

CS270: LAB #9

Game of Thrones: SAT Solver

Unlike most labs, for this one please work in groups of three people (2 or 4 if there's not a multiple of 3 in class). Unless stated otherwise, the lab is due to be submitted into Gradescope at the end of the day.

In order to receive credit, follow these instructions:

[a] Every team member should be discussing simultaneously the same problem – do NOT try to divvy up the labor and assign different problems to different students since the material is cumulative.

[b] Directly edit this lab PDF using Sedja/PDFescape with your answers (extra pages can be added in the rare event you need more than the allotted space)

[c] Each lab, rotate which member has the responsibility of being the Scribe. This is the person that is typing the answers and uploading the final PDF – note that only a single copy of the filled in PDF is turned into Gradescope. Only one lab needs to be submitted for the entire team, and all members receive the same score. Make sure to use a font that your PDF editor is compatible with (otherwise you might find your answers appear as weird shapes/sizes or simply disappear entirely!)

[d] The Gradescope submission must have each answer properly tagged with the appropriate question. Moreover, every member of the team must be listed as a submitter. Although it is the Scribe which executes these actions, it is still the responsibility of the entire team to make certain this is done properly (thus it is highly recommended that the Scribe share their screen so the entire team can witness it). Answers which are improperly tagged cannot be seen by the grader and thus cannot be scored.

[e] **FOR REMOTE ONLY:** Each lab, rotate which member has the responsibility of being the Recorder. This is the person who hits the Zoom Record button (once the technical permission is granted by the TA/RCF/Professor) and ensures that everyone has their camera/microphone on. They are also the member that is responsible to make sure the DrexelStream video is marked as viewable and entered into the <https://tinyurl.com/VidLinkForm> webform before 11:59pm (they should also email the rest of their team as confirmation.) Note that the video file doesn't get created/processed until after the Recorder has quit Zoom.

[f] Each lab, rotate which member has the responsibility of being the Manager. This is the person that ensures that everyone is participating equally and honestly, keeps the group on task, ensures that all team members understand a solution before going on to the next question, and presses the “hand up” button in Zoom to summon a TA or the professor (but they only do so after surveying the group to make sure everyone has the same question).

Team Name (CS pioneer): Tim Berners-Lee

Scribe name: Brendan Hoag

Recorder name: Cole Bardin

Manager name: Jackson Masterson

Other team member (if any): Jeremy Mathews

Each of five people (Renly Baratheon, Yara Greyjoy, Tyrion Lannister, Eddard Stark, and Dani Targaryen) has exactly one unique family mascot (Dragon, Kraken, Lion, Stag, Wolf... but not necessarily in that order) and has had a unique number of friends die (zero, one, two, three, and four... but not necessarily in that order).

Your goal is to use the SAT solver [linked in the lefthand side bbLearn nav panel](#) to identify the pet and the number of dead friends for each person. In order to successfully solve the puzzle, each team will have to share information with the others. You will find your team's clue in your team's tab in the shared spreadsheet: <https://tinyurl.com/Lab9GoT> (make sure you are in the **correct clue tab!**) There are four of each type of clue: Hard, Medium, and Easy.

Your team should read your clue(s) and then translate it into DIMACS. Hard clues have multiple clauses (but at most 5), where each clause has multiple variables (at most six) and will have a mix of positives and negatives. Medium clues might have negs/positives but not mixed, and no clause will have more than two vars. Easy clues can be done with a single clause. Most teams will start with one clue, but depending on the number of students present, your team might get two clues (although definitely not both hard!). When done, view spreadsheet and assist other teams with their clues. It is wise to have a second pair of eyes double checking the DIMACS work of other teams since if they have a wrong computation it will mess up your answers too! To ensure consistency among the groups, we will all use the following labeling convention for the variables:

Designate each feature as 0 to 4 (in the order listed in the first paragraph), and set

$$\text{Number} = 25 * \text{Family} + 5 * \text{Pet mascot} + \text{Deaths}$$

As an example, the proposition "Tyrion Lannister's pet is a Kraken and he had three friends die" would be the variable numbered as $25*2 + 5*1 + 3 = 58$

Remember that that since DIMACS uses 0 as the end-of-clause token, we'll need to reset the variable "Renly Baratheon has a pet Dragon and had no friends die" to be 125 instead of 0.

Q0 [0 pts]: for practice, just to make sure your Team understands the encoding, what would be the variable number for "Stark's pet is a Dragon and he had two friends die"? What proposition corresponds to the number 73? Please verify your answers here with the TA/Prof before moving on.

$$25*3+5*0+2 = 77$$

Tyrion Lannister's pet is a Wolf and he had three friends die

Q1 [10 pts]: Write your clue as a logic expression:

$$\begin{aligned} \text{Easy1} &= (\text{BL2} \wedge \text{GL2} \wedge \text{LL2} \wedge \text{SL2} \wedge \text{TL2}) \\ \text{Hard12} &= (\text{GD4} \vee \text{GK4} \vee \text{GL4} \vee \text{GS4} \vee \text{GW4}) \Rightarrow (\text{LD3} \vee \text{LK3} \vee \text{LL3} \vee \text{LS3} \vee \text{LW3}) \end{aligned}$$

Q2 [10 pts]: Convert that logic expression into CNF:

$$\text{Easy1} = (\text{BL2} \wedge \text{GL2} \wedge \text{LL2} \wedge \text{SL2} \wedge \text{TL2})$$

$$\begin{aligned} \text{Hard12} = & (\neg \text{GD4} \vee \text{LD3} \vee \text{LK3} \vee \text{LL3} \vee \text{LS3} \vee \text{LW3}) \wedge \\ & (\neg \text{GK4} \vee \text{LD3} \vee \text{LK3} \vee \text{LL3} \vee \text{LS3} \vee \text{LW3}) \wedge \\ & (\neg \text{GL4} \vee \text{LD3} \vee \text{LK3} \vee \text{LL3} \vee \text{LS3} \vee \text{LW3}) \wedge \\ & (\neg \text{GS4} \vee \text{LD3} \vee \text{LK3} \vee \text{LL3} \vee \text{LS3} \vee \text{LW3}) \wedge \\ & (\neg \text{GW4} \vee \text{LD3} \vee \text{LK3} \vee \text{LL3} \vee \text{LS3} \vee \text{LW3}) \end{aligned}$$

Q3 [30 pts]: Convert that CNF into DIMACS and enter each line in its own cell on the spreadsheet
For grading purposes, write your answer here:

$$\text{Easy1} = 12 \ 37 \ 62 \ 87 \ 112 \ 0$$

$$\begin{aligned} \text{Hard12} & \\ -29 \ 53 \ 58 \ 63 \ 68 \ 73 \ 0 & \\ -34 \ 53 \ 58 \ 63 \ 68 \ 73 \ 0 & \\ -39 \ 53 \ 58 \ 63 \ 68 \ 73 \ 0 & \\ -44 \ 53 \ 58 \ 63 \ 68 \ 73 \ 0 & \\ -49 \ 53 \ 58 \ 63 \ 68 \ 73 \ 0 & \end{aligned}$$

Q4 [20 pts]: Enter the DIMACS for all the clues into the SAT solver. What does it say the answer is? Does that answer satisfy all the clues? Why is it going wrong?

The answer is 12, 55, 65, 104. This does not satisfy all the clues because there aren't 5 answers.

Q5 [20 pts] : Ask the professor for the “secret file” that resolves the issue. NOW what does it say the answer is? Show that answer satisfies all twelve clues.

$$23 \ 37 \ 66 \ 80 \ 104$$

Q6 [10 pts]: Is there any other possible scenario that also satisfies all twelve clues? If so, give it. If not, how do you know there isn't?

There is no other solution that satisfies all clues. We know this because we took the correct output and negated it to see if there was another possible output and it said unsatisfiable.