Cough Guideline model in GLIF

(Based on the Chronic Cough management guideline from ACP)

1)Chronic cough is cough that lasts for at least 3 weeks. Chest radiographs should be ordered before any treatment is prescribed in nearly all patients with chronic cough (Grade II-2). Chest radiographs do not have to be routinely obtained before beginning treatment, for presumed PNDS (post nasal drip syndrome) in young nonsmokers, in pregnant women, or before observing the result of discontinuation of an ACE-I (ACE Inhibitor) for 4 weeks for patients who developed cough shortly after beginning to take an ACE-I.

2) Note: When the chest X-ray is normal PNDS, Asthma, and GERD (Gastroesophageal reflux disease) are the likely causes of chronic cough. In PNDS, sinusitis may be the cause up to approximately 30% of the time when cough is nonproductive, and up to approximately 60% of the time when cough is productive.

A negative recommendation: Sinus CT scans are not routinely recommended to evaluate for sinusitis as the cause of cough.
Four-view sinus radiographs should be ordered instead.

3) While 24 hour esophageal pH monitoring is the most diagnostically useful test for assessing for GERD as the cause of cough, conventional indices used by gastroenterologists to assess for esophagitis may be misleadingly normal. Therefore, until future studies provide better guidelines, the test should be read as normal when conventional indices are within the normal range and no suspicious reflux-induced coughs appear during the monitoring session (Grade II-2).
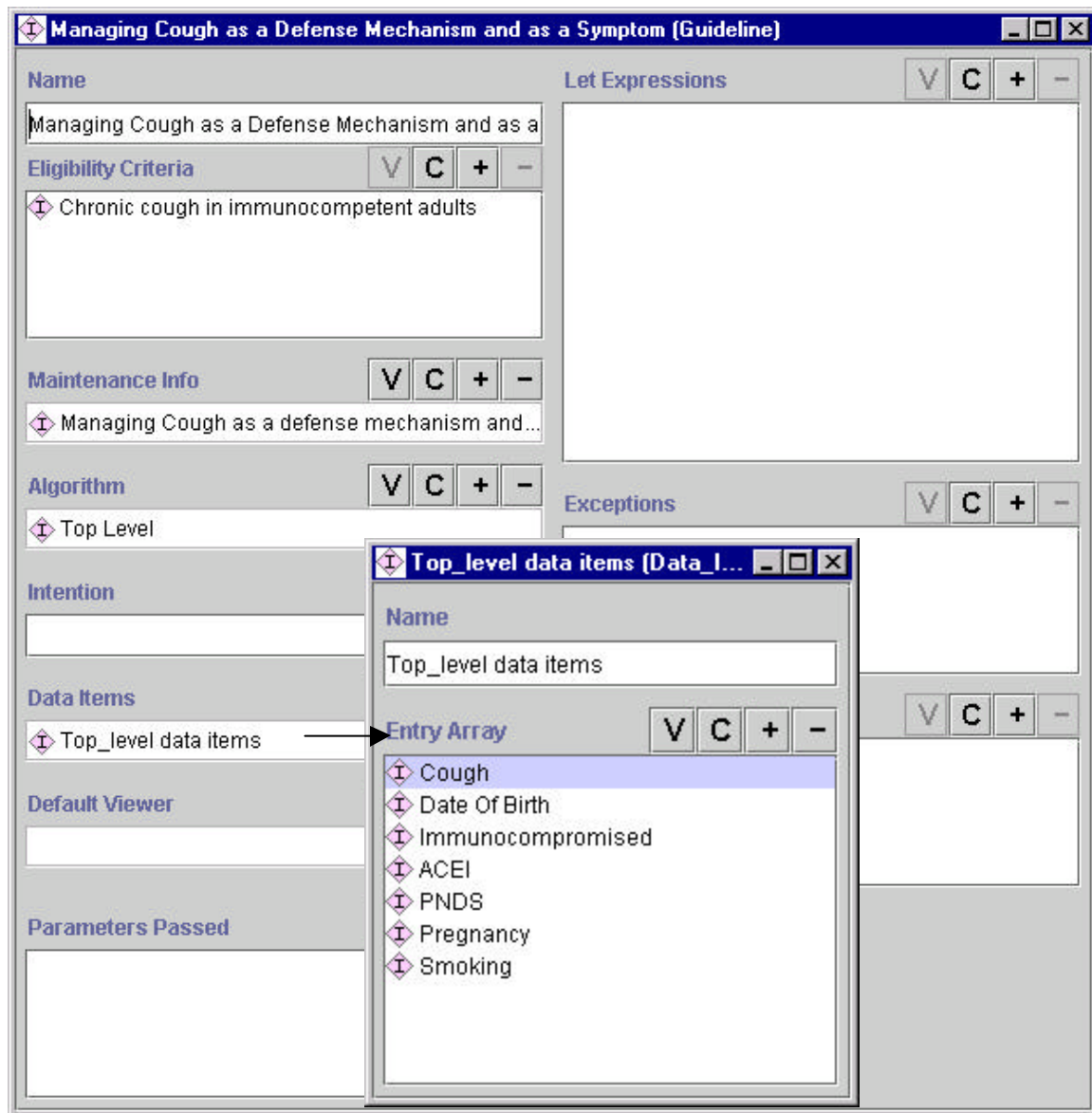
The top-level guideline object is shown in Figure 1.

Figure 1. The top-level guideline object

The eligibility criterion for **chronic cough** is shown in Figure 2. It is formally expressed in the Guideline Expression Language (GEL).

Figure 2. Eligibility criteria for the cough guideline

Data is retrieved from the EMR via Get_Data action specifications that translate the data into a GEL-compatible format. A Get_Data object for date of birth is shown in Figure 3. a Let_Expression, shown in Figure 4, is used to derive Age out of the current time and the date of birth value.

Figure 3. Getting the date of birth data item from the EMR and translating it to the GEL format. An observation object that holds the Date Of Birth data item is stored in a Query_Result called dateOfBirth. The primary time is the recording time of the observation.

Figure 4. A Let expression that uses a GEL expression to compute the Age based on the difference between the current time and the date of birth.
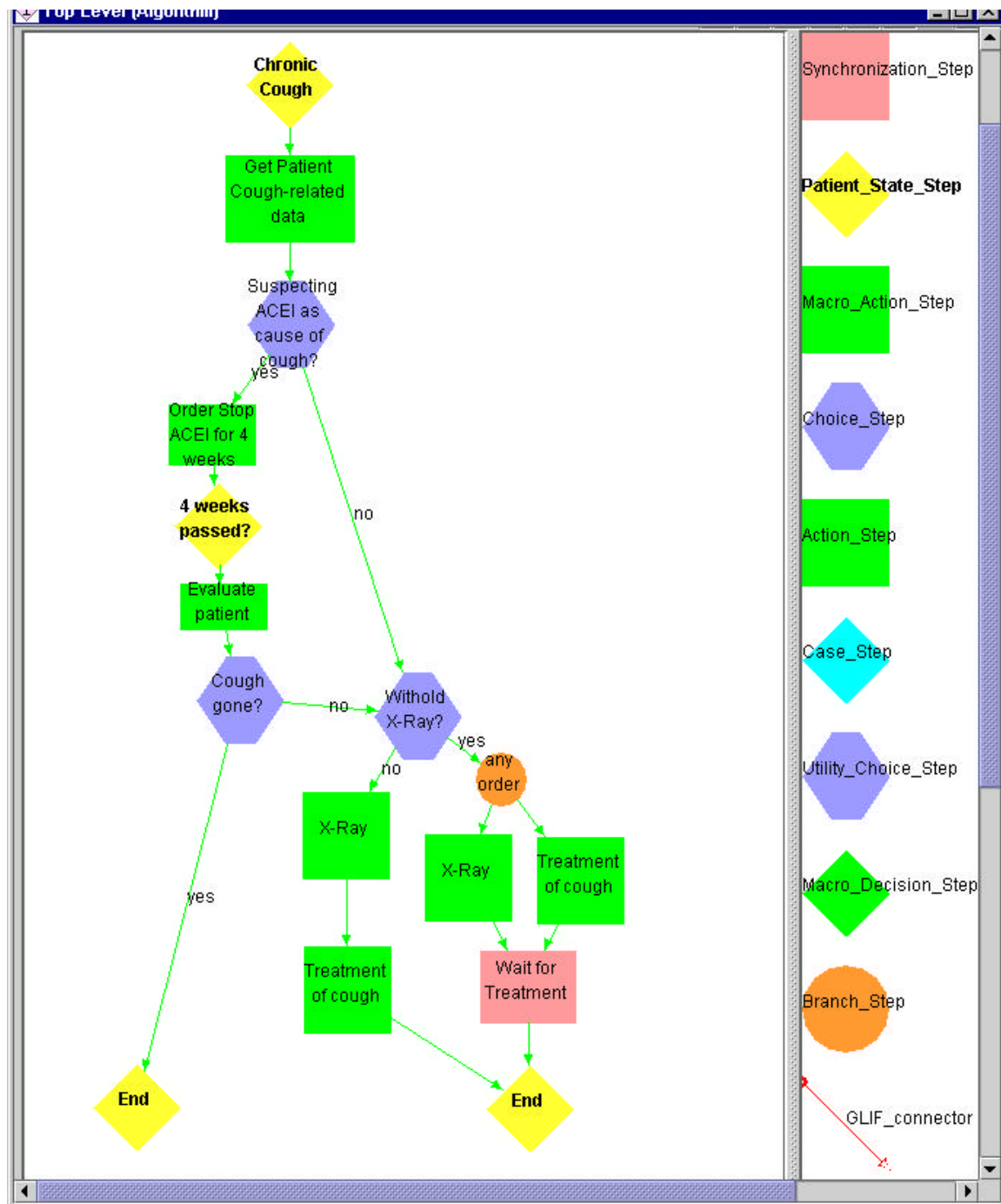
The top-level algorithm is shown in Figure 5.

Figure 5. The top-level cough management algorithm.

Chest X-ray do not have to be routinely ordered for presumed PNDS (post nasal drip syndrome) in young nonsmokers, in pregnant women, or before observing the result of discontinuation of an ACE-I (ACE Inhibitor) for 4 weeks for patients who developed cough shortly after beginning to take an ACE-I. That is, they may or may not be obtained, and both options are valid. This is modeled in the following way.

First, relevant patient data is collected in an action step, whose details are shown in Figure 6.

Figure 6. Details of "Get patient cough-related data"

Then we decided whether "suspecting ACEI as the cause of cough" (a user choice step). The details of this step are shown in
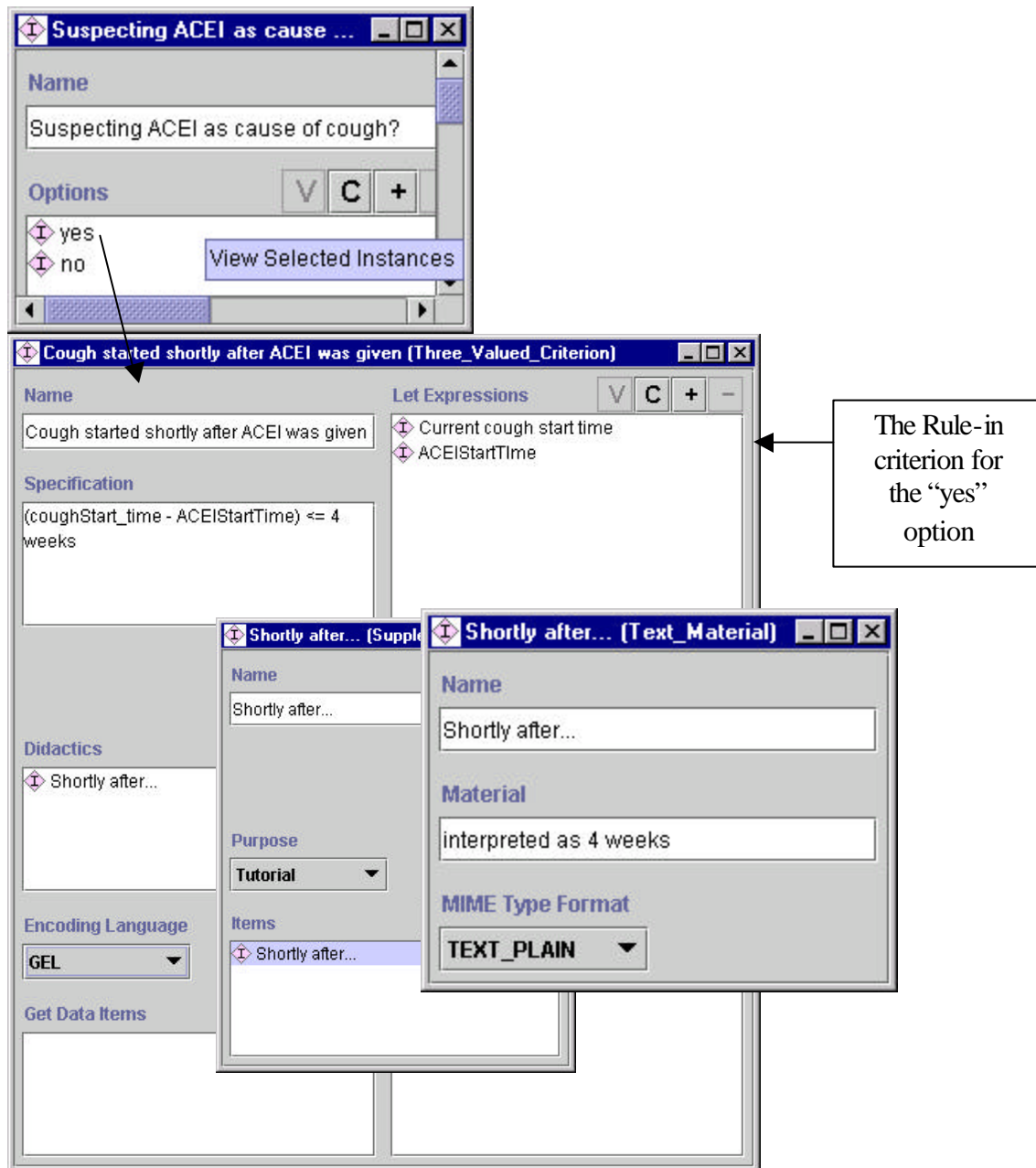
Figure 7. The details of the "suspecting ACEI as the cause of cough" choice step. ACEI is suspected as the cause of cough if the cough started within 4 weeks after the administration of ACEI.

If ACEI is suspected to be the cause of cough, then we order to stop the ACEI through the action step "Order stop ACEI for 4 weeks" that has a medically-oriented action specification task, shown in Figure 8. Note that this negative recommendation is expressed as a Medication object in the "order not to" mood. The critical time is set to the interval starting "now" and ending 4 weeks later. At the time that the order to stop ACEI is given, the current time is assigned to the variable "time_ACEI_stopped". This will be used to determine the time of 4 weeks after ordering to stop ACEI, in the patient state step "4 weeks passed?".
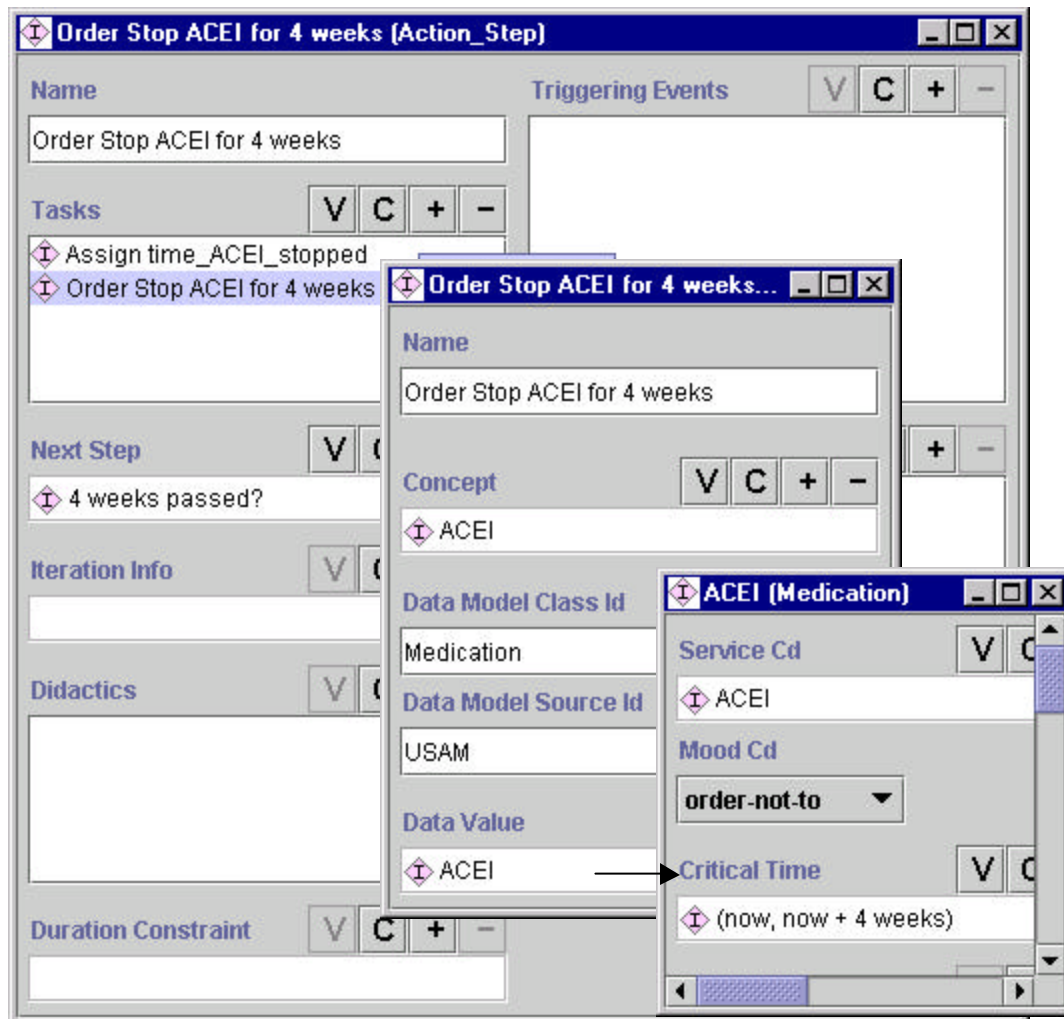
Figure 8. Ordering stopping an ACEI

The patient is sent home for 4 weeks. When he/she arrives at the clinic again, he/she is matched to the patient state step "4 weeks passed?" whose criterion is expressed in the following GEL expression: "(timeACEIStopped + 4 weeks) < now". If 4 weeks passed, then the patient is evaluated through the action step "Evaluate patient". This action has a Get_Data task that queries for the status of the latest Cough, as shown in Figure 9. This action step follows a patient state step that marks a state of at least 4 weeks after the patient was taken off ACEI. Instead of using a patient state step, the action step of "Evaluate patient" can be triggered by an event that signals that 4 weeks passed, as shown in the action step's triggering_events slot. Having a triggering event means that we monitor for the event and when it occurs, we trigger the action step. It is different from having the patient come in for a visit and then matching his state to the entry points of the guideline (the patient state steps).

Figure 9. The "Evaluate Cough" action step

After the patient is evaluated, and the latest Cough value is taken, we can ask if the cough is gone. This is done via a choice step that has two options: "yes" and "no". The Rule-in for the "yes" option is shown below.

Figure 10. The Rule-in for "cough gone"

Now that we have observed the patient for 4 weeks we can go on to the rest of the guideline. The next step is a user choice step. The user needs to decide whether there are

reasons to withhold the X-Ray or not. If we need to withhold the X-Ray, we perform the X-Ray and the Treatment sub-guideline in any order and then wait until the "Treatment" action is executed before we end the guideline (see branch and synchronization steps below). Otherwise, we perform them in sequence, as shown in the algorithm of Figure 5.

Figure 11. The branch and synchronization steps that allow performing the X-Ray and Treatment action steps in any order, and synchronize after the Treatment action step, whose ID is CoughStudy_00279, is executed.

Specifying reasons to withhold the X-Ray

This is done in the choice step: "Withhold X-Ray?". The rule-in for the "yes" option is shown below. PNDScertainty represents the certainty attribute of the current (latest and end time >= now) PNDS observation. PregnancyDueDate is the the end time of the current Pregnancy observation.
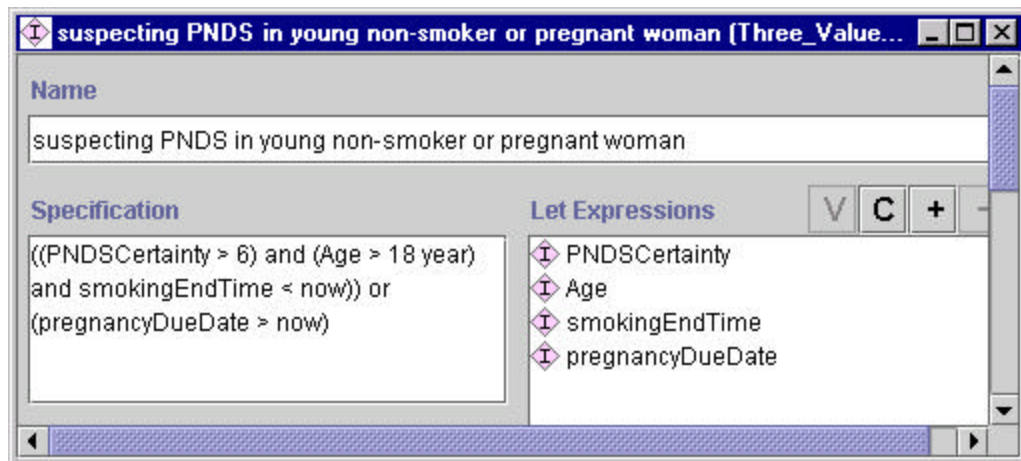
Ordering an X-Ray

Ordering an X-Ray is modeled as an action step, as shown in

Figure 12. It shows the **grade of evidence**.

Figure 12. The X-Ray action

The task done in the X-Ray action step is a medically-oriented task, as shown in Figure 13.
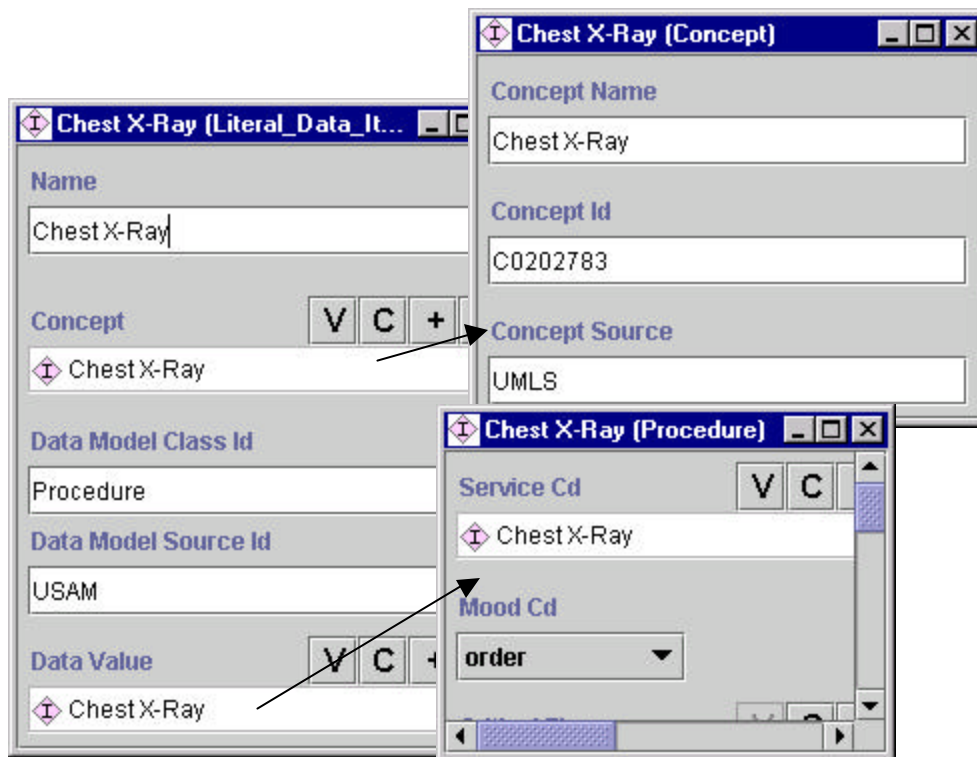
Figure 13. The medically-oriented task of ordering an X-Ray.

Treatment is modeled as the action step "Treatment of cough" that is nested into a sub-guideline, shown in

Figure 14.

Figure 14. The "treatment of cough" sub-guideline. The parameters are passed in both directions (in and out).

The treatment algorithm is shown in Figure 15.
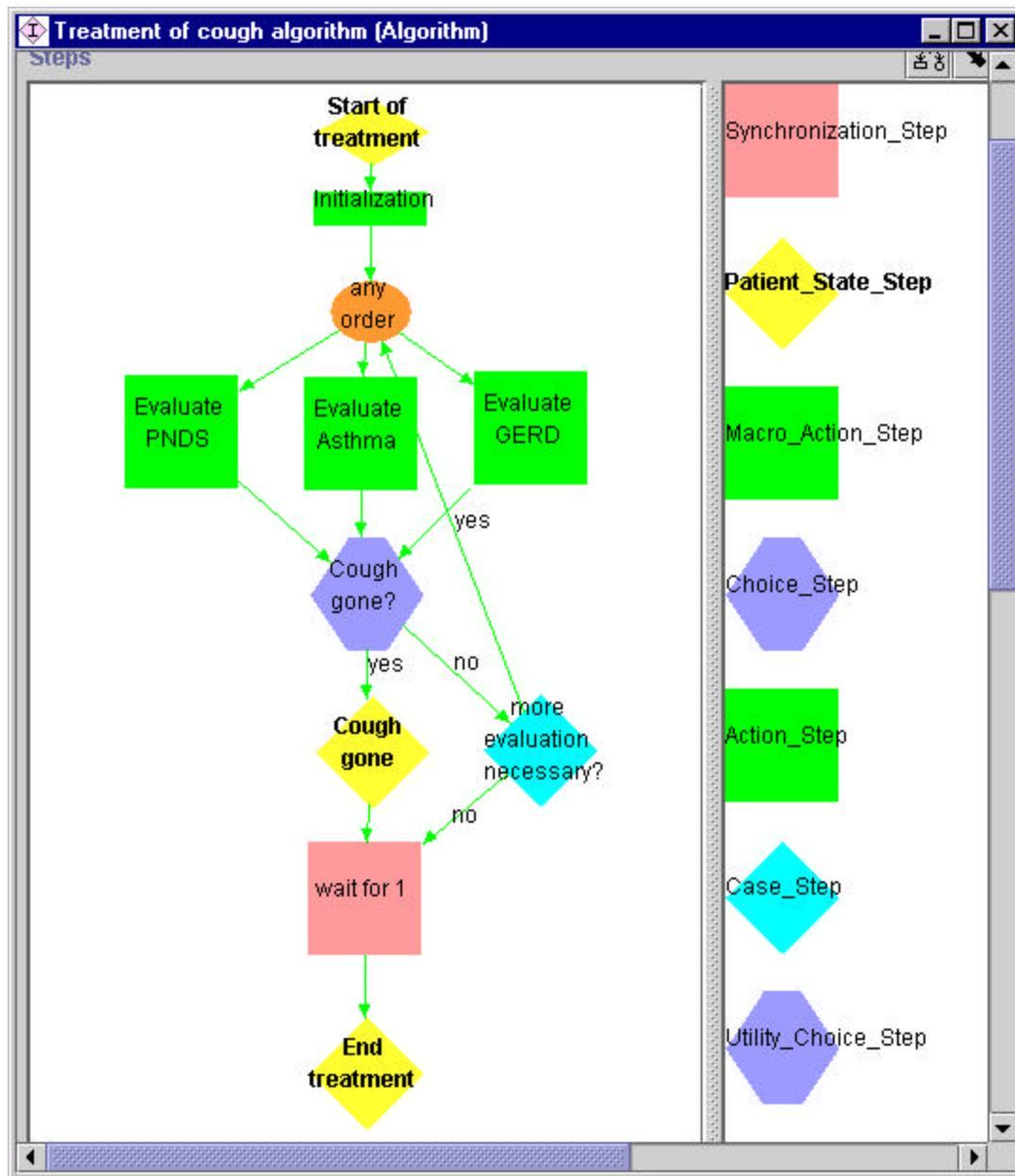
Figure 15. The treatment algorithm

The "Initilization" action step is used to initiate the values of flags that specify whether PNDS was evaluated, GERD was evaluated, and Asthma was evaluated. The treatment sub-guideline lets the user execute the 3 evaluation actions in any order. Synchronization occurs after the cough is resolved, or after all three evaluation action steps were executed. When an evaluation step is executed, the appropriate flag is set to "True". The automatic case step "more evaluation necessary" checks to see whether one of the evaluation flags signals that an evaluation was not done yet. The case expression is shown in Figure 16. Its result matches "True" or "False" and this determines the traversal of the algorithm. The synchronization step is shown in Figure 17.

Figure 16. The case expression of "more evaluation necessary"?

Figure 17. The synchronization step of the treatment algorithm

The Initialization action step has 3 assignment tasks, as shown in Figure 18.

Figure 18. The "Initialization" action step

The "Evaluate Asthma" action step is not further modeled in this case study. "Evaluate PNDS" has a sub-guideline task. The sub-guideline is shown in
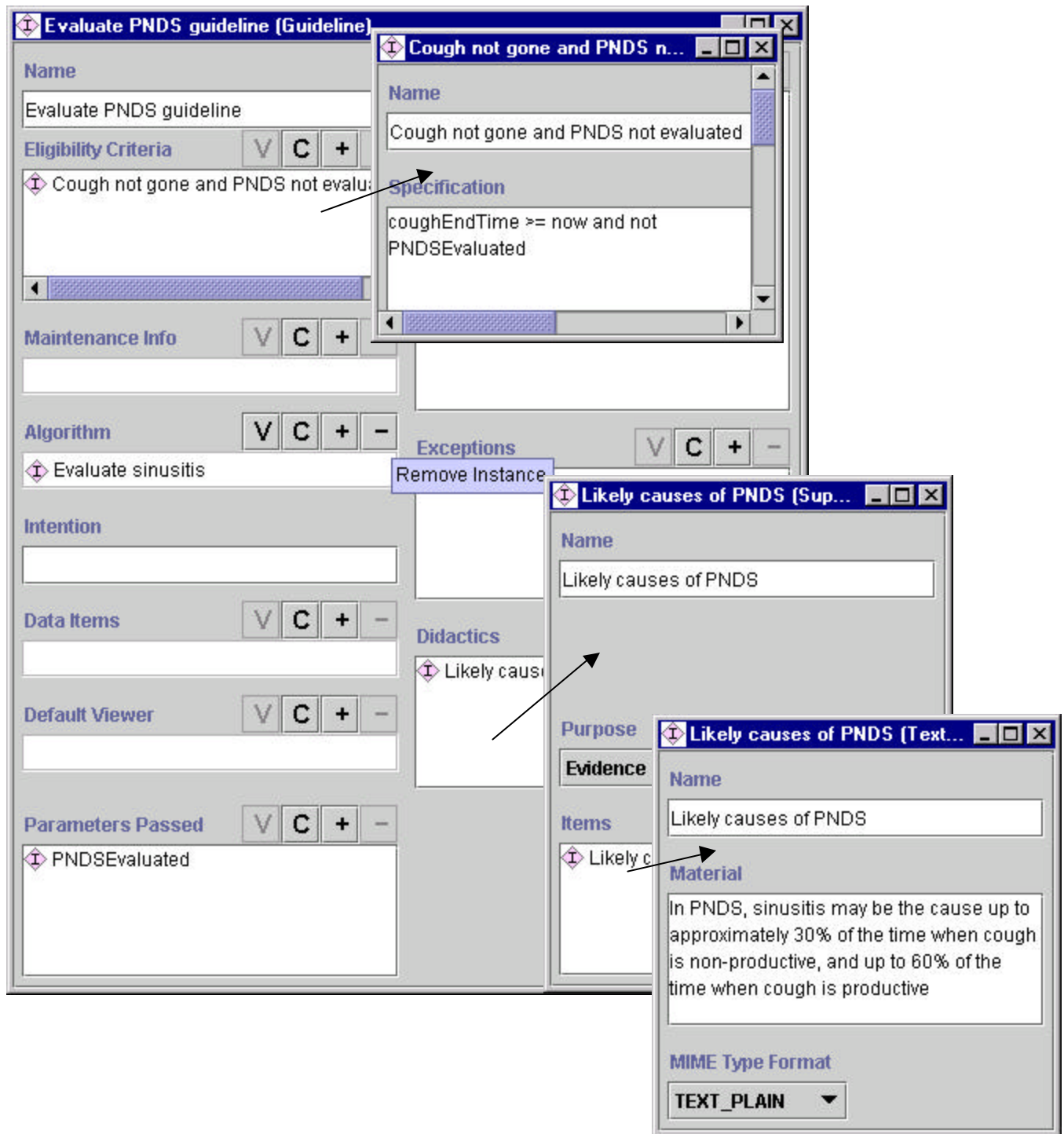
Figure 19.

Figure 19. The "Evaluate PNDS" sub-guideline

The eligibility criterion for this guideline is that the cough is not gone and that PNDS was not evaluated before, as the cause of cough. The algorithm of the evaluate PNDS sub-guideline is shown below.
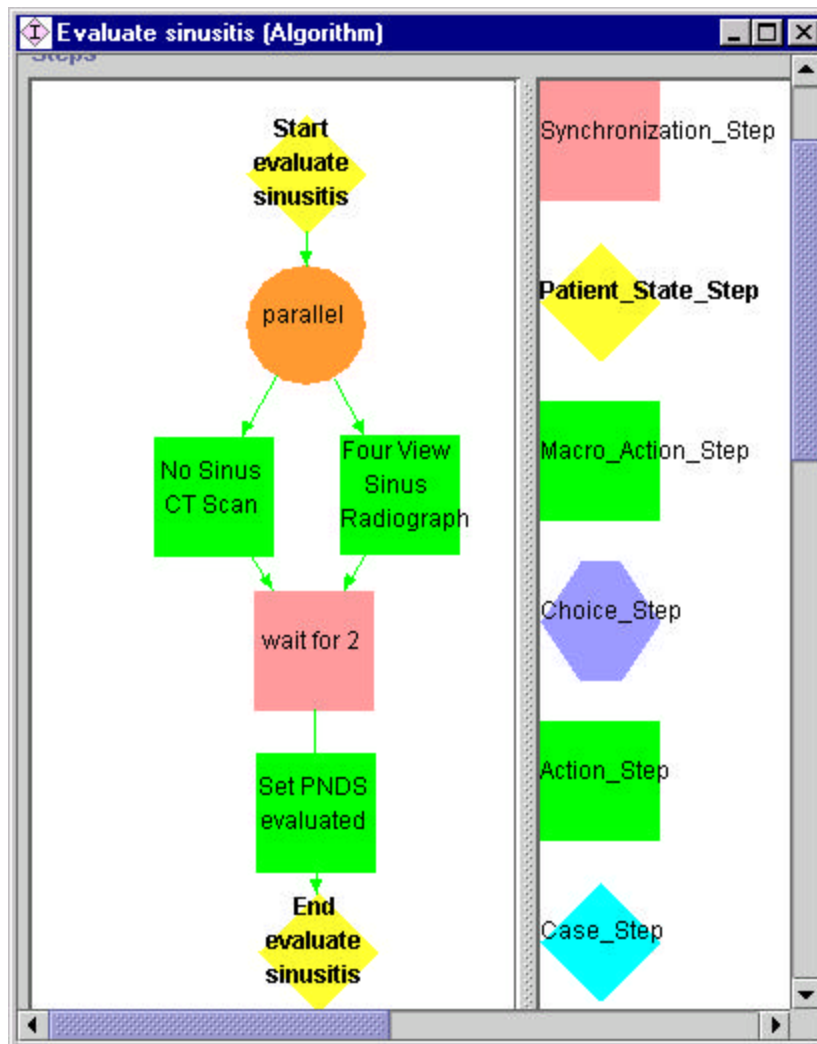
Figure 20. The PNDS evaluation algorithm

In this algorithm, two actions are done in parallel: a negative recommendation no to order sinus CT Scan, shown in Figure 21 and an order of Four View Sinus Radiograph, shown in Figure 22.

Figure 21. The medically-oriented task of the "No Sinus CT Scan" action step is modeled as a Procedure that has an "order-not-to" mood

Figure 22. The medically-oriented task of the "Four View Sinus Radiograph" action step

"Set PNDS evaluated" has an assignment task that sets the flag PNDS_evaluated to "True".

The "Evaluate GERD" action step of Figure 15, has a sub-guideline task that references the GERD sub-guideline, shown below.
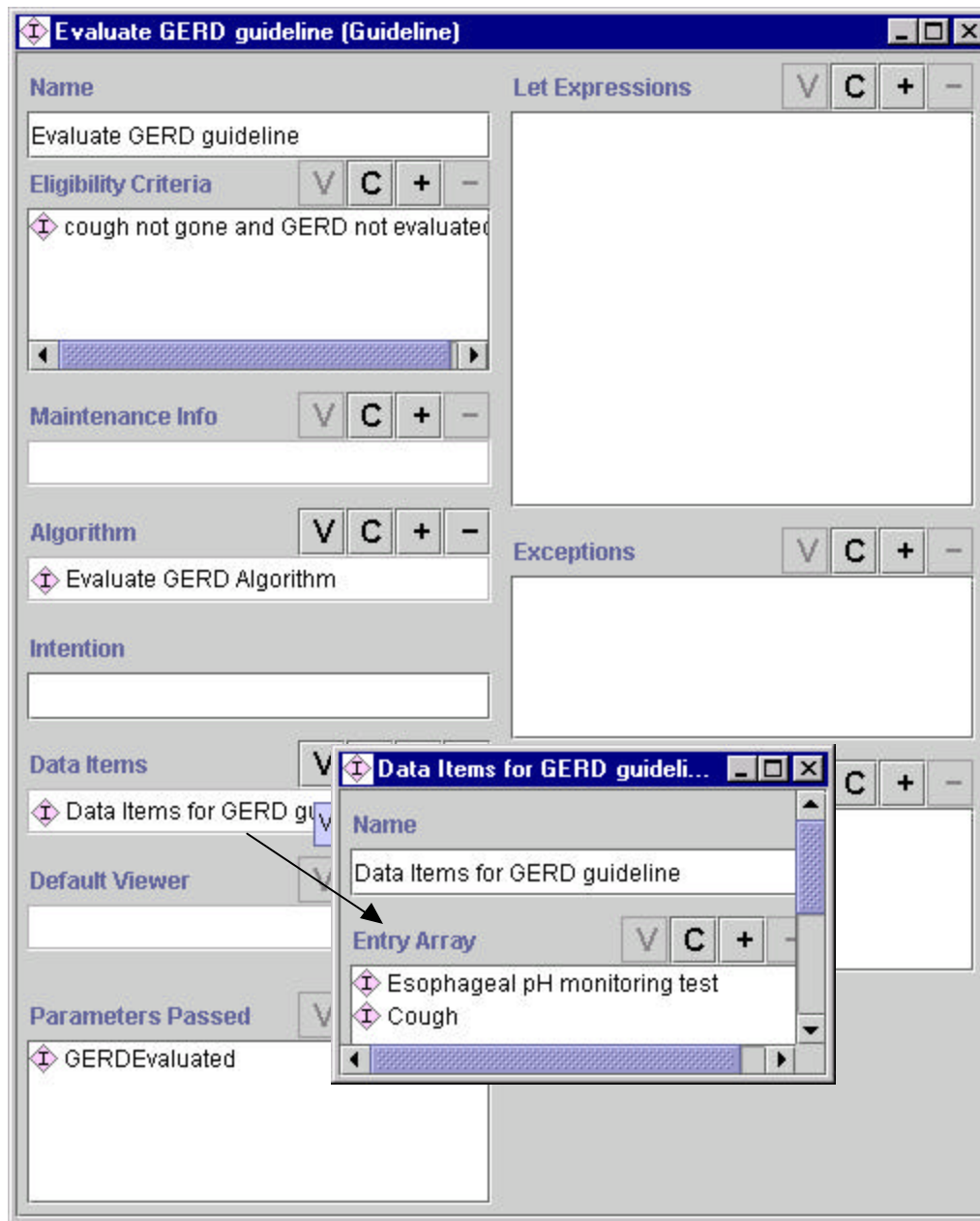
Figure 23. The Evaluate GERD sub-guideline

The eligibility criterion for this sub-guideline is similar to that of the PNDS sub-guideline.
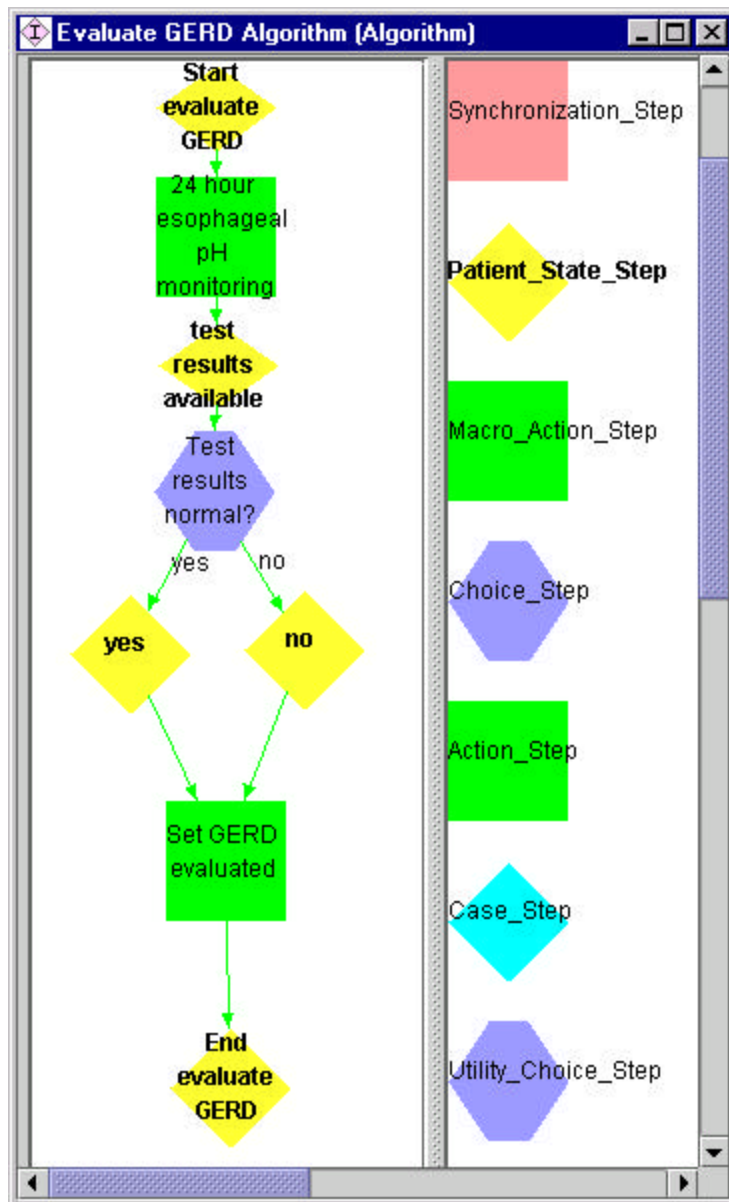
The GERD algorithm is shown below.

Figure 24. The Evaluate GERD algorithm

The action step "24 hours esophageal pH monitoring" has a medically-oriented task that is shown below.

Figure 25. The medically-oriented task of the action step "24 hours esophageal pH monitoring" . The duration of 24 hours is specified as the critical duration.

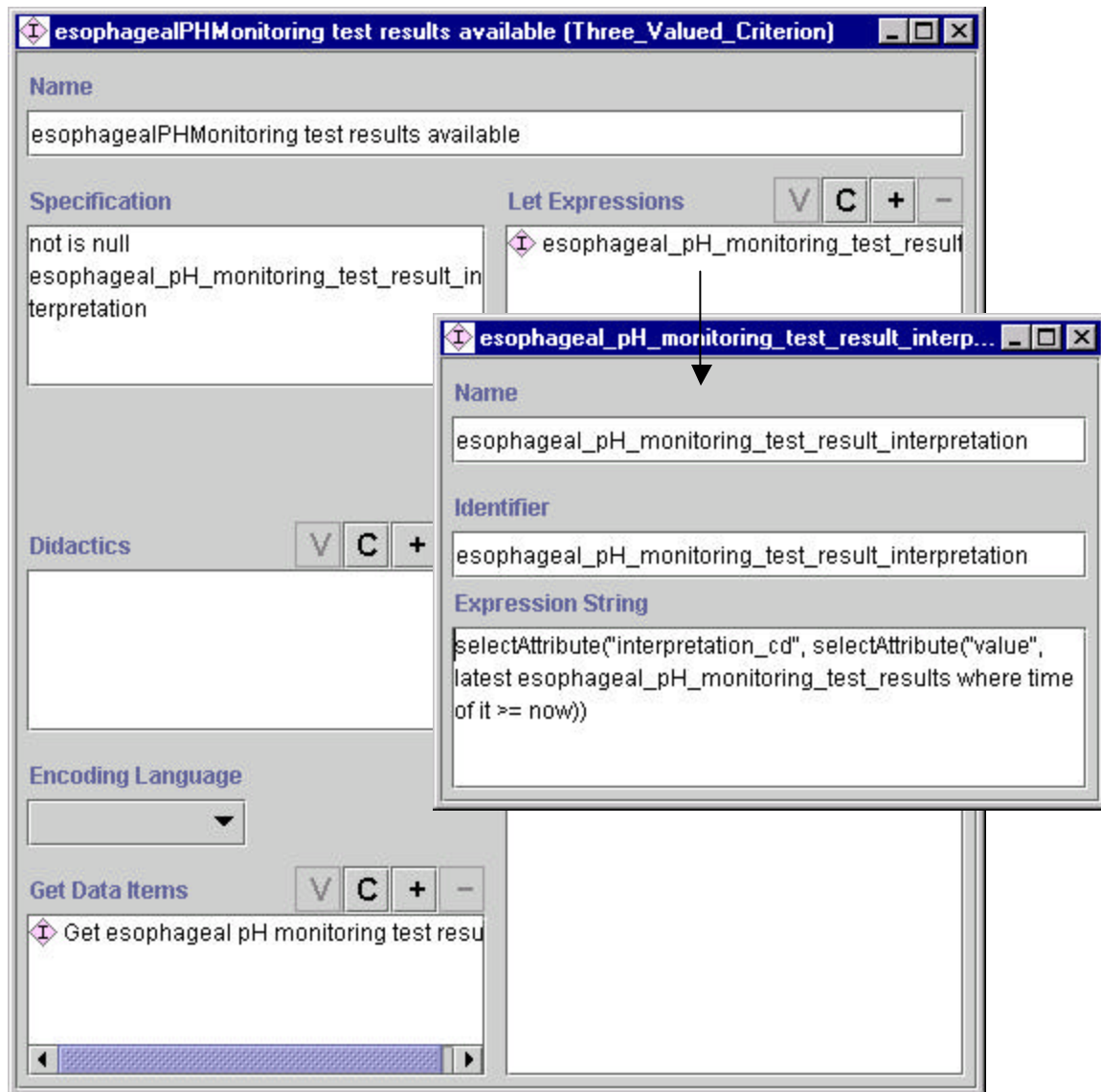The "test results available" patient state step is specified by the following criterion.

Figure 26. The criterion "esophageal pH monitoring test results available".

This criterion uses the Let_Expression definition that takes the interpretation_code attribute of the current (latest and time of it >= now) observation corresponding to the concept "24 hours esophageal pH monitoring". If the interpretation code is not null, then this means that the test results are available.

Next, a choice is made on whether the test results are normal.

Figure 27. The choice step "test results normal?"

Note that this choice has a specified grade of evidence.

The user should decide whether the test results are normal. Test results are considered normal if they are normal by conventional indices and in addition, no reflux occurred during the pH monitoring. We assumed that interpretation codes for observations would not contain a specialized term such as "reflux", so we decided to let the user know about the reflux using a didactic. The didactic is shown below.

Figure 28. The didactic for interpretation of the pH monitoring test results

Modeling a "normal" interpretation code can be easily done, as shown by the following criterion:

The choice step can follow a patient state step of test results available, or be triggered by an event of test results available. The triggering event is shown below.

Figure 29. The event that can trigger the choice step "test results normal?"