# Application of Greedy Algorithm to Solve Multiple Activities Selection Problem in RTS Game Warcraft III

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***Abstract – Entertainment world has a lot of categories. One of them is video games. Video games itself has many genres, like fighting, role-playing game, action, first-person shooter, real-time strategy, and many others. In this paper, author will explain about a game with fantasy real-time strategy genre, Warcraft III.***

## I. Introduction

Warcraft III is a fantasy real-time strategy game created by Blizzard Entertainment in 2002. In its era, Warcraft III stood with Starcraft as one of the most competitive game, showing up in most tournaments such as ESWC (Electronic Sports World Cup) and WCG (World Cyber Games). Those tournaments were using Warcraft III Melee Map, which means no mods/customs added to that map.

In the melee map mode, a player can choose over 4 races; they are Human, Orc, Undead, and Night Elf. The game itself starts with a main hall and some units to retrieve resources nearby. This is where the real thing begins, the thing called "micro skill". Micro skill is a player's capability to control multiple units at a time. If a player doesn't have a good micro skill, his/her units will be idle for most time.

Meanwhile, the greedy algorithm can solve an activity selection problem, where we are given a resource—such as meeting room—which is only capable of holding one activity at a time (we don't want to hold multiple meeting inside one meeting room) and we must choose as many as possible activities from a given data.

Finally, author merges the correlation between micro skill and the activity selection problem to form multiple activities selection problem. The main goal of this problem is to optimize multitasking, so we can make a lot of actions with the least time.

## II. Basic Theories

### 1. Greedy Algorithm

Greedy Algorithm is one of the most popular ways to solve optimizing problems, such as finding minimum or maximum value. Although it is popular, greedy algorithm doesn't always give optimum solution.

The greedy algorithm has five elements; they are set of candidates, set of solution, selection function, feasible

function, and objective function. In this paper, set of candidates is set of actions that represent all actions available for a player in order to obtain the optimum solution. Set of solutions is the "mini-force" consists of a hero and 3 basic infantries. Selection function will choose the activity with the most time usage from the set of candidates. Feasible function will validate the mini-force count (not less, not more, exactly one hero and 3 basic infantries). Objective function will determine there is a system idle time or not.

## 2. Activity Selection Problem

Activity Selection Problem is a problem where a resource is only capable of holding one activity at a time, such as meeting room. The solution of this problem is a set of activities that has the most activities. Below is a picture showing the solution of an activity selection problem.

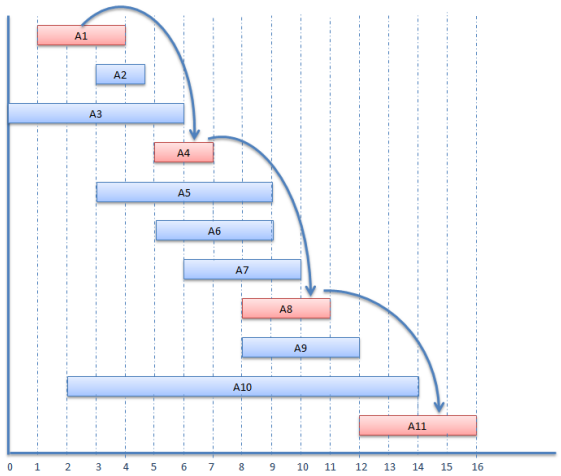


**Figure 1. Activity Selection Problem Solution**

## 3. Micro Skill

Micro skill is the ability to control multiple units at a time. Players with good micro skill won't have difficulties in controlling multiple units, even if each of those units has unique abilities.

## 4. Multiple Activities Selection Problem

Multiple activities selection is the merge result of micro skill and activity selection problem. While activity selection problem only takes a snapshot of a unit, the multiple activities selection problem takes a snapshot of multiple units. The concept is same, but there is one important key for this problem. There should not be a system idle time, because if there is a system idle time, it means more time usage. Here's an example of a good and average MASP solution:

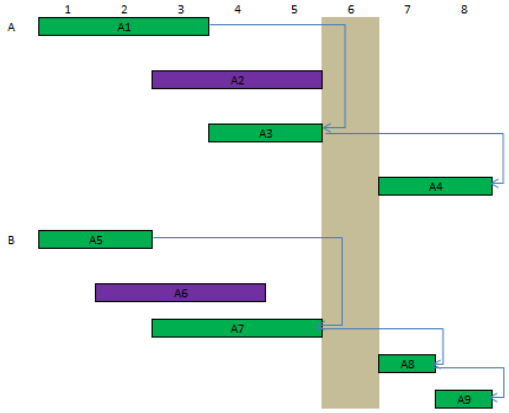


**Figure 2. MASP with idle time**

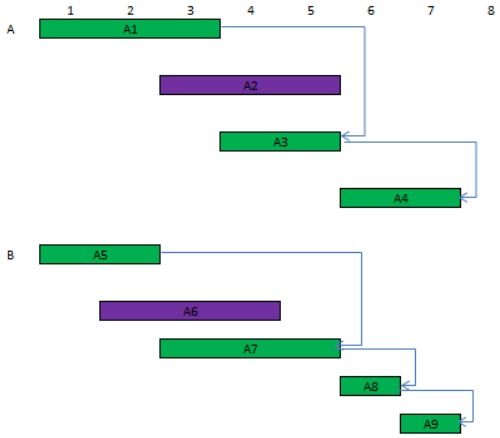


**Figure 3. MASP without idle time (compressed)**

If we look closer, Figure 3 takes 1 less unit of time than Figure 2. Although they both are a solution of an activity selection problem, but in MASP a set of activities is seen as a system. In Figure 2, the latest work is A8 from activity B at t = 8, meanwhile in Figure 3, it is finished at t = 7.

This is why author picked the MASP as a representation of playing a RTS game, because a player simply wants to do everything quickly and efficiently. If we only use the normal algorithm without compression like Figure 2, the player will waste one unit of time.

## 5. Warcraft III Melee Initialization


**Figure 4. Melee map initialization for human race**

The game starts with a main hall and 5 starting units. Except for an Undead player, he/she will be given a main hall, 3 starting units, and 1 basic infantry (Ghoul) since Undead can't gather trees with their starting unit (Acolyte), but with Ghoul instead. Every starting unit can build structures, but in this paper, author will only explain about 3 Human structures consists of Farm, Barracks, and Altar of Kings. Farm is used to provide food. Food is used to "provide living for a unit" at a time. Each farm provides additional 6 foods, and Human Town Hall provides 12 foods. Barracks is used to train infantries such as Footman, Rifleman, and Knight. Footman is Human basic infantry. Each Footman uses 2 foods. Altar of Kings is a structure to create Heroes. Each hero uses 5 foods. Below is a build time table and a unit train table:

| Building Name | Build Time (s) | Gold, Lumber |
|---|---|---|
| Farm | 35 | (80,20) |
| Barracks | 60 | (160,60) |
| Altar of Kings | 60 | (180,50) |

**Figure 5. Build time table**

| Unit Name | Train Time (s) | Gold, Lumber |
|---|---|---|
| Peasant | 15 | (75,0) |
| Footman | 20 | (135,0) |
| Any Hero | 55 | 1st hero free |

**Figure 6. Train time table**

## 6. Neglected Conditions

For easier understandings, author assumes these things:

- Neglect unit movements, so we assumes that when a peasant is ordered to build something, he instantly teleports to the building location and builds it right away
- Neglect any bug that might cause miscalculation during the process
- Neglect Z-axis position gold mine relative to Town Hall which causes lowering movement speed of gold-gathering Peasants, so this means all gold mine's position will be X-axis or Y-axis relative to Town Hall (like Figure 4)
- N Peasants gathering the gold mine = 10 gold each 5/N seconds

- N Peasants gathering the lumber = 10 lumber each 10 seconds

**7. Other Important Warcraft III Mechanics**

- A building can only train one unit a time, the rest is on waiting state. After the first unit's training is complete, the rest will follow
- We can't continue unit production if we have no foods

## III. Implementation

### 1. Greedy Approach

First, determine set of solutions which is one Hero and 3 Footmen. Selection function will select from the system, which building/unit has the most build/train time, which is Altar, Hero and Barracks. So, these 3 priorities are above everything. Unfortunately, we can't train a Hero without Altar, so we have to build the Altar first, then the Hero. Feasible function is the mini-force validation and the objective function is to ensure there is no system idle time.

Let's start with the game initialization. Human race has a Town Hall and 5 Peasants. Starting gold is 500 and starting lumber is 150. From Figure 5 and Figure 6 we know that Farm has less build time than Barracks and Altar of Kings. According to Activity Selection Problem, we will prefer to build Altar of Kings OR Barracks first than Farm, because in the end Farm will be the first to finish. This is the selection function.

Now let's do the math. If we build Altar of Kings and Barracks first (following the greedy algorithm steps), then we will use 340 gold and 110 lumber. Ideally, we will want to train 2 more Peasants to gather the gold mine. So the remainder of our resource is 10 gold and 40 lumbers. Using the gold income formula, 5/3 equals to 10 gold every 1.33 seconds. Don't forget we now have 7/12 food limit, so if we create a hero, we can't create a Footman, and vice versa. We have to create at least one Farm to continue the unit production. To earn 70 gold, we have to wait 1.66 * 7 = 11.21 seconds to build Farm. Then from t = 11.21s (where we order the Peasant to build Farm) until t = 15s, we earn additional 3.79 seconds / 2.5 * 10 = ~10 gold. After t > 15s, we earn 10 gold every 1.66 seconds. After t > 30s, we earn 10 gold every 1.25 seconds. So, using the gold formula, we earn more 15/1.66 * 10 = 90 at t = 30s and we train 1 another Peasant to increase gold income. At this point, we have 25 gold. Considering Farm will be completed at t = 44.31s, the Peasant who built the Farm can continue gathering lumber. Right after Farm completion, a Peasant is ready to gather gold mine at t = 45s. At this point, we add another 90 gold from gold formula. At t = 60s we have completed the building of Altar and Barracks, we have a grand total of 265 gold and 40

lumbers at t = 60s. This means we can only create 1 Footman first. Then we build a new Farm, because we will have a total of 19 foods (5 hero, 6 footmen, and 8 peasants) and if we don't build it, the food will stuck at 17 (limit 18). Now, we only have 50 gold and 20 lumbers. As the time flies, we will train 2 more Footmen to complete the mini-force and met the requirement of feasible function. Finally, at t = 120s, third Footman has been trained as we gain another 300 gold and 80 lumbers, minus 270 gold to train Footmen. Now, we have finished the mini-force at t = 120s with spare 80 gold and 160 lumbers.

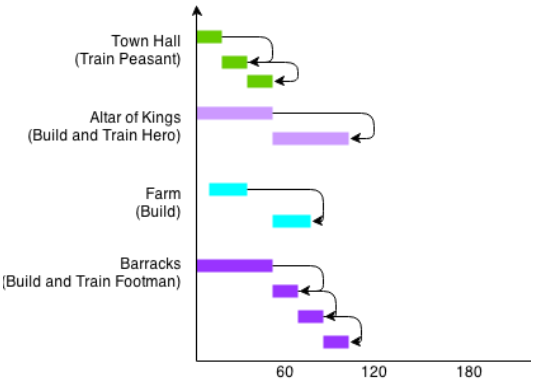


**Figure 7. MASP solution for greedy approach**

Figure 7 is the solution with greedy approach. There is no system idle time, so the objective function requirement has been met.

## 2. Normal Player Approach

Normal player will want to balance between resource and forces. So, instead of building Barracks and Altar at the same time, we now try to build Altar and Farm first. The rest 3 idle Peasants are ordered to gather gold from nearby gold mine. Then we will order Town Hall to train 2 Peasants (just like before), leaving us 90 gold and 80 lumbers. Unlike greedy, this approach tends to wait the training of first Peasant before building a Barracks. So before the first Peasant completes its training, we get 10 gold per 5/3 = 1.66s for 15 seconds which means we get 15/1.66 * 10 = 90 gold. Having 180 gold and 80 lumbers in pocket, we order that Peasant to build Barracks which costs us 160 gold and 60 lumbers. Now we have 20 gold, 20 lumbers, and 3 Peasants gathering the gold mine at t = 15s.

Until t = 30s, we earn 5/3 = 1.66s for 15 seconds (until the next Peasant appears from the Town Hall) which gives us an additional 15/1.66 * 10 = 90 gold. Then, the Peasant training has been finished and we quickly send him to gather the gold mine as we start to train another Peasant for the fifth gatherer. Five seconds later—at t = 35s – the Farm building will be completed. Then the Peasant who built the Farm, we will order it to gather lumber. At t = 45s, we will gain another 15/1.25 * 10 = 120 gold. Fifteen seconds later, we got another 150 gold. At t = 60s and t = 75s, after Altar and Barracks construction have been finished, respectively, the Peasant who created these buildings will gather lumbers. At this time, we have 315 (20+ 90 +

120 + 150 - 75) gold and 40 (20 + 20) lumber. Then we will build a Farm from a lumber-gathering Peasant to increase unit production limit and one Footman which costs us 215 gold and 20 lumbers. With current condition (5 Peasants gathering the gold mine), there should be no problem on gold income. We will get 600 gold from (20 * 3 * 10) Footman train time minus 270-- the cost to train them during that one minute-- and 140 (2*60 + 1*20) lumbers. So in the end, at t = 135, we got the mini-force, 430 gold, and 160 lumbers.

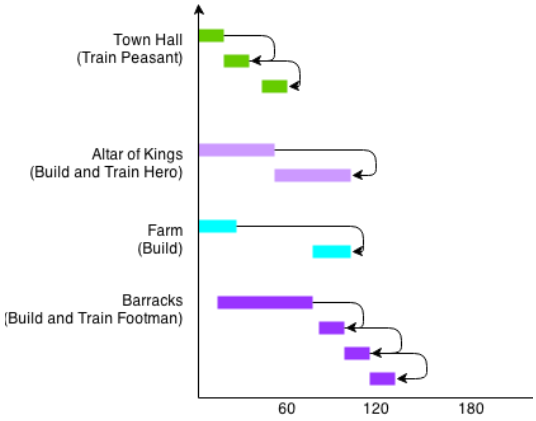


**Figure 8. MASP for Player Approach**

## 3. Comparison between Both Approaches

From these theory-crafting, we can see that greedy approach might finish faster (cost less time), but less resource than player approach. Even if we add another 15 seconds for the greedy approach to make it equal 135 seconds, player approach is still way ahead of resource (430 gold vs 230 gold).

Both solutions have met MASP criteria with no system time idle.

## IV. Conclusion

Greedy approach is effective to optimize time while player approach is effective to optimize resource in Warcraft III RTS game.

## V. References

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[2] Slide kuliah Algoritma Greedy IF2211 – Strategi Algoritma

[3]http://classic.battle.net/war3/human/units/footman.shtml - accessed on May 16th, 2014

[4]http://classic.battle.net/war3/human/units/peasant.shtml - accessed on May 16th, 2014

[5] Warcraft III World Editor

PERNYATAAN

Dengan ini saya menyatakan bahwa makalah yang saya tulis ini adalah tulisan saya sendiri, bukan saduran, atau terjemahan dari makalah orang lain, dan bukan plagiasi.

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