

A Scenario Management Case Study: Measuring Scenario Similarity in the EMS

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Abstract

A scenario is a sequence of events that describes expected system behavior. In Requirements Engineering, scenario documents are used to specify the requirements for a system. When there are many scenarios, scenario management poses a significant challenge. The challenge is to create a requirements specification that contains scenarios that are consistent with one another, that do not duplicate one another, and that do not contain terms that are synonymous with one another. This report discusses our validation of Alspaugh et al.'s similarity measures, which were applied to the EMS (Enhanced Messaging System) Scenarios Document [AAM01a].

1. Introduction

Requirements Engineering has long had the burden of producing a useable, thorough, and organized requirements document. Even requirements documents that are produced by experts have many flaws that result in flaws in the overall system it describes [ACDO1]. Many experts have addressed this problem, but few have suggested a viable solution. Alspaugh, et al. offer a solution by introducing similarity measures for managing scenarios¹ [AAB99]. Scenarios are created to detail requirements for a system by producing a sequence of events² that must be completed to form a scenario. These scenarios in turn can be used to produce goals that the system must accomplish for use in creating a requirements document. Several factors make scenario management complex. Duplication of scenarios is possible because a system may have hundreds of scenarios. There also exists a lack of consistency between scenarios because different stakeholders may use synonymous terms. [AAB99] proposes a tool³ that can check for the similarity between scenarios, saving users valuable

¹ A “scenario” is a linear sequence of events, with associated attributes [AAB99].

² An “event” consists of an ACTOR and an ACTION that the ACTOR performs [AAB99].

³ This tool is currently being developed at NC State Univ. under the name SMaRT (Scenario Management and Requirements Tool). The analyst worked extensively with this tool during this case study and some of the data from this case study was used to enhance SMaRT. Further information can be found at: <http://tigger.csc.ncsu.edu/~smart/>.

time in identifying these duplicate, inconsistent or synonymous scenarios. This tool will use the Similarity Index to alert stakeholders to possible duplication of scenarios and to possible episodes⁴. Use of this tool will help analysts produce more consistent scenario documents with less human error resulting in a requirements document that is consistent, complete, and correct.

Section 2 of this report contains the hypotheses that were made by the analyst before the case study began. Section 3 details the data that was examined and the different comparisons that the analyst made. Section 4 contains information about glossaries and their use in this case study. Section 5 describes the spreadsheet that the analyst used to record her data. Section 6 analyzes the data and extracts information that both refutes and upholds each hypothesis. Section 7 outlines the conclusions drawn by the analyst and the lessons learned during the course of the case study. Appendix A contains a subset of scenarios from the scenario document [AAMO1a] that the analyst used to conduct similarity measures listed exactly as they are in the document. Appendix B shows scenario 26 and 32 from the spreadsheet (the complete spreadsheet can be viewed at [http://tigger.csc.ncsu.edu/~smart/ScenarioCaseStudy\(2\).xls](http://tigger.csc.ncsu.edu/~smart/ScenarioCaseStudy(2).xls)).

2. Hypotheses

The following hypotheses were made before any of the scenarios were examined for similarity:

1. Two “similar”⁵ scenarios with the same ACTOR(S) and no ACTION(S) in common will have a higher Similarity Index when compared without the attribute ACTION(S).
2. Two “similar” scenarios with the same ACTOR(S) and one or more ACTION(S) in common will have a higher Similarity Index when compared with the attribute ACTION(S).
3. Two “similar” scenarios with zero or more of the same ACTOR(S) performing the same ACTION(S) will have a higher similarity when compared with the attribute ACTION(S).
4. Reconciliation of synonymous terms will more likely occur in ACTION(S), not ACTOR(S).
5. “Similar” scenarios will have a higher Similarity Index than “dissimilar” scenarios in all three comparisons.
6. A glossary will produce greater consistency, which will result in an increase in the similarity between the scenarios.

⁴ An “episode” is a named sequence of one or more events that forms all or part of a scenario’s sequence and is usually shared among several scenarios [AAB99] (See “Make Recording” and S28 in Appendix A).

⁵ Two scenarios are “similar” if they share events with the same ACTOR(S) performing zero or more of the same ACTION(S) or they share zero or more of the same ACTOR(S) performing the same ACTION(S); all other groups of scenarios are classified as “dissimilar”.

7. Distinguishing between pre-conditions and post-conditions will produce a lower Similarity Index than grouping them all together in one category.⁶

3. Data Examined

Attributes Examined: Each scenario in Appendix A contains attributes that can be used to measure the similarity between scenarios. These attributes are the ACTOR(S) and ACTION(S) from each event, the PRE-CONDITION(S) and POST-CONDITION(S) from each scenario, and the REQUIREMENT(S) from the requirements document that the scenario supports. In keeping with the process as prescribed in [AAB99], the analyst chose to only list ACTOR(S) once that were used multiple times in a scenario (those that participate in more than one event in a single scenario).

The Comparisons: Each set of scenarios was compared three different times with a different set of attributes.

- (1) The first comparison made does not include the ACTION(S) from the events and does not reconcile synonymous terms [Ant97]. The ACTION(S) are left out to comply with the process outlined in [AAB99], where ACTION(S) are not considered.
- (2) The second comparison includes the event ACTION(S) and does not reconcile synonymous terms. ACTION(S) were included in this comparison in order to measure the impact ACTION(S) have on the similarity between scenarios.
- (3) The third comparison includes the event ACTION(S), employing the terminology resulting from our reconciliation of synonymous terms. This comparison enables one to examine the impact glossaries have upon similarity between scenarios. For example, if scenario S_1 has the event ACTION “press key 5” and scenario S_2 has the ACTION “dial key 5”, the two events are the same if the word ‘press’ is substituted in for ‘dial’. Similarly, if scenario S_3 has the event ACTOR “EMS” and scenario S_4 has the event ACTOR “the system”, the ACTOR in both scenarios would be identical if “EMS” was substituted in for “the system”. Reconciling synonymous terms ensures consistency between scenarios.

Each of these 3 comparisons generates a Similarity Index from 0 to 1 where 1 denotes that two scenarios are the same and 0 denotes that two

⁶ After the first three comparisons were made, the analyst realized that placing all the pre-conditions and post-conditions into one category called “Conditions” could affect the similarity. The analyst had initially placed the pre-conditions and post-conditions into one category because some pre-conditions could be post-conditions and vice versa. Grouping them all together could produce incorrect results regarding scenario dependencies and similarity.

scenarios have nothing in common. Since three comparisons were made for each pair of scenarios in the previously discussed subset of 12 scenarios, a total of 198 comparisons were made.

4. Glossary

A glossary of ACTOR(S) and a separate glossary of ACTION(S) were maintained as the similarity of scenarios was examined. Every time a new ACTOR or ACTION appeared in the EMS Scenarios Document, the analyst⁷ documented the term in the corresponding glossary. When two ACTOR(S) or ACTION(S) appeared synonymous in the third comparison, the analyst took one of two actions. If the term seemed inappropriate in the context it was used, an appropriate term was selected and exchanged for the inappropriate term. For example, the term “dials” is inappropriate in the context of “dials the ‘urgent’ command”. A more appropriate term would be “presses” and this term would be used to make the ACTION “presses the ‘urgent’ command”. Another example is the term “tells”. If a choice is not given to the ACTOR, then “tells” is an appropriate term such as “tells the subscriber to enter a subscriber’s telephone number”. If a choice is given to the ACTOR, then “asks” is an appropriate term such as “asks for a confirmation or rejection.” If two terms were identical in the context it was used, then the analyst would take the word previously inputted in the glossary and exchange it for the similar word in the current event. For example, if the ACTION “marks” already appears in the glossary, and the ACTION “flags” is the ACTION to be inputted in the glossary, “marks” would be substituted for “flags” and “flags” would not be inputted in the glossary. However, if “marks” does not appear to be synonymous with “flags” in the context it is used, “flags” is added into the glossary and the terminology is not reconciled.

The analyst exchanged more formal terms for less formal terms e.g. the ACTOR “EMS” is more formal than the ACTOR “the system” and therefore, “EMS” was substituted in for “the system” wherever it occurred. The analyst reconciled events that may be episodes. For example, the episode “Make Recording” with the ACTOR “caller” was substituted in for the event “The caller leaves a message” since these two are synonymous. The episode was used because the single event “The caller leaves a message” does not give enough information about how the caller leaves a message as opposed to the episode that describes it in depth. Finally, the analyst divided ACTIONS that contained the word “and”. For example, the ACTION “answers and announces the subscriber’s name” was separated in the “Reconciled Action(s)” field as “answers” for one event and “announces the subscriber’s name” for another event. The glossaries were kept to create consistency between scenarios and to prove that this consistency has a notable effect on similarity.

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5. The Spreadsheet

Appendix B shows scenarios 26 and 32 from the Excel spreadsheet case study data.

View 1 contains the following information:

- SID: the Scenario ID (the letter 'S' followed by the number of the scenario, used by the analyst only for scenario identification)
- SName: the name of the scenario (used by the analyst only for scenario identification)
- Req.: the requirement the scenario supports
- Condition: the pre- and post-conditions for the scenario. The conditions are distinguished by (pr) for pre-condition and (po) for post-condition, which were used after the initial three comparisons to test hypothesis 7.
- Actor(s): each actor from the scenario
- Action(s): the actions from the scenario

View 2 contains the following information:

- Reconciled Action(s): contains the actions that were reconciled for synonymous terms
- SID Compared With: the Scenario ID of the scenario that was compared to the current scenario (a scenario was compared to every other scenario except itself)
- Total Similar (1): the number of similar attributes found in Comparison 1 (e.g. the total number of similar attributes for S26 and S32 in this comparison is 3 because they have 'Left Message', 'EMS', and 'Caller' in common)
- Total Similar (2): the number of similar attributes found in Comparison 2 (e.g. the total number of similar attributes for S26 and S32 in this comparison is 5 because they have the 3 from the previous comparison plus 'calls the subscriber's telephone while it is busy' and 'leaves a message').
- Total Similar (3): the number of similar attributes found in Comparison 3 (e.g. the total number of similar attributes for S26 and S32 in this comparison is 7 because they have the 3 from Comparison 1 plus 'calls the subscriber's telephone while it is busy', 'plays the subscriber's name', 'plays the subscriber's announcement', and 'Make Recording' because these terms were reconciled).
- Attr. Total (no act.): the total number of attributes minus all actions. The analyst initially determined this by counting the number of attributes in the given scenario comparison and then checking the answer produced by the COUNTA() function in Excel which counts all non-null fields in the columns passed to it (e.g. S26 has an attribute total minus actions of 8 and S32 has 5 so the attribute total for both is 13).

- Attr. Total (act.): the total number of attributes, including all actions. This was also initially determined by counting the number of attributes and then by using the COUNTA() function (e.g. S26 has an attribute total with actions of 11 and S32 has 10 so the attribute total for both is 21).

View 3 contains the following information:

- Attr. Total (recon): the total number of attributes, including all reconciled actions and actors used for Comparison 3. This number was calculated using the COUNTA() function (e.g. S26 has an attribute total with reconciled actions and actors of 12 and S32 has 12 so the attribute total for both is 24).
- Index (1): the Similarity Index calculated by multiplying Total Similar (1) by 2 and then dividing that by Attr. Total (no act.), in compliance with the algorithm set forth in [AAB99], (e.g. the total similar for S26 and S32 in Comparison 1 is 3 so $3*2/13 = 0.46$).
- Index (2): the Similarity Index calculated by multiplying Total Similar (2) by 2 and then dividing that by Attr. Total (act.) (e.g. the total similar for S26 and S32 in Comparison 2 is 5 so $5*2/21 = 0.48$).
- Index (3): the Similarity Index calculated by multiplying Total Similar (3) by 2 and then dividing that by Attr. Total (recon) (e.g. the total similar for S26 and S32 in Comparison 3 is 7 so $7*2/24 = .58$).
- Time (1) [min]: the total time in minutes it took the analyst to perform Comparison 1
- Time (2) [min]: the total time for Comparison 2
- Time (3) [min]: the total time for Comparison 3
- Total Time [min]: Time (1) + Time (2) + Time (3)

The spreadsheet does include the reconciled actor(s) field, but the views in Appendix B do not contain this field because the two scenarios listed in these views do not have any reconciled actor(s). The data is in ascending order according to the Scenario ID for each scenario. Grey cell shading marks the “similar” scenarios used only by the analyst as a visual representation of the “similar” scenarios as defined in this report. The analyst checked the data three times and found 23 errors the first time, 2 errors the second time, and no errors the third time. All the errors were classified as human addition errors, which would not be made by computers. Finally, the total time the analyst spent on performing 198 comparisons was 432 minutes. Additionally, View 3 shows that the Total Time for the comparison between S1 and S26 as well as S32 is a lot higher than the rest of the comparisons. This is due to the learning curve for the analyst. Scenario one took more time for each comparison because the analyst had to figure out how to optimize the comparisons. Also, some of the comparisons had to be done again because the spreadsheet was not complete as was found out during the initial few comparisons.

6. Data Analysis

Hypothesis 1: *Two “similar”⁸ scenarios with the same ACTOR(S) and no ACTION(S) in common will have a higher Similarity Index when compared without the attribute ACTION(S).*

This hypothesis was tested by comparing the Similarity Index for Comparison 1 to the Similarity Index for Comparison 2 in all the “similar” scenarios that had no action(s) in common. For example, S26 is “similar” (as indicated by the grey cell shading) with no actions in common to S27, S29, S30, S31, and S33. When comparing the Similarity Index 1 (0.46) to the Similarity Index 2 (0.33) between S26 and S27, Index 1 is higher than Index 2 thus upholding this hypothesis. (Reminder: Index 1 is the Similarity Index computed without actions). This was done for all the pairs of “similar” scenarios that had no actions in common, which totaled 24. All 24 have a Similarity Index 1 greater than Similarity Index 2 thus upholding hypothesis 1.

Hypothesis 2: *Two “similar” scenarios with the same ACTOR(S) and one or more ACTION(S) in common will have a higher Similarity Index when compared with the attribute ACTION(S).*

This hypothesis was tested by comparing the Similarity Index for Comparison 1 to the Similarity Index for Comparison 2 in all the “similar” scenarios that had one or more action(s) in common. For example, S26 is “similar” to S32 and they have 2 actions in common. When Similarity Index 1 (0.46) is compared to Similarity Index 2 (0.48), Index 2 is greater than Index 1 and thus upholds this hypothesis. However, when S26 is compared to S33, Index 2 is not greater than Index 1 thus refuting this hypothesis. In fact, only 1 out of the three “similar” scenarios with one or more actions in common upheld this hypothesis. It is good that this hypothesis was refuted in some cases. When S26 was compared to S33, the first Similarity Index declares the two scenarios are identical. When the second Similarity Index is computed, it shows that the two scenarios are not identical because their actions are very different. This distinction is important because any human looking at these two scenarios can see that they are not similar to the point of being identical (Appendix A) and therefore, when compared without the actions should return a lower Similarity Index.

Hypothesis 3: *Two “similar” scenarios with zero or more of the same ACTOR(S) performing the same ACTION(S) will have a higher similarity when compared with the attribute ACTION(S).*

This hypothesis was tested by examining the episode “Make Recording”. Since an episode is one or more events that forms all or part of a scenario’s sequence, an episode may be a scenario in itself. An episode may also be

⁸ Two scenarios are “similar” if they share events with the same ACTOR(S) performing zero or more of the same ACTION(S) or they share zero or more of the same ACTOR(S) performing the same ACTION(S); all other groups of scenarios are classified as “dissimilar”.

considered a “similar” scenario because an episode is meant to be reused. Therefore, the episode “Make Recording” can be used as two “similar” scenarios with zero or more of the same ACTORS performing the same ACTIONS by using “Make Recording” as it is and also by substituting “caller” in for “subscriber”. In the EMS document, both “callers” and “subscribers” may be ACTORS in the episode “Make Recording”. When the analyst compared the “two” episodes without ACTIONS, she calculated 1 similar attribute out of a total of 4 attributes for a Similarity Index of 0.5. When they were compared with ACTIONS, she calculated 8 similar attributes out of a total of 18 attributes for a Similarity Index of 0.889. This data upholds this hypothesis.

This data also alerted the analyst to a problem in [AAM01a]. An episode is named so it may be used in multiple scenarios. Either a “caller” or “subscriber” may do the named episode “Make Recording”. As such, this episode is not truly an episode as it is written. Only a “subscriber” may use the episode as it is written. This alerted the analyst to the need for a group of ACTORS to be used for episodes. If a group “User” existed that had the ACTORS “subscriber” and “caller” in it, then the group “User” could be substituted in for “subscriber” or “caller” in any episode that allowed either ACTOR to perform the ACTIONS in the episode. The analyst did not input “User” into the ACTOR glossary since it is a group of ACTORS and not a specific ACTOR. At the time the episode is inserted into a scenario, the stakeholder would specify, using a parameter, what ACTOR in the group would perform the ACTIONS in the episode. If this approach is used for creating episodes, then two episodes will truly be identical with a Similarity Index of one instead of less than one due to different ACTORS performing the same ACTIONS. The definition of “episode” in [AAB99] is then altered to be a named sequence of two or more events that are created by ACTIONS and parameterized ACTORS that forms all or part of a scenario’s sequence and is usually shared among several scenarios. The change to “Make Recording” was documented in the “Reconciled Actors” field by substituting the ACTOR “caller” in for “subscriber”. “Make Recording” was also listed as a single event with the ACTOR “caller” instead of listing all of the events in the episode. This was done to follow the recommendations of [AAB99].

Hypothesis 4: Reconciliation of synonymous terms will more likely occur in ACTION(S), not ACTOR(S).

This hypothesis is upheld because the field “Reconciled Actor(s)” was only included in the data sheet to reconcile the ACTOR(S) in the episode “Make Recording”. This field was used once whereas the “Reconciled Action(s)” field was used seven times.

Hypothesis 5: “Similar” scenarios will have a higher Similarity Index than “dissimilar” scenarios in all three comparisons.

This hypothesis was tested by averaging the Similarity Indexes for Comparison 1, 2, and 3 for all “similar” scenarios and doing the same for all “dissimilar” scenarios. For example, S26 is “similar” to S27, S29, S30, S31,

S32, and S33. The average Similarity Index for all these scenarios for Comparison 1 is 0.53, the average for Comparison 2 is 0.42, and the average for Comparison 3 is 0.43. S26 is “dissimilar” to the rest of the scenarios, S1, S11, S12, S23, and S28. The average Similarity Index for all these scenarios for Comparison 1 is 0.19, the average for Comparison 2 is 0.13, and the average for Comparison 3 is 0.16. Therefore, the average Similarity Index for all comparisons for the “similar” scenarios is 0.46 and the average Similarity Index for all comparisons for the “dissimilar” scenarios is 0.16. This shows that the “similar” scenarios for S26 have a higher Similarity Index than the “dissimilar” scenarios for S26. The average Similarity Index for all “similar” scenarios in this case study is 0.42 and the average for all “dissimilar” scenarios in this case study is 0.19. This data upholds this hypothesis showing that the scenarios denoted as “similar” are in fact more similar than those that are denoted as “dissimilar” showing the algorithm to be accurate in finding similar scenarios.

Hypothesis 6: A glossary will produce greater consistency, which will result in an increase in the similarity between the scenarios.

This hypothesis was tested by comparing the Index found in Comparison 2 to the Index found in Comparison 3 for all scenarios that have reconciled actions and/or actors. For example, S32 has three reconciled actions (“plays the subscriber’s name and announcement”, “stops playing the name and announcement”, and “leaves a message” were all reconciled for synonymous terms). When it is compared to S26, the Index found for Comparison 3 is 0.58 as opposed to 0.48 in Comparison 2. Reconciling three actions caused the Similarity Index to raise 0.1 thus upholding this hypothesis. There were 16 total changes in terminology in 7 out of the 12 scenarios examined. This resulted in scenarios that were consistent, easier to read, and easier to compare to other scenarios.

Hypothesis 7: Distinguishing between pre-conditions and post-conditions will produce a lower Similarity Index than grouping them all together in one category.

This hypothesis was tested by doing Comparison 1 again and only counting “Conditions” as the same if they were both pre-conditions or both post-conditions. If Comparison 1 proved to create a different Similarity Index for any of the scenario pairs, Comparison 2 and Comparison 3 would have been performed in the same manner. The analyst found that distinguishing pre-conditions from post-conditions did not change the Similarity Index for any of the scenarios examined. She also examined all the scenarios in [AAM01a] and found that distinguishing between conditions made no difference. After examining the updated scenario document, [AAM01b], the analyst found a few pairs of scenarios⁹ that would have a lower Similarity Index if they were compared with pre- and post-conditions distinguished from one another rather than if they were placed all in one category. Similarity measures were

⁹ Scenario 10 and 11; Scenario 15 and 17

not actually carried out on these scenarios since this document is outside the scope of this case study. Even though distinguishing between pre- and post-conditions in the data did not produce any real conclusive evidence to their importance in similarity, a scenario's pre- and post-conditions are very important. If one scenario has a pre-condition of "Left Message", that means that this scenario cannot occur unless there is a message e.g. "The subscriber listens to a message". On the other hand, if another scenario has a post-condition of "Left Message", that means this scenario produces a message that is left for the subscriber e.g. "The caller calls EMS directly and leaves a message". These two scenarios are not similar, yet if the condition "Left Message" was not distinguished to be a pre-condition in one scenario and a post-condition in another scenario, they would seem to be similar according to the algorithm used.

Distinguishing between pre- and post-conditions is also very important for establishing dependencies to be used in scenario networks¹⁰. The analyst found that pre- and post-conditions were used to produce scenario networks [AA01]. Examining one scenario's pre-condition(s) and matching them up with another scenario's post-condition(s) and vice versa creates a network of scenarios. This network is then used to help stakeholders identify missing and incomplete scenarios. Since this case study was conducted to validate the algorithm in [AAB99], scenario networks were not examined and no further mention of them are made in this report.

7. Conclusions and Lessons Learned

The following conclusions and lessons were drawn from this case study:

The sets of attributes used to compare scenarios for similarity is very important.

When actions were used, the similarity was greatly affected and thus came closer to the human definition of "similar" and "dissimilar" that were defined in this report. To obtain a higher accuracy for the Similarity Index, the largest set of attributes possible must be used.

The algorithm used as suggested in [AAB99] was effective in finding similarity, but not for the purpose of recognizing episodes.

The algorithm portrayed those scenarios that were "similar" and those that were "dissimilar" with the accuracy that can match human comparisons. This algorithm allows a computer to do what a human can do at a much faster speed. The algorithm did not produce results that alerted the analyst to possible episodes as [AAB99] suggests. If the algorithm was extended to alert the user when two or more identical event ACTIONS occur in the same order in

¹⁰ A "scenario network" is a set of scenarios and the connections from each scenario to those that may follow it; at least one of the scenarios is distinguished as initial, and at least one as terminal [AA01].

different scenarios, then the algorithm would sufficiently recognize episodes. The analyst found episodes by using the extension to the algorithm suggested. For example, S27 and S28 both have the event ACTIONS “presses the ‘review message’ command” and “plays the message the caller just left” in the same order (refer to Appendix A). These two ACTIONS are by definition an episode. Another episode the analyst identified by using this method is in S26 and S33. The event ACTIONS¹¹ “plays the subscriber’s name and announcement” and “leaves a message” occur in the same order in these two scenarios and are considered an episode even though they were not denoted as such.

Episodes may have post-conditions¹² that arise out of performing an episode and may be helpful in identifying missing post-conditions in scenarios.

The analyst found that S32 was missing the post-condition “Left Message” even though it was very clear to the analyst that the scenario should have this post-condition. After examining other scenarios with “Left Message” as a post-condition, she found this post-condition to be related to the episode “Make Recording” or the event ACTION “leaves a message”. If either this episode or this ACTION occurs in the scenario, then the post-condition “Left Message” may also exist. Since the analyst found this event ACTION and the episode “Make Recording” synonymous, the analyst determined that episodes may be associated with at least one post-condition that is a result of the episode. After determining that S32 does end with a “Left Message”, the analyst inserted the post-condition “Left Message” into S32 before any similarity measures were run on the scenarios.

Glossaries are useful in creating consistency throughout the scenario document.

A glossary allowed the analyst to compare two synonymous terms and by changing a word or two, reconciled those terms to be identical. This made the document more consistent, which created ease of reading and in some cases increased the similarity between scenarios. The glossary in this way could identify identical or very similar scenarios that would be dissimilar due to conflicting terms.

Events should only express one atomic action.

Dividing an event where the ACTOR performed more than one ACTION joined by ‘and’ (e.g. “a caller calls EMS directly AND chooses the ‘Leave Message’ menu item”) also helped with creating a more consistent document. The analyst found the act of having to separate events into ACTORS and ACTIONS

¹¹ The reconciled terms were not used for this example because Appendix A uses the terminology that resides in [AAM01a].

¹² This is not always the case and it is not recommended that the tool enforce that episodes have post-conditions. It is recommended to stakeholders that they look at certain episodes and determine their outcome in most cases and then analyze the scenarios the episode resides in to determine if the scenarios should have that post-condition.

made the analyst recognize these complex events that needed to be divided. The analyst determined that having a tool would force the stakeholder to divide these events and therefore, create a consistent document.

A tool is needed to perform these similarity comparisons.

The analyst spent many hours doing tedious comparisons very cautiously that a tool could have done in seconds. This tool also could have analyzed the full set of 33 scenarios that the analyst could not analyze due to time constraints. Also, no matter how cautiously the analyst compared scenarios, 25 errors were made and only 23 of those were found on the first check through the data. The remaining errors were only found after the analyst had the Excel spreadsheet compute the sums in the Attr. Total (no act) and the Attr. Total (act) fields. These errors were addition errors that a computer would not have made.

A tool that uses a glossary can produce a set of scenarios that is consistent, thorough, and not redundant for use in producing a requirements document that is consistent, complete, and correct. This tool is a necessary step in requirements engineering that will lead to a system that is well-defined and in turn, well-built.

Appendix A

Scenarios Subset

S1 Subscriber authentication

Requirements: R1.1, R1.3, R1.4.

Precondition: Subscribed.

Postcondition: Authenticated.

1. The subscriber dials EMS on his or her telephone.
2. EMS answers and announces the subscriber's name.
3. The subscriber dials his or her passcode.
4. EMS authenticates the passcode.

S11 Subscriber listens to a new or held message

Requirements: R3.2.1, R3.2.2.

Precondition: Authenticated, Has (n > 0) New.

Postcondition: Authenticated, Has (n-1) New, Played.

1. The subscriber dials the "listen to next new or held message" command.
2. EMS plays the next new or held message. (The next new or held message is the oldest urgent new message, if there is an urgent new message, or the oldest new or held message if there isn't an urgent new message.)
3. If the message is a new message, EMS changes its state to "held".

S12 Subscriber listens to an archived message

Requirements: R3.2.1, R3.2.3.

Precondition: Authenticated, Has Archived.

Postcondition: Authenticated, Has Archived, Played.

1. The subscriber dials the "listen to next archived message" command.
2. EMS plays the next archived message. (The next archived message is the oldest archived message that hasn't been played during this EMS session).

S23 Subscriber doesn't take any action for a long time

Requirements: R3.2.15.

Precondition: Authenticated.

Postcondition: Authenticated.

1. The subscriber doesn't take any action for more than a certain length of time.
2. EMS disconnects and hangs up.

S26 Caller calls subscriber and leaves a message

Requirements: R4.1, R4.2, R4.7.

Precondition: Has (n) New.

Postcondition: Has (n+1) New, Left Message.

1. A caller calls the subscriber's telephone while it is busy.
2. EMS plays the subscriber's name and announcement.
3. The caller leaves a message.

S27 Caller reviews his/her message

Requirements: R4.3.

Precondition: Left Message.

Postcondition: Left Message.

1. The caller presses the "review message" command.
2. EMS plays the message the caller just left.

S28 Caller reviews and re-records his/her message

Requirements: R4.3.

Precondition: Left Message.

Postcondition: Left Message.

1. The caller presses the "review message" command.
2. EMS plays the message the caller just left.
3. The caller presses the "re-record message" command.
4. *Episode:* Make Recording.

S29 Caller distinguishes his/her message as urgent

Requirements: R4.4.

Precondition: Left Message.

Postcondition: Left Message.

1. The caller presses the "urgent" command.
2. EMS marks the message as urgent.

S30 Caller distinguishes his/her message as private

Requirements: R4.4.

Identical to the urgent message scenario, with "urgent" replaced by "private" everywhere.

S31 Caller decides he/she needs to speak to a receptionist

Requirements: R4.5.

Precondition: None.

Postcondition: No change.

1. The caller presses the "receptionist" command.
2. EMS connects the caller to the receptionist.

S32 Caller doesn't want to listen to the subscriber's announcement

Requirements: R4.6.

Precondition: Announcement Skippable.

Postcondition: No change.

1. A caller calls the subscriber's telephone while it is busy
2. EMS begins to play the subscriber's name and announcement.
3. Before the name and announcement are complete, the caller presses the "skip announcement" command.
4. EMS stops playing the name and announcement.
5. The caller leaves a message.

S33 Caller calls EMS and leaves a message

Requirements: R4.1, R4.2, R4.7.

Precondition: Has (n) New.

Postcondition: Has (n+1) New, Left Message.

1. A caller calls EMS directly and chooses the "Leave message" menu item.
2. EMS asks the caller to enter a subscriber's telephone number.
3. The caller dials the subscriber's telephone number.
4. EMS plays the subscriber's name and announcement.
5. The caller leaves a message.

Episode(s)

MakeRecording

1. *Iteration with explicit exit:*
 - 1.1. EMS tells the subscriber to begin recording.
 - 1.2. The subscriber says what he/she wants, then presses the "stop recording" command.
 - 1.3. EMS plays back the recording and asks for a confirmation or rejection.
 - 1.4. *Alternation:*
 - 1.4.1. The subscriber dials the confirmation command. – *Exit from iteration.*
 - 1.4.2. The subscriber dials the rejection command.