A Simple Guide to
GMCR+

by Rami Kinsara

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This document is intended as a short and simple guide to using GMCR+. Although GMCR+ was built to be intuitive and user-friendly, this guide aims at maximizing the benefits from this advanced decision support system. The approach in designing this guide is to be succinct by maximizing illustrations and avoiding unnecessary details. Since Microsoft Windows® is the most common operating system, it will be used for explanation purposes. However, the illustrations shown can be navigated on other operating systems as well.

1 Installation

You can download GMCR+ from its official website. Simply navigate to the URL: `http://www.gmcrplus.com` and click *Download* on the main page. After downloading the installation package, simply double click the installation file. You will face a typical installation welcome screen where you can modify the default installation path. Clicking next will install GMCR+ and you are all done.
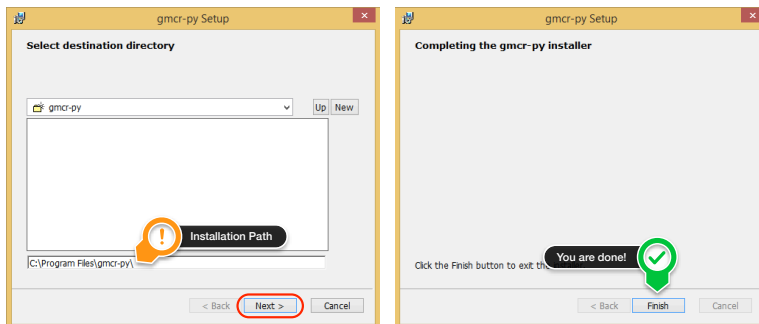

Figure 1: Installation Wizard Windows. *Notice that this process requires only two simple clicks*

After installation is completed, you will find a shortcut icon on your desktop as shown in Figure 2.
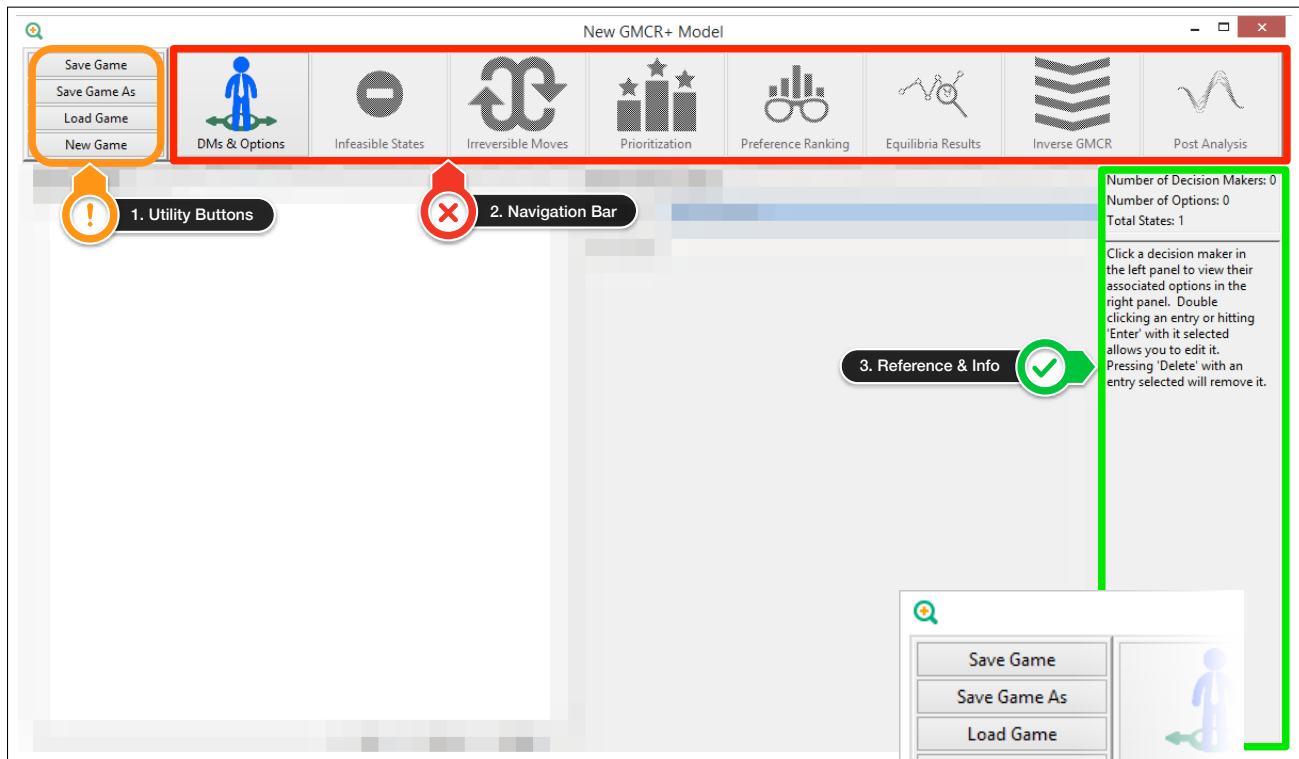

Figure 2: You will find a link to GMCR+ on your desktop

2 Starting GMCR+ *and the Main Screen*

Double clicking the GMCR+ icon (Figure 2) will start GMCR+ and a new conflict model is loaded as shown in Figure 3.

Figure 3: Main GMCR+ Screen.

The main screen is divided into four main areas. At the top left of the screen, the user can find standard utility buttons to load, save, and create new conflict models (Figure 4). The top of the screen contains a large navigation bar (Figure 5). This bar displays each of the logical steps in the modeling of a conflict, and allows the user to easily move between them. The active stage button is colored while the other buttons are dimmed.

Figure 4: Standard Utility Buttons.

Figure 5: Main Navigation Bar. *Notice that each modeling step is referred to as button in the main navigation bar*

Along the right edge of the screen, a column provides a quick reference about how to use the interface for the current stage of the modeling process (Figure 6). The remainder of the screen is used to display and edit information related to the active stage of the modeling process.

Figure 6: Quick Reference and Info Area.

3   Modeling Conflicts with GMCR+

For the sake of making this guide practical, an actual conflict will be analyzed in the process of explaining the functions of GMCR+. The conflict that took place in 1975 between Syria and Iraq over the Euphrates River will be analyzed. For a detailed historical background and analysis for this conflict and other related conflicts along the Euphrates, please refer to the work done by Hipel et al. [2].

[2] Keith W Hipel, D Marc Kilgour, and Rami A Kinsara. Strategic investigations of water conflicts in the middle east. *Group Decision and Negotiation*, 23(3): 355–376, 2014

3.1   Inputting DMs and Options

Make sure you are located in the *DMs & Options* screen by clicking on its button (Figure 7). The DMs and options for the Syria-Iraq conflict are given in Table 1.

DM	Option		Description
Syria	1. Release Water	**Y**	Syria agrees to halt the filling of Thawra Dam and let the Euphrates flow into Iraq
		N	Syria continues to fill its dam
	2. Escalate	**Y**	This could be done by cutting relations with Iraq, sending troops to the shared border, closing the air space to Iraqi aircraft, or any combination of these actions
		N	Syria does not undertake any of the escalating options
Iraq	3. Attack	**Y**	This includes bombing of the dam and going to war with Syria
		N	Iraq does not act and accepts the situation

Table 1: DMs, options and descriptions for the Syria-Iraq conflict. *For when an option is taken (Y for yes) or not selected (N for no)*


Figure 7: DMs & Options Button.

Start adding Syria as a DM by double clicking on *"Double Click to Add an Item"* at the left of the screen (Figure 8a). Once you double click, the middle screen becomes active and you can type the DM's name (Figure 8b). *New Option* button allows you to add options to the active DM. As you can see, the two options of Release Water and Escalate for Syria have been added. Do the same for DM Iraq.
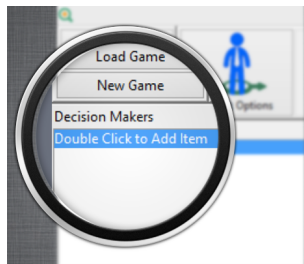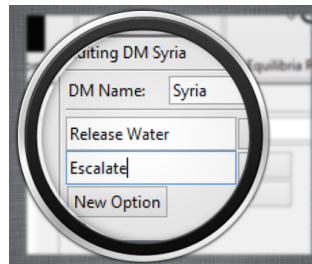
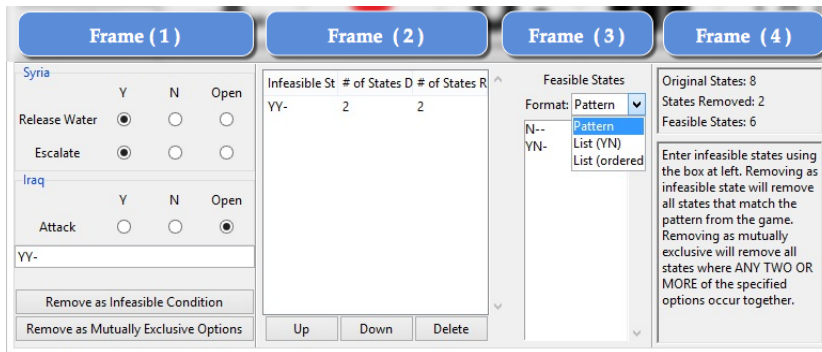(a)   (b)

Figure 8: (a) Adding DMs. (b) Editing DM's Name and Adding Options.

After inputting all DMs and options, you can see the full list of DMs in the conflict to the left of the screen. Clicking on a DM's name

will select it and display the DM's associated options in a list to the right. While a DM or option is selected, it can be deleted, or its name can be modified. Buttons at the bottom of the screen allow the order of DMs to be changed or a DM deleted (Figure 9). The information panel at the right edge of the screen displays the number of DMs already defined, the options, and the total number of states that would be in the game if no infeasible states were removed.

3.2   Removing Infeasible States

After defining DMs and options, GMCR+ will generate a list of all possible states. There are usually infeasible states that must be removed from the conflict model. In order to do that, navigate to the *Infeasible States* screen (Figure 10).

Figure 9: Buttons for Arranging and Deleting DMs.

Figure 10: Infeasible States Button.

Figure 11: Infeasible States Removal Screen.

The panel to the left (Frame 1 in Figure 11) contains a set of toggle buttons where option selections can be made to specify an infeasible condition. Clicking *"Remove as Infeasible Condition"* will remove all states satisfying this condition from the conflict model and display the infeasible condition along with the number of removed states in the middle of the screen (Frame 2 in Figure 11). Clicking *"Remove as Mutually Exclusive Options"* generates a list of conditions prohibiting any states where two or more of the chosen option selections are taken. In the Syria-Iraq conflict, there is one infeasible situation in which Syria both releases the water and escalates the situation at the same time (mutually exclusive options). Inputting this pattern generates two infeasible conditions as shown in Figure 11. The remaining feasible states can be viewed in different formats as illustrated in Frame 3 of Figure 11. The set of feasible states can be displayed either as a list of feasible conditions, as a full list of feasible states in YN format, or as ordered and decimal state numbers. Finally, Frame 4 of Figure 11 is an informational panel displaying the original number of states in the conflict, the number of states removed, and the number
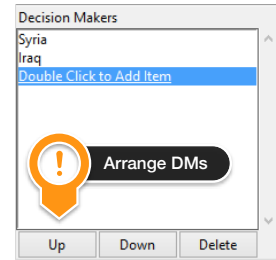
of feasible states remaining. Below is a brief set of instructions for using the *Infeasible States* screen.

3.3   Specifying Irreversible Moves

In order to specify the reversibility of options, navigate to the *Irreversible Moves* screen (Figure 12).

By default, all options in the conflict are displayed with a two-headed arrow pointing between 'Y' and 'N' denoting that all moves are reversible (Figure 13). Clicking the arrow toggles the direction of reversibility. This way, the user or analyst can leave the option as reversible, or define the direction of irreversibility. For the case of Syria-Iraq conflict, all moves are assumed to be reversible.

3.4   Inputting Preferences Using Option Prioritization

Preferences for DMs can be specified through preferred conditions or through direct ranking of states. The preferred conditions method allows you to define preference prioritization conditions to make the ranking of states easier and more intuitive. Direct ranking, on the other hand, allows you to fine tune the results from prioritization or assumes that you are certain about the ranking of states for each DM. In order to input preferences using prioritization, navigate to the *Prioritization* screen (Figure 14).

Figure 12: Irreversible Moves Button.

Figure 13: Irreversible Moves Screen.

DM	P#	Preference Information (From most to least important)	Further Explanation
Syria	1	Remain at the status quo	Syria continues filling its dam and Iraq accepts the situation without any escalation or intervention
	2	Escalate the situation if Iraq decides to attack	Syria next prefers going to war with Iraq if it is attacked, which is more preferred than releasing water
Iraq	1	Syria releases more flow of the Euphrates River	Iraq most prefers the situation in which Syria stops filling its dam without any escalation
	2	Execute an attack if Syria does not release more water	Iraq's interest in water far outweighs the consequence of going to war

Table 2: Preference Prioritization Information for the Syria-Iraq Conflict.

The panel to the left of the *Prioritization* screen contains all DMs and their corresponding preference rankings as shown in Frame 1 of Figure 15 is a table with all . Clicking *Edit* next to any DM will change its color to green and allow the preferences for that DM to be modified. A user can click *"Done"* to clear the DM selection. Frame 2 of Figure 15 includes toggle buttons for all DMs and their options. In order to add a preferred condition, simply make option selections (current toggle selection is shown in 'YN' format at the bottom bar *Balloon A* of Frame 2). Then, you can either add them directly as a preferred condition (Frame 4) or move them to a staging area (Frame 3) where multiple conditions can be added together with

Figure 14: Prioritization Button.

Figure 15: Prioritization Screen.

equal weight. Moreover, you can add conditions using logical state-
ments via the input bar at the bottom of Frame 2 as shown in Balloon
B. *IF* and *IFF* logical statements are allowed to speed the preferences
input process. Simply type *if* or *iff* between the option numbers (pos-
itive for Y) and (negative for N), see below.

Table 2 presents the preference prioritization information for each
DM in the Syria-Iraq conflict. The first preference statement for Syria
is to remain at the status quo. Therefore, you should choose 'N'
across all options to indicate the status quo, then you simply click
"Add as Preferred State". The second statement for Syria is to *Escalate*
if DM Iraq *Attack*s. This information is entered using the logical
statement input bar by typing "2 if 3" then you can add it directly
as a preferred state. Suppose the statement was *Don't release water
if Iraq attacks*, then the logical statement would be "-1 if 3" and so
on. If the syntax entered is invalid, you will receive an error message
next to the input bar.

Frame 4 of Figure 15 displays the preferred conditions for the
selected DM and the weights associated with those conditions. Frame
5 displays a prompt ensuring preferences are valid and below that is
a quick reference guide for using the *Prioritization* screen. Finally, a
large table displaying the conflict in option form occupies the bottom
of the screen as shown in Frame 6 of Figure 15. A pink indicator

follows the mouse to highlight the selected row and column. The states are ordered according to their ranking for the active DM. The table also displays the ordinal payoff value of each state according to the active DM. If no DM is selected, the states are ordered based on state number and payoff values for all DMs will be shown.

3.5 *Inputting Preferences Using Preference Ranking*

In order to fine tune or input preferences information directly, navigate to the *Preference Ranking* screen (Figure 16). At the top of Frame 1 in Figure 17 is a large button entitled *"Press to enable manual preference ranking changes"* which allows you to enable the screen when clicked. Then you can start modifying the preference rankings shown for the DMs in the fields below (Balloon (B) of Frame 1 in Figure 17). States are listed using their ordered numbers, and equally preferred states can be indicated by enclosing them in square brackets. In the middle of the screen (Balloon C of Frame 1), a large text box displays feedback on the validity of the entered preference rankings. Each preference ranking must contain each state once and only once to be considered valid. At the bottom of the screen (Balloon D of Frame 1), an option form table for the conflict is shown, similar to that on the *Preference Prioritization* screen. If you wish to revert to the preferences of the *Preference Prioritization* screen, you can return to the *Preference Prioritization* screen and click the large button that appears at the top of the screen.

Figure 16: Preference Ranking Button.

Figure 17: Preference Ranking Screen.

DM	States					
Syria	**1**	**3**	**6**	**2**	**4**	**5**
Iraq	**2**	**4**	**6**	**1**	**5**	**3**
	Most Preferred				*Least Preferred*	

Table 3: Ranking of States for the DMs in the Syria-Iraq Conflict.

Table 3 presents the ranking of states for the Syria-Iraq conflict from most to least preferred for both DMs. This information can be easily entered into the input bars corresponding to each DM. For Syria enter [1, 3, 6, 2, 4, 5] and for Iraq enter [2, 4, 6, 1, 5, 3].

At this point, make sure you have saved the conflict model using the standard save button (Figure 4). Now that you have a graph model, we will guide you through the analysis functionality of GMCR+ in the next section.

4   Analyzing Conflicts with GMCR+

In this section, the different analyses and output representation capabilities of GMCR+ are illustrated.

4.1   Equilibria Results and Visualizer

In order to display equilibria results, navigate to the *Equilibria Results* screen (Figure 18). The top of Frame 1 in Figure 19 shows the option form table for the conflict. Below that you can see equilibria calculation results for all states and solution concepts. You can filter the results, which is handy in large conflicts, using the toggle buttons (Balloon B of Frame 1). Results can also be ordered according to each DM's preferences. You examine the equilibria for coalitions by merging possible coalitions in square brackets in the bar to the top of the screen (Balloon A of Frame 1). Frame 2 of Figure 19 is the narration panel, which allows you to check for individual stability by selecting a DM, state, and solution concept; then the process used to determine that individual stability or instability is explained. At the bottom of Frame 1 (Balloon C), the option to launch a visualizer will draw the graphs in a separate screen.

Notice that Figure 19 shows equilibria results for the Syria-Iraq conflict and the results are sorted according to Syria's preferences. Click on *"Launch Visualizer"* to launch a web application within the GMCR+ system allowing you to see the actual graph of the conflict model as shown in Figure 20. The default view is a status quo analysis tree diagram. The top of the tree denotes the status quo and the
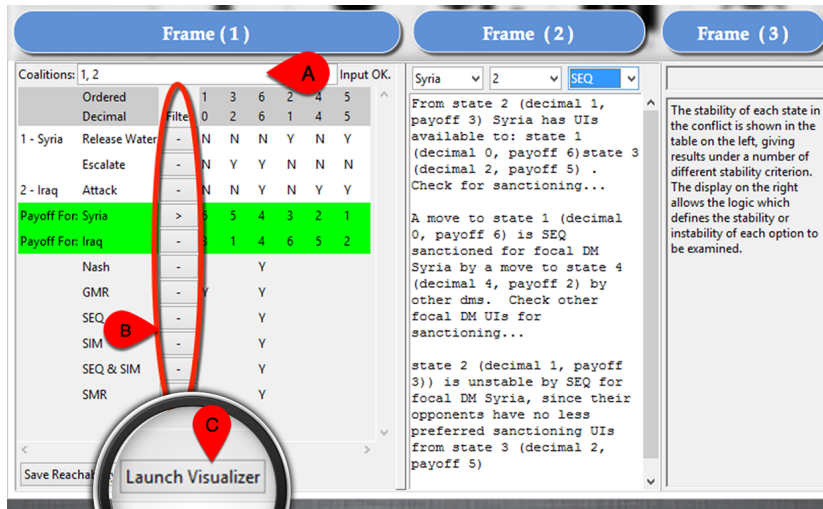

Figure 18: Equilibria Results Button.

Figure 19: Equilibria Results Screen. *Note that **Nash** stands for Nash stability, **GMR** for general metarationality, **SMR** for symmetric metarationality, and **SEQ** for sequential stability. Simultaneous stability (**SIM**) examines the strategic impact of two or more DMs moving together at the same time from a given state*
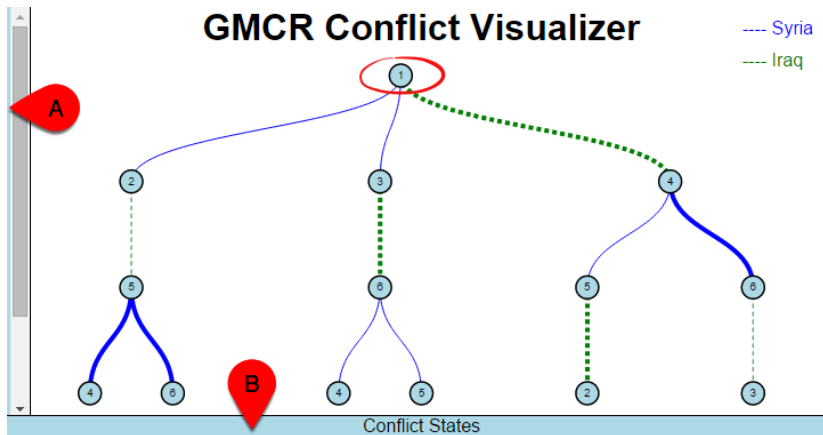

Figure 20: Default Visualizer Screen. *Notice that it is the tree diagram*

branches are the possible unilateral moves from that state by each DM. Lines are color- and dash-coded for each DM. Hovering the mouse on any state shades all circles with that state within the tree. Hovering the mouse at the bottom of the screen (Balloon B of Figure 20) displays an option form table for the conflict model. Hovering the mouse to the left of the screen (Balloon A of Figure 20) shows the display options panel as shown in Figure 21. This panel allows you to change the display method between a tree and a graph diagram (See A in Figure 21). Switching to the graph diagram mode will show the actual graph model for the conflict at hand as shown in Figure 22. In the *Display Options* panel, Differentiating or showing UIs only can be achieved from the *Display Configuration* area as shown in Balloons B and C of Figure 21. Other configurations include adjusting the tree depth and the shape of connections in the graph diagram. The op-

tions shown in the area of Balloon D in Figure 21 allow you to select a specific DM(s) to see individual graphs instead of integrated ones.
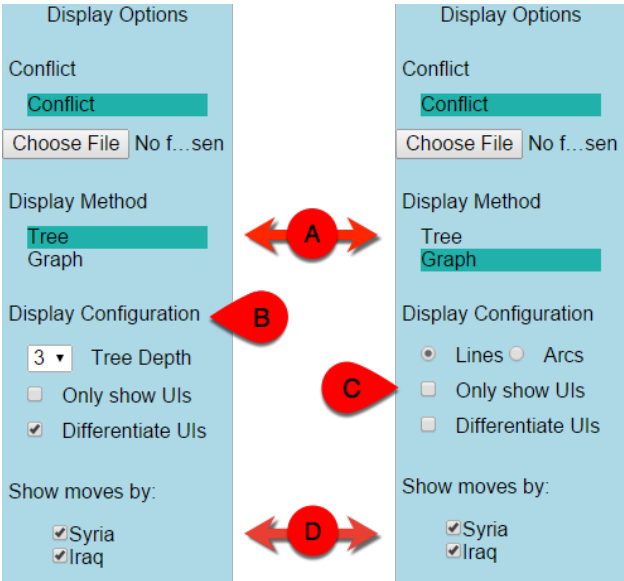

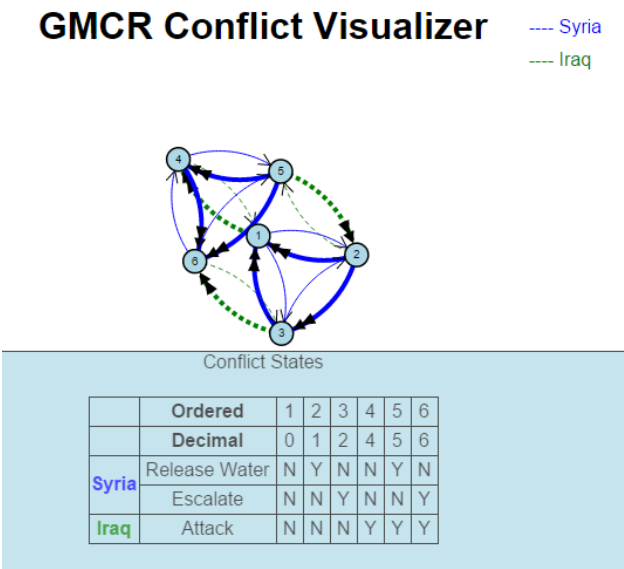Figure 21: Display Options Panel for Tree and Graph Diagrams

Figure 22: Conflict Model Graph Diagram

4.2 Inverse GMCR

In order to perform Inverse GMCR analysis, navigate to the *Inverse GMCR* screen (Figure 23). Frame 1 of Figure 24 contains the control panel. This control panel allows you to specify a desired equilibrium state (Balloon A). Furthermore, you can select a preference variance range for each DM and then perform the Inverse GMCR calculations

Figure 23: Inverse GMCR Button.

(Balloon B). Frame 2 explains the conditions required to achieve the desired stability according to each solution concept. Long form results can be displayed on the bottom of Frame 2 by selecting to display all permutations in the control panel (Balloon C) and can be filtered by the solution concepts check boxes (Balloon D). This is a useful addition allowing you to perform extensive sensitivity analysis on preferences.

Figure 24: Inverse GMCR Screen.

For the Syria-Iraq conflict, a more desired resolution would be state 2 in which both Syria and Iraq stop escalating and water is released to Iraq. Choose state 2 as a desired equilibrium, make sure you specify the variation range for Syria then click on *"Perform Inverse Calculations"*. You will see that 240 and 420 possible preference profiles can achieve the desired resolution according to Nash and SEQ solution concepts, respectively. In Frame 2 of Figure 24, you can see the explanation as follows:

1. **Nash Stability:** if and only if Syria prefers state 2 to states 1 and 3.

2. **Sequential Stability:** if and only if Syria prefers state 2 to states 1 and 3. *OR*

   (a) if Iraq prefers state 4 to state 1, then Syria must have state 4 less preferred than 2.

   (b) or if Iraq prefers state 6 to state 3, then Syria must have state 6 less preferred than 2.

4.3   Post Analysis

To carry out more advanced post analysis functions, navigate to the *Post Analysis* screen (Figure 25). In this screen you can specify coali-
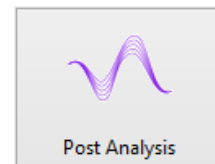

Figure 25: Post Analysis Button.

tions within the control panel (Balloon A in Frame 1 of Figure 26) similar to the way illustrated in the *Equilibria Results* screen mentioned in Section 4.1. In addition, you can choose a specific state to act as a status quo for the conflict and carry out the analysis from it. Frame 2 will automatically show the selected state as the top of the tree with a '+' sign to expand the branch at Frame 2 in Figure 26. Clicking the '+' sign expands the branch into reachable states and UIs are shaded green. This feature allows you to know if a possible equilibrium is reachable from the status quo and whether it is reachable solely by UIs. This information is also given in the narration panel to the right of the screen (Frame 3).
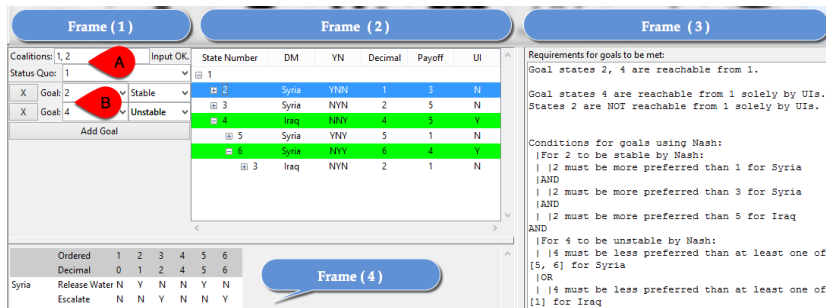

Figure 26: Post Analysis Screen.

The tool highlighted in Balloon B of Frame 1 in Figure 26 is called the *Goal Seeker*, which is an extensive version of the *Inverse GMCR*. You can experiment with different scenarios by setting particular states to be stable while setting other states to be unstable. Whether these choices are possible or not is explained in Frame 3 and how they can be achieved if possible is narrated as well. Frame 4 contains the conflict table in option form for your convenience.

5 *Highlights of GMCR+ Capabilities through Examples*

In this section, you will learn about distinct GMCR+ features through various built-in examples. GMCR+ comes with ready-made examples that are accessible from the standard utility button *"Load Game"* as shown in Figure 27. The file extension for all games modeled with GMCR+ is `.gmcr`. Built-in examples include:

Figure 27: Load Utility Buttons.

- Prisoners' Dilemma (`Prisoners.gmcr`).

- The Cuban Missile Crisis (`Cuban.gmcr`).

- The Elmira conflict (`Elmira.gmcr`).

- The Garrison Diversion Unit (GDU) (`Garrison.gmcr`).

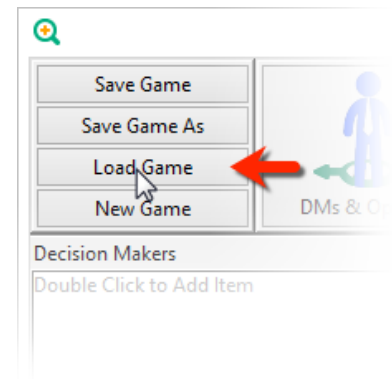- The Syria-Iraq conflict (used earlier in this guide) (`SyriaIraq.gmcr`).

5.1 Equilibria Filtering

Load the GDU model by clicking on *"Load Game"* and opening
(Garrison.gmcr) file. Navigate to the *Equilibria Results* screen (Figure
18). The filtering feature mentioned briefly in Section 4.1 is a very
handy tool for large conflicts such as the GDU conflict [3]. This con-
flict has 23 feasible states, which may be challenging to keep track of.
But using the filtering feature, it is easy to navigate through the rel-
evant states. Assume that you are interested only in states in which
U.S. Support does not proceed to complete full GDU and that are at
least *GMR* stable. You can achieve this by clicking the toggle button
in front of each option (Ballon A in Figure 28). You can then sort
the results according to *U.S. Support* from most to least preferred by
clicking in front of its payoff (Ballon B in Figure 28).

Figure 28: GDU Equilibria Filtering.

	Ordered		2	8	11	15	13	17	19	21
	Decimal	Filter	36	58	74	90	84	148	154	276
1 - US Support	Full	N	N	N	N	N	N	N	N	N
	Reduced	-	N	Y	Y	Y	N	N	Y	N
	Appease	-	Y	N	N	N	Y	Y	N	Y
2 - US Opposition	Legal Challenge	-	N	Y	Y	Y	N	N	Y	N
3 - Canadian Opposit	Treaty Challenge	-	N	Y	N	Y	Y	Y	Y	Y
4 - IJC	Full	-	Y	Y	N	N	N	N	N	N
	Reduced	-	N	N	Y	Y	Y	N	N	N
	Lonetree	-	N	N	N	N	N	Y	Y	N
	Suspend	-	N	N	N	N	N	N	N	Y
Payoff For:	US Support	>	21	18	15	14	12	10	7	6
Payoff For:	US Opposition	-	23	19	20	21	23	23	22	23
Payoff For:	Canadian Opposition	-	15	12	19	17	16	20	21	22
Payoff For:	IJC	-	23	23	23	23	23	23	23	23
	Nash	-	Y		Y			Y		Y
	GMR	Y	Y	Y	Y	Y	Y	Y	Y	Y
	SEQ	-	Y		Y			Y		Y
	SIM	-	Y		Y			Y		Y
	SEQ & SIM	-	Y		Y			Y		Y
	SMR	-	Y	Y	Y	Y	Y	Y	Y	Y

5.2 Coalitions

The Elmira conflict [4] is an environmental case that demonstrates
the power of *Coalitions*. Load the Elmira model by clicking on *"Load
Game"* and opening (Elmira.gmcr) file. Navigate to the *Equilibria
Results* screen (Figure 18). As you can see in Figure 29, state 7 is an
equilibrium, indicating that the conflict will be deadlocked at this

state. However, if a coalition is formed, the situation will change. Modify the coalitions bar to be `Coalitions:[1,2],3` indicating a coalition between *MoE* and *Uniroyal* instead of the original unilateral game with `Coalitions:1,2,3` (Balloon A in Figure 30).
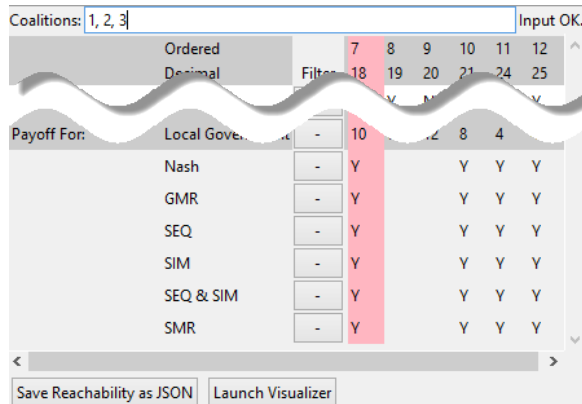

Figure 29: Original Elmira Equilibria.

Notice that members of the coalition are enclosed between square brackets. If the format is incorrect, you will see a prompt `Invalid Syntax` or `Missing DMs` in Balloon B of Figure 30. As you can see, state 7 is no longer an equilibrium. The following section highlights the significance of this information with the use of interactive status quo analysis.
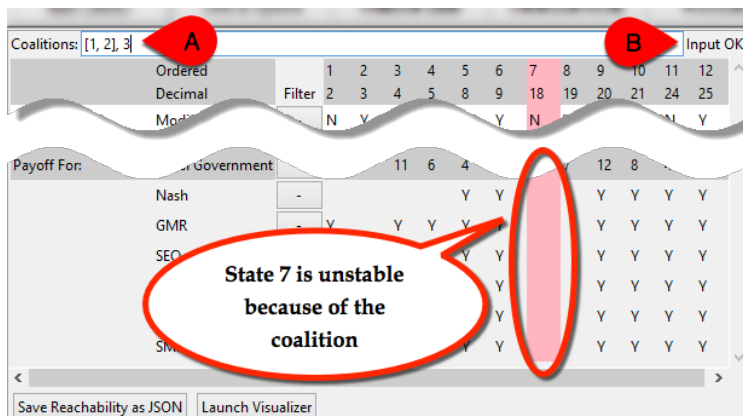

Figure 30: Elmira Equilibria with Coalition.

5.3   *Interactive Status Quo Analysis*

GMCR+ system is equipped with two different interfaces to carry out status quo analysis. Following up with the aforementioned Elmira conflict; while you are in the *Equilibria Results* screen (Figure 30), click on *"Launch Visualizer"*. A web application will start loading the tree diagram of the conflict as depicted in Figure 31. Notice that, since the model has defined coalitions, the tree diagram treats the

coalition as an individual *Entity* represented by a single line (Figure 31 has the coalition marked with a solid blue line). If you checked the *Differentiate UIs* box within the *Display Configuration* on the left, you can see bold lines indicating UIs. From the status quo, state 1, the *Local Government* has a UI to state 7, from which the coalition, *MoE* and *Uniroyal*, has a UI to state 10. Prior to the coalition, there were no possible moves from state 7 to state 10.
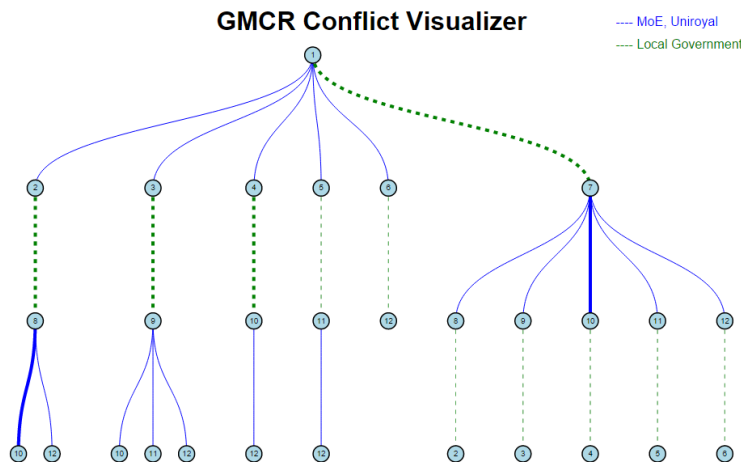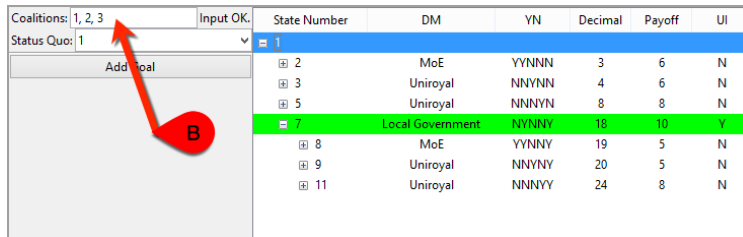

Figure 31: Elmira Tree Diagram with Coalition.

Another way of conducting status quo analysis is by navigating to the *Post Analysis* screen (Figure 25). Click on the (+) sign as shown by Balloon A in Figure 32 to expand the tree from the status quo, which in this example is state 1. As you can see, there is only one UI available, which is by the *Local Government* highlighted in *green*. Expanding this node reveals the five possible moves from state 7, of which only one is a UI that can be carried out by the coalition (*MoE* and *Uniroyal*).

Figure 32: Elmira Status Quo Analysis with Coalition.

Try removing the coalition by simply removing the square brackets from the *coalition bar* as shown by Balloon B in Figure 33. Expanding the status quo tree reveals that only one UI to state 7 is available and no moves can be made to state 10 by any DM unilaterally.

Figure 33: Elmira Status Quo Analysis without Coalition.

6   Visualizer and JSON Files

An advanced feature of GMCR+ is the ability to export the *Java Script Object Notation* (JSON) file of the conflict. A JSON file contains the conflict description including DMs, options, coalitions, reachability matrix, and ordinal payoffs. This file can be easily imported into GMCR+ visualizer. Say you want to share or communicate a conflict model, simply navigate to the *Equilibria Results* screen (Figure 18) and click on *Save Reachability as JSON* (Figure 34). You can then import the conflict model into any computer (even if it does not have GMCR+ installed) by opening your web browser and navigating to the URL: `http://gmcr.rkinsara.com`. Once you open this URL, you will see a *GMCR Conflict Visualizer* web application with a default tree diagram of the *Prisoners' Dilemma* game. Hovering the mouse to the left of the screen (Balloon A of Figure 36) will reveal the *Display Options* panel where you can click the *Choose File* button to import the JSON file as shown in Figure 35.
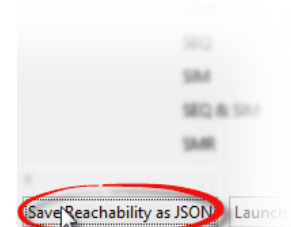

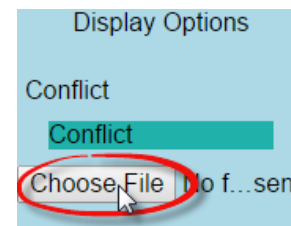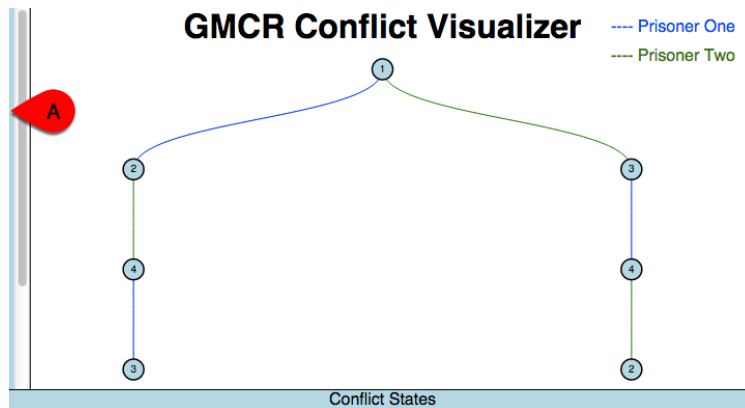Figure 34: Exporting a Conflict Model as JSON.

Figure 35: Importing a Conflict Model into the Visualizer.

Figure 36: GMCR+ Visualizer Web Application .