate the difference of the top three players to the bottom three. The reason was so that we could understand how the last three players transformed their graph. I detected that their connections were longer in length and not being constraint to a 4:1 ratio.

6. Conclusion

In reality I enjoyed my time I spent in the DREU doing research. I got along well with my teammates and had fun in the process of learning. This program helped me to work better in a team environment. When Dr. Mehta and I first talked about the research we were going to be engaging in this summer I had no clue about the material. She first sent me a research paper explaining Coarse-Grained Re-configurable Architectures and I can honestly say I never heard of it. Once I told her about my situation she told me she would work with me and she did just that. I came out of Texas with a great deal of knowledge on working with algorithms. I also learned that I have a special skill in observation. I will unquestionably benefit from my keen eye sight in the long run

On my visit to the company "Stryker" I realized what it would take to become successful in my career field. Stryker employees maintain an informal work environment and even had a gym, pool table, and ping pong table. Though Stryker un-doubtfully was a down to earth company to work for, they were extremely serious when it came down to their work ethic. After seeing how the real life situation worked I now know what I want to do when I get my degree and have a career in technology.

References

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Lilian Bossuet, Guy Gogniat, Jean-Philippe Diguet, Jean-Luc Philippe

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