

Handling Conflict Between Design Descriptions Using Computer-Supported Negotiation

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Conflict is an inevitable part of both knowledge elicitation and system design. People will disagree over how to interpret features of the application domain, what the requirements for a new system are, and how to meet those requirements. Conventional systems analysis techniques avoid such conflicts, leaving any resolution untraceable and adding to the communication problems. This paper surveys a number of fields which have addressed the problems of conflict resolution. A mode of computer-supported negotiation is presented which can be used to address conflicts in systems analysis directly. The mode begins with an exploratory phase in which the conflict is broken down into its components, eliciting the issues which underlie disagreements and criteria to measure their satisfaction. A set of options for possible resolutions are generated using design techniques. Finally, these options are compared to the original issues and evaluated according to the criteria associated with the issues. The mode emphasizes communication and encourages investigation of other viewpoints. The mode has been used to develop a system called Synoptic which provides a set of tools to support the exploration of conflicts.

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This paper discusses the occurrence of conflict in the software engineering process and how it might be handled. In the computing literature, mention of the need to handle conflict is rare, which is perhaps surprising given the importance attached to it in the social sciences. For many years it has been recognised in management science and sociology that conflict is an inevitable feature of group interaction, to be harnessed for its positive aspects rather than suppressed. Robbins, Deutsch, Strauss, and others. Some recent software engineering research has identified conflict as an issue. Curtis, Krasner, Iscoe, Anderson, Fichas, and Feather.

Unless the application domain with which the software deals is free of conflict, then the resulting software must incorporate this conflict. For small programs, the domain can be restricted until the conflict is excluded. For any large-scale software, this is not practical. When the application knowledge is spread over many people, there is likely to be much disagreement between them and fitting together the many contributions will inevitably lead to inconsistency.

Even if a domain appears to be free of conflict, quite often there will be areas in which there are inconsistencies.

will refer to *participants* of the resolution process to cover a similar diversity. Not all parties to a conflict need necessarily be participants in its resolution.

The approach used to settle a conflict is a *Resolution Method*. Methods include negotiation, competition, arbitration, coercion, and education. Strauss (1988) states that not all conflicts need a resolution method, as not all conflicts need to be resolved. Three broad types of resolution method can be distinguished: *Co-operative* or *co-operative* methods, which include negotiation and education; *Competitive* methods, which include combat, coercion, and competition; and *Third Party* methods, which include arbitration and appeals to authority.

Negotiation is a co-operative approach to resolving conflict by exploration of the range of possibilities. It is characterised by the participants attempting to find a settlement which satisfies all parties as much as possible. Such an approach has been variously termed *integrative behaviour* or *constructive negotiation* to distinguish it from *distributive* or *competitive* negotiation. This definition of negotiation is not universal. Authors such as De Bono (1986) restrict negotiation to its distributive variety, implying a process of bidding and concession making, and so attack it as being inferior to an integrative approach. We prefer to give negotiation its broader definition, and call the concession making process *Bargaining*.

There are other co-operative methods than negotiation. Some conflicts might be resolved by education, where the participants gain a better understanding of the problem or simply learn about each other's viewpoint. Another important technique is to reformulate the problem so that it disappears or becomes unimportant.

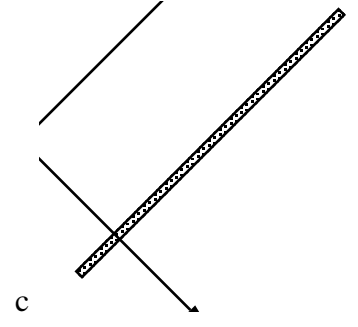
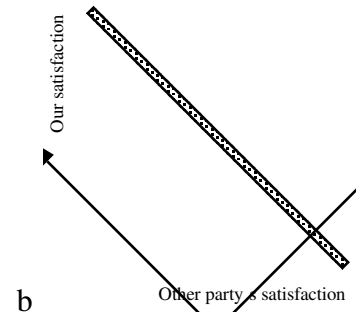
In contrast to negotiation, *Competition* concentrates on achieving maximum satisfaction for a participant, without regard for the degree of satisfaction of other parties. However, a competitive approach is not necessarily hostile. An extreme form of competition is when all gains by one party are at the expense of others, which in game theory is termed a zero-sum game.

Third Party Resolution covers any situation where participants are unable to resolve a conflict between themselves, and so have to appeal to an outside source, whether this be the rule book, a figure of authority, or the toss of a coin. Such a situation can occur with the breakdown of either negotiation or competition as resolution methods. There are two types of third party resolution: those in which the cases presented by each participant are taken into account, which we might term *judicial*, and those where a decision is determined arbitrarily, e.g. tossing a coin, or by factors other than the cases presented, e.g. by the relative status of the participants, which we might term *extra-judicial*.

Bidding and *Bargaining* are phases of the resolution process. Bidding is where participants state their desired terms for the settlement, often with an indication of the relative importance of the issues as a basis for bargaining. Bidding takes place in some form or other in most resolution methods, as participants must present their side, although in methods such as coercion, the bidding might be one-sided and implicit. A *position* is the set of terms that a participant commits itself to by making a bid. In bargaining, participants search for a satisfactory integration of bids. In the simplest case, this involves a converging sequence of bid and counter-bid, while at the other extreme, participants seek to blend complex bids together. Note that the description of the outcome as *satisfactory* depends on your viewpoint. However, bargaining usually results in a compromise, whereas true constructive negotiation seeks to develop a new solution which fully satisfies all participants.

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Decision theory is a prescriptive approach to analysis of a set of pre-specified alternatives. The interesting problems are concerned with resolving multiple conflicting objectives. Keeney and Raiffa (1976) state that decision theory assumes a single entity is making a choice, in contrast to conflict where there is more than one entity, each with a different perspective. Decision theory has a role in conflict resolution in helping participants to evaluate bids, to justify such evaluations, and to persuade the other participants that a solution is satisfactory.



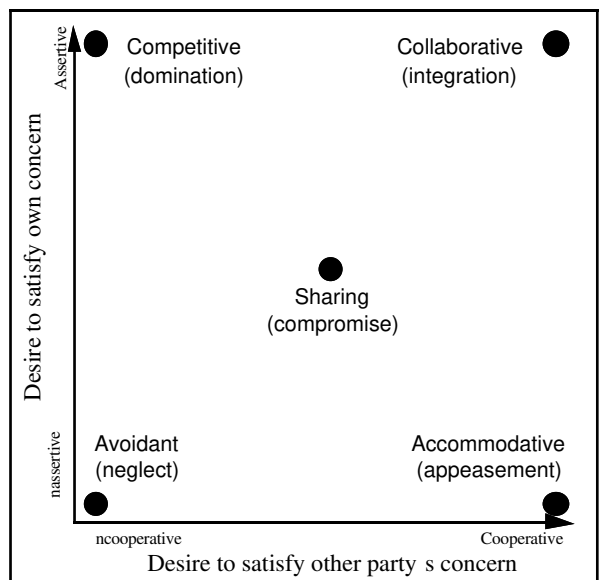


Figure 3: Behavioural modes of tackling conflict with (in brackets) the outcome sought in each mode.

important and need to be merged rather than compromised

Avoidant the conflict is recognised to exist but is suppressed by one or more parties or handled by withdrawal. It is useful where an issue is unimportant where the potential disruption would outweigh the benefits of resolution or where information gathering is more important

Accommodative a party becomes self-sacrificing to appease another and places the other's interests above their own. It is useful when issues are far more important to one party than another where one party is losing and needs to minimise loss or simply to build harmony and gain social credits

Sharing each party makes some concessions in order to reach a compromise. It is appropriate where temporary settlements or expedient solutions are needed especially under time pressure or where goals are directly opposed

Each of these modes is appropriate in some circumstances the more aware people are of the possibilities the more likely a suitable mode will be used. It is useful to compare these modes with the methods available for conflict resolution. For example collaborative methods such as negotiation and education which are most often used in the collaborative mode can also be adopted in other modes. Education can be used to achieve conflict avoidance or accommodation by enabling participants to understand their differences better. Similarly negotiation can assist with achieving a compromise seeing an accommodation or regulating competition. It is likely that successful negotiation requires at least some assertiveness and at least some cooperation from each participant. This in turn implies that each participant must have some motivation to resolve the conflict rather than avoid it.

A number of modes have been proposed for conducting face-to-face negotiation in a commercial setting e.g. Scott, Fisher, Rhymer, De Bono, Scott. Scott gives advice for preparation and the opening moments setting the climate and procedure of a negotiation. He uses a four-stage mode to pace the negotiation: Exploration, Bidding, Bargaining, and Settling. The exploration stage is emphasised as the most crucial, allowing participants to explore a range of possibilities before any confrontation takes place. In particular it allows the participants to explain to each other their interests, figure out and discover shared goals which were previously obscured from both.

De Bono discusses the flaws in argumentation that render it ineffective as a means of negotiation. The adoption of a particular perspective or theory dictates how the world will be perceived and leads to a rejection of alternative theories, making argumentation a polarising process. The key to De Bono's method is the use of a third party to design solutions to conflict as opposed to fighting, negotiating or problem-solving. However, his complaints against negotiating and problem-solving are based on very narrow definitions of these methods. Steffi *et al.* suggest that removing the personal attachment to positions prevents polarisation. Their computerised meeting room allowed participants to dispense with the feeling of ownership of

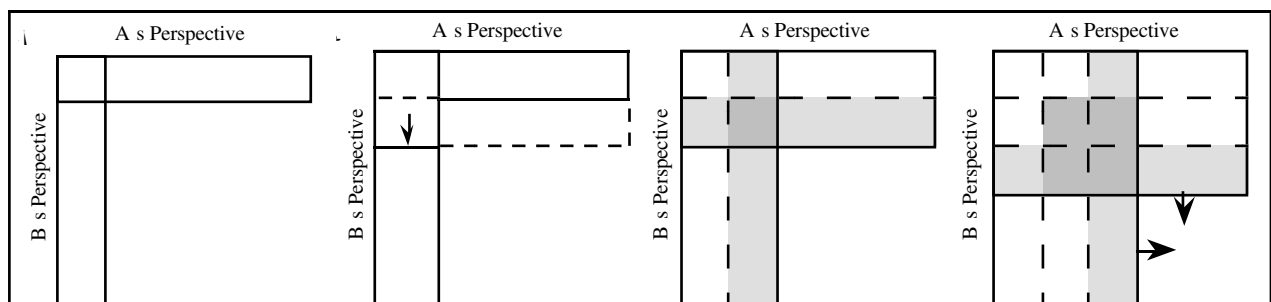


Figure 4: Scott [1988] explains the process of exploration in this way. In the first diagram, A and B's perspectives are very different, with little overlap. In (2), B begins to explain her perspective to A. Because A's perspective is different, A is able to take a great leap forward. In the process of learning more about each other's perspectives, they discover joint interests, shown by the darker shaded areas. These areas are likely to yield a jointly acceptable solution to the conflict.

ideas and so reduce the associated emotions when ideas are discarded or adopted. Similarly, Fisher et al. (1991) recommend that rather than bargaining over positions, participants should focus on interests and investigate options for mutual gain.

Some of the recommendations made in these negotiation modes are clearly useful for design. To summarise the main points:

- Exploration of each other's perspective is essential to constructive negotiation.

- Participants should be separated from the bids in order to avoid polarization.

The code is intended to be prescriptive in that it acts as a set of guidelines without being a rigid formulaic process. The tools developed to support the code are highly interactive and are designed to provoke discussion of the conflict situations as well as elicit a suitable resolution. The code is based on the behavioural approaches used in organisational design and in particular takes note of

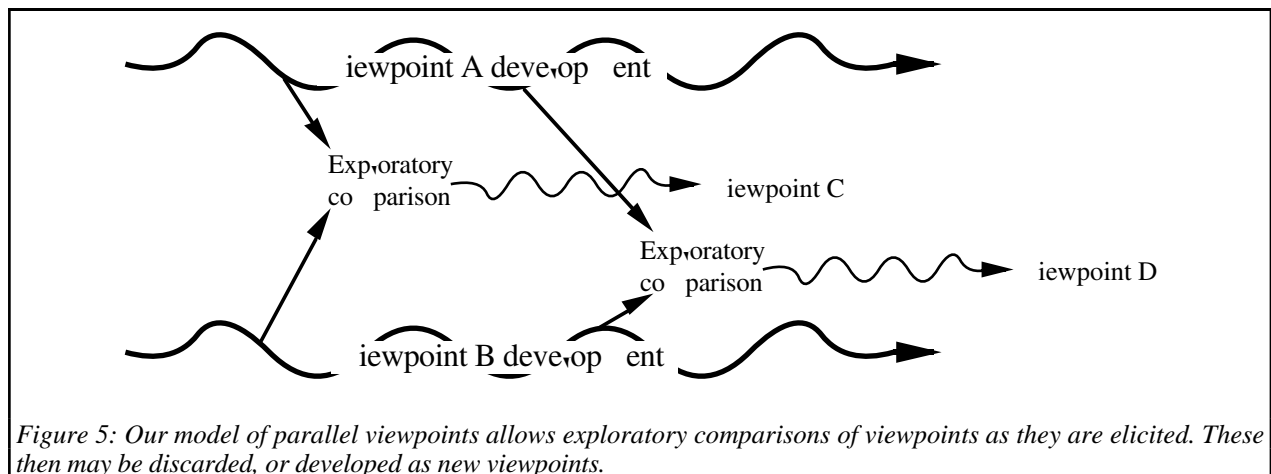


Figure 5: Our model of parallel viewpoints allows exploratory comparisons of viewpoints as they are elicited. These then may be discarded, or developed as new viewpoints.

for instance to modify terminology or to elicit information that the originator neglected. The results of any exploratory integrations can be treated as new viewpoints which can continue to take part in the development process (figure 5). Such derived viewpoints effectively represent coalitions of perspectives, which have been shown to arise in software projects (Curtis, Krasner, Iscoe).

The ordering of viewpoints allows differences between perspectives to be captured and accommodated. If only a single description was maintained, differences between parties would tend to be avoided or suppressed, and often go unnoticed. As the viewpoints contain formal descriptions, it is possible to combine parts of different viewpoints to reason with, and detect inconsistencies. The process of parallel development of viewpoints, with exploratory integrations being initiated at any point, provides the context for our model of conflict resolution.

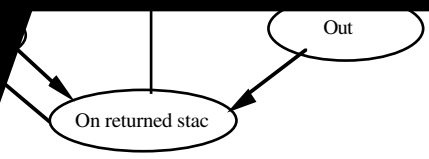
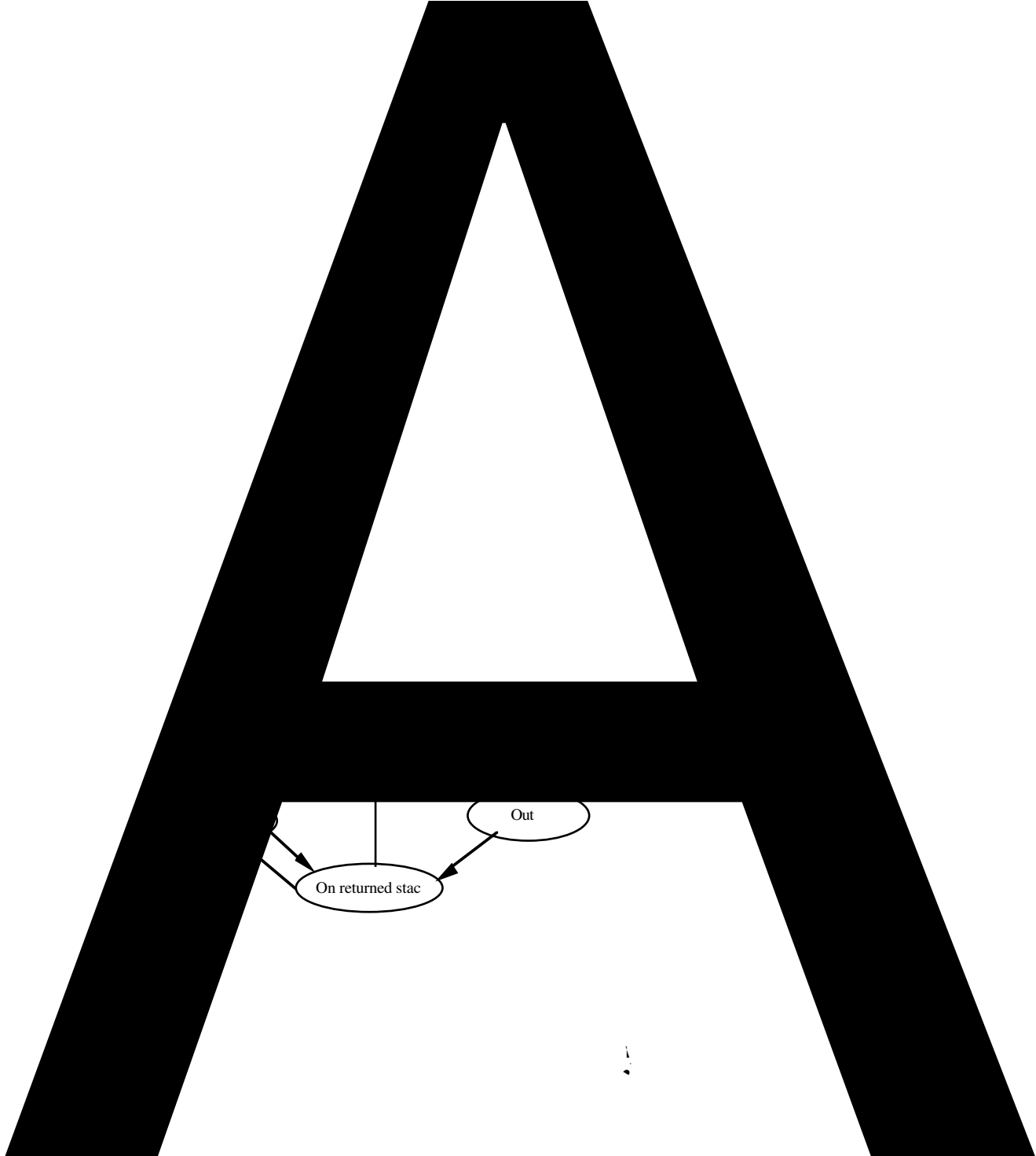
3.1.2. Detection of Conflict

The first problem for conflict resolution is to recognise that a conflict exists. This might be harder than it seems for a number of reasons. The terminology used by the participants is unlikely to match exactly (Shaw, Gaines, 1986), and the styles in which knowledge about an issue is expressed will differ. This difference may be because of different representation schemes, or different descriptions within the same representation scheme. Also, participants will have different areas and different amounts of knowledge, making it difficult to make comparisons. These problems make it hard to tell where participants are agreeing, yet alone where they are disagreeing.

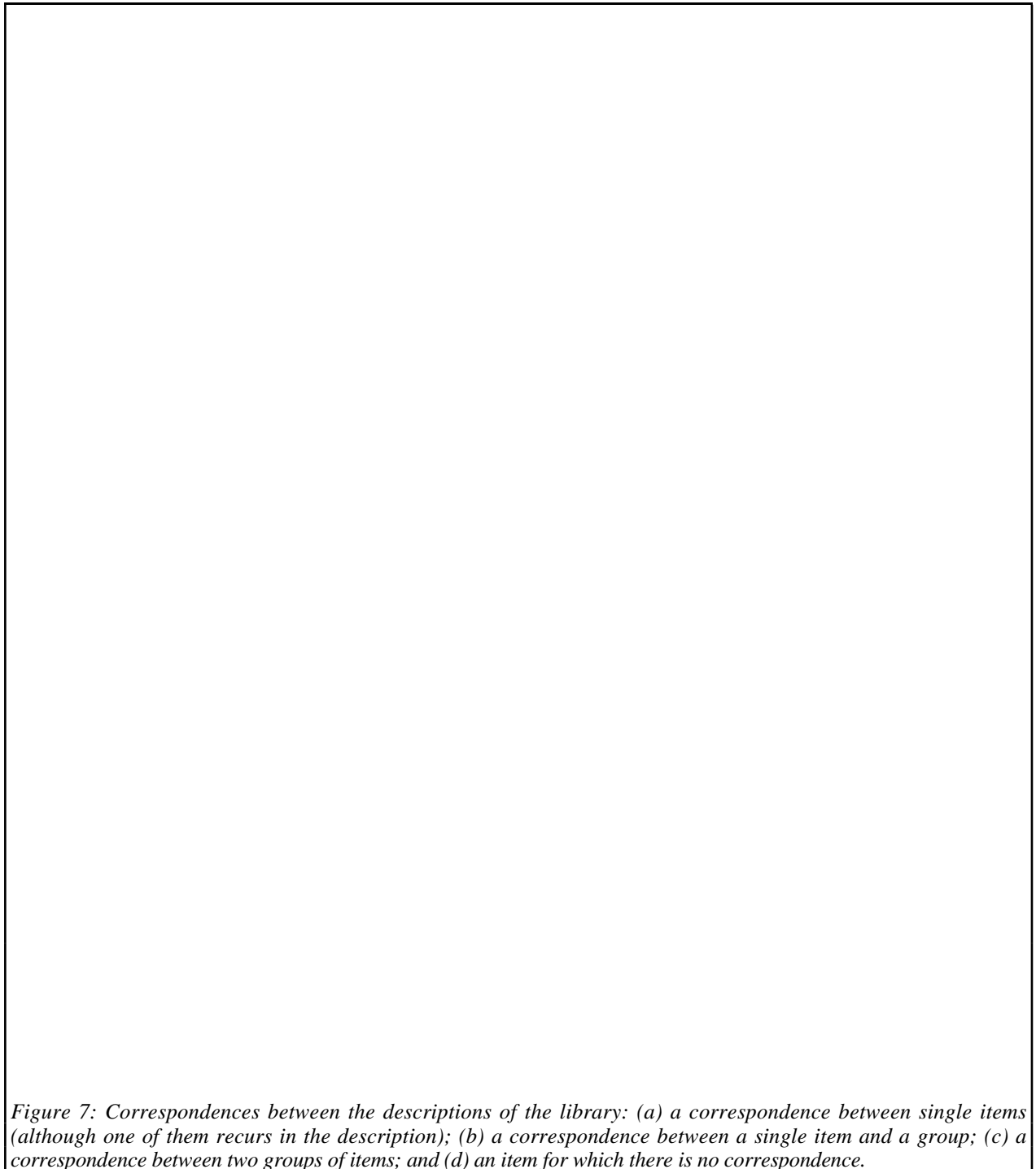
Our definition of conflict was based on interference: two parties are in conflict if the activities of one adversely affect the interest of another. Hence, viewpoints are free to differ, and only conflict when that difference matters for some reason, leading to interference. There are a number of situations in which the differences matter:

- when viewpoints need to be compared
 - when there is a need to reason with knowledge from several viewpoints
 - when the originators insist their viewpoints are better than others, and so perhaps should be adopted at the expense of the others
 - when a coherent description is needed for further progress
- Under normal circumstances, differences between viewpoints are ignored, allowing them to develop independently. By only entering the conflict resolution process when differences between viewpoints matter, we avoid attempting to resolve conflicts unnecessarily. A conflict, then, is simply a difference that matters.

Note that defining conflicts as differences that matter will include any things that might not normally be regarded as conflicts. The distinction that Deutsch (1980) draws between real and apparent conflicts is deliberately ignored. Apparent conflicts here might include where one party has misunderstood another's position, where viewpoints use different terminology to describe the



detected. For example, given the descriptions in figure 1, let us say that the analyst is trying to establish when a book is available for loan. The states ON SHELF in figure 1a and AVAILABLE in figure 1b seem to correspond roughly, but there is conflict, as neither the names nor the transitions attached to these states match. In this case we begin the exploration with these two diagrams and an indication that the conflict is between ON SHELF and AVAILABLE.



not be exact, as decomposition usually reveals details about a description not considered at a coarser grain. Again, such comparisons yield issues that one description may not have addressed, which could be usefully discussed.

Correspondences between a group of items in one description and a different group of items in another description reveal where different types of decomposition have taken place. For example, the states ON SHELF and ON RETURNED STACK in the first description correspond to the group AVAILABLE ON RESERVE and RECALLED in the second figure c. In this example, both groups are decompositions of In the Library. The two groups will not necessarily match exactly. For example, the RECALLED

the comparison reveals issues that have been neglected in either description. Example: An assumption may be attached to the component above to note that a librarian's code assumes that books waiting to be shelved can be located for loan.

Issues—these are points that need to be addressed. There are many circumstances under which issues arise, but often components and assumptions will result in an issue. Example: the assumption above might lead to the issue, "How can books that have been returned but not shelved be traced?"

Justifications—These are added to support a particular viewpoint or proposal. Often these will be added in response to assumptions and components to provide a rationale for the original item. They will also be added in the next two phases of the process to relate solution components to issues.

Several of the examples in the previous section showed how issues arise during the comparison of descriptions. Typically, issues are prompted by the creation of a correspondence, and the supporting tools prompt the user to note any assumptions or issues that arise when creating a correspondence. Assumptions have an issue attached automatically, questioning whether the assumption is reasonable, to ensure that the assumption is discussed when the issues are considered later in the process.

3.2.3. Agreeing Resolution Criteria

The final part of the exploration phase is the establishment of criteria by which to judge possible resolutions. Fisher et al. suggest that objective criteria should be agreed before any resolutions are generated, to ensure that an agreement can be reached. This is to prevent participants moving the goal posts to get their personal preference accepted. However, it is often not clear before any solutions are proposed what the criteria should be. It is an open question as to

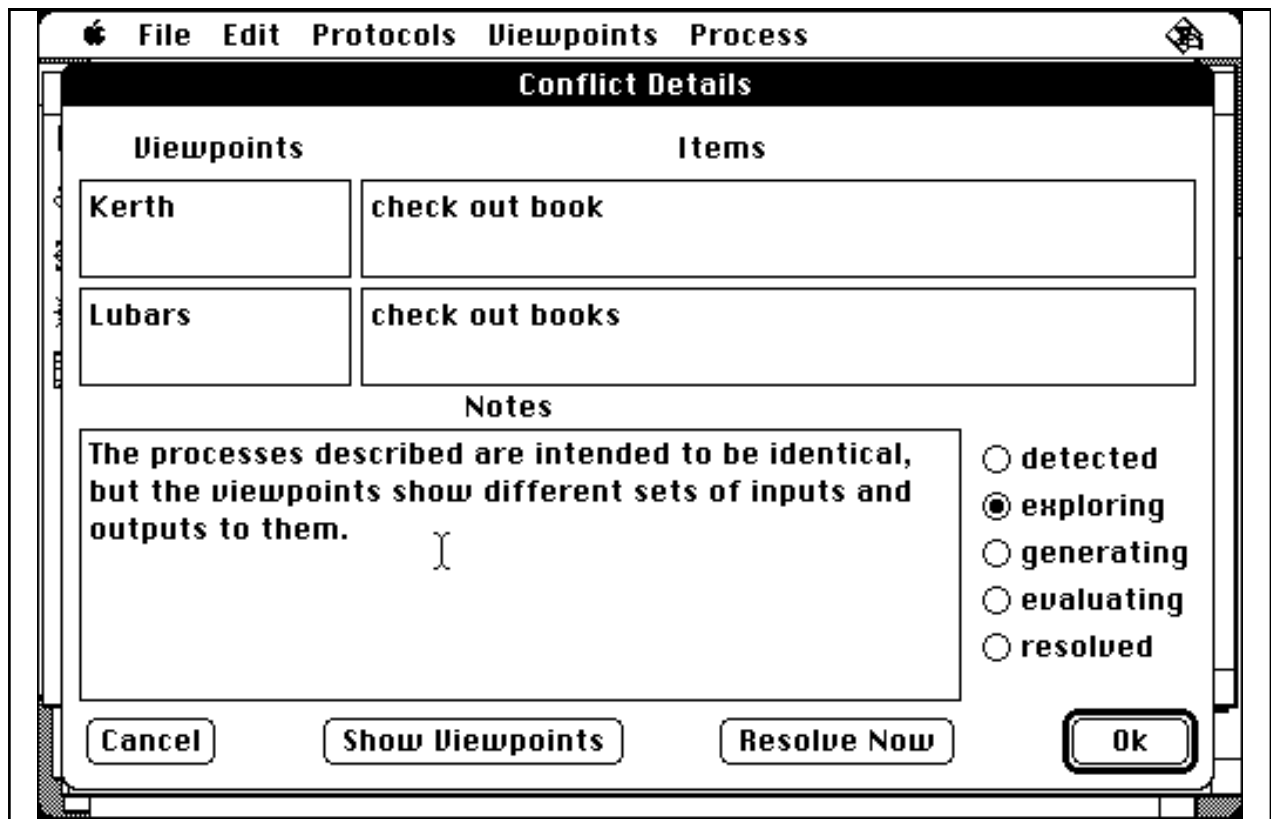


Figure 8: A screen snapshot from Synoptic 1.0, showing the form to be filled in when a conflict is detected. The system keeps track of the resolution process automatically.

3.2.4. Functionality of the Exploration Tools

Synoptic is an extension of the *Analyser* system described in Easterbrook [1987]. It provides a set of tools to support the conflict resolution mode. A single menu selects which phase of the mode is in operation and within each phase a palette of tools is available.

Conflicts between viewpoints can be noted by filling in a conflict form as shown in figure 8. When a difference between viewpoints needs to be resolved, the conflict resolution process is invoked by selecting the exploration phase from the conflict menu. The same menu is used to move from one phase to the next and to move back to a previous phase if necessary. The display of this menu is modified to show the current state: completed phases are marked with a tick, while phases beyond the next are shaded to show they are unavailable (see figure 9).

When noting a conflict, the user is asked to select those items in the viewpoint descriptions which are in conflict. In the exploration phase, these items, together with their immediate context, are displayed side by side in a synoptic window. A palette of tools is attached to this window to allow the following operations:

- Selector arrow icon for selecting items within the displayed descriptions, for some subsequent action, such as attaching a note. The selected items are displayed in grey.
- Mover hand icon for moving a displayed description around. As items can be added or removed from the displayed descriptions, it may become necessary to adjust their relative positions within the synoptic window.
- Extend description expand icon. This tool extends descriptions in the synoptic window by adding more items from the source viewpoints. For any selected item in the synoptic window, all immediately connected items in the viewpoint description that are not already displayed in the synoptic window are added.

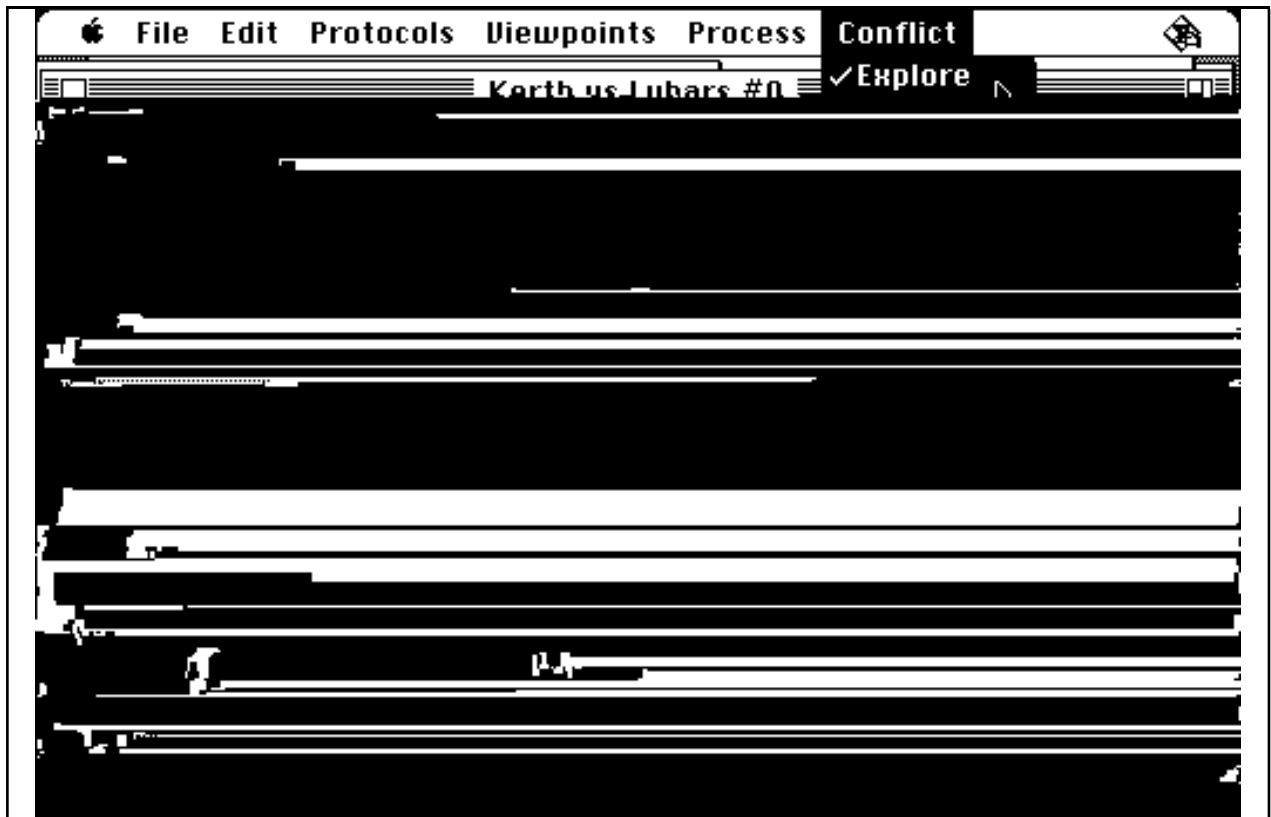


Figure 9: A screen snapshot from Synoptic 1.0, showing the window created to compare two descriptions, and the tool palette (down the left hand side). The "Conflicts" menu, which allows the user to move between phases is also shown.

Tri description icon This tool allows the user to tri items from the descriptions displayed in the synoptic window. Items that are listed as part of the conflict on the conflict for cannot be tri ed.

Conflict for icon This displays the conflict for

Attach note excitation icon This tool allows the user to attach a note to any item or in. The user will be asked to select the type of note to attach (see). Each type of note has a form to fill in. In the case of issues and assumptions, the form has slots for criteria and justifications. For any type of note the user is prompted for a brief title by which the note can be referred.

Create correspondence icon A correspondence is created between the selected items. The user will be asked whether the correspondence is exact or approximate and will be prompted for any issues to attach.

Find correspondence icon Displays any correspondences involving

Copy text into asud records on issues to respond to

Conflict icon This tool allows the user to copy text from the descriptions displayed in the synoptic window into the conflict for. The user will be asked whether the text is exact or approximate and will be prompted for any issues to attach.

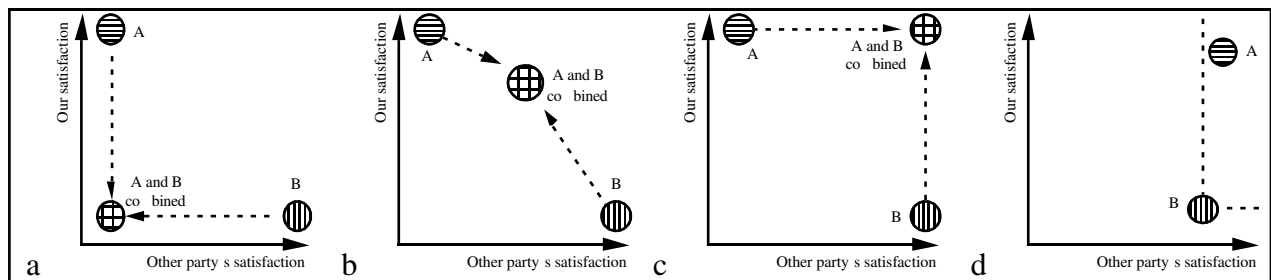


Figure 10: These diagrams show conflicts of different severity. In (a) the viewpoints are mutually exclusive, as their combination satisfies neither (the combination might not even be possible). In (b) the viewpoints can be combined, but with some loss of optimality for each party, and in (c) the viewpoints are non-interfering and can be directly combined. A variant of the non-interfering type is shown in (d), where one of the viewpoints already satisfies the other's concerns.

original viewpoints and respond to the issues identified in the exploration phase. At this stage, the options are not evaluated, nor are they checked against the issues. This prevents the creative process being stifled by pragmatic considerations (Steffi *et al.*). The options might be generated in a variety of ways, from directly combining elements of existing viewpoints to techniques such as lateral thinking and brainstorming.

The result of the generative phase is a list of options for resolution. These options are not intended to be complete resolutions, but might be combined in various ways to arrive at one. It is also possible that some of the options will be incompatible with one another; the evaluation phase will examine how the options can be combined.

3.3.1. Types of Conflict

Before the generative process gets underway, it is useful to characterise the type of each component of the conflict revealed by the exploration process. This will help to decide what for the generative phase will take and what a possible resolution might consist of. We can identify three broad categories of conflict that might arise in systems analysis, as follows:

Conflicting interpretations – descriptions of the current situation or the current requirements do not match, usually because different perspectives interpret things differently. This category corresponds to the category *Beliefs* or „How things are“ as described by Deutsch.

Conflicting designs – suggestions or partial designs for how the system should be do not match. This roughly corresponds to the Deutsch's category *Values* or „How things should be“ here a requirements specification would not normally be expected to contain design information; participants are likely to express some of their requirements as partial designs, representing their preconceptions of the system.

Conflicting terminologies – the terms in which things are described do not match. This covers the communication problems suggested by Robbins, as being a major cause of conflict.

In addition to these three categories of conflict, a scale for the severity of the conflict is used. This ranges from *non-interference* at one end to *mutual exclusion* at the other. The former implies the items in conflict can be combined directly without compromising either, whilst the latter indicates that each totally negates the other, and only one can be used (figure 10).

Using this scheme, conflicts identified as non-interfering can be eliminated from further resolution work, as the direct combination of the two viewpoints provides an instant resolution. Where the two viewpoints provide alternative views or alternative terms, the circumstances under which each should be used still needs to be examined. For the remaining conflict types, there is plenty of scope for the design of novel resolutions which circumvent the conflict, by satisfying the underlying issues in other ways.

Table 1 describes typical examples of each of the categories and levels of severity, together with examples from the library books conflict. The examples are from the list of specific

correspondences and differences discovered in the exploration phase. Some of the examples are phrased in a way that suggests possible resolutions – consideration of where these conflicts should appear in the table helped identify potential solutions. Note that these individual options are not exhaustive and may obscure other possibilities. For example, exploration of this particular conflict revealed that one viewpoint was concerned with the physical whereabouts of a book while the

	Interpretations are not wholly consistent and if both are to be used, some resolution is required.	Designs can be combined but interfere and the direct combination may not be the ideal resolution.	The same verbs have been used for similar concepts. The differences need to be resolved.
Interpretations are not wholly consistent and if both are to be used, some resolution is required. <i>Example: the possibility of books going missing has been omitted from the first viewpoint, and could be added directly if necessary.</i>	The design can be directly combined without compromising either. <i>Example: The recall facility, which is assumed to be a design suggestion, could be added directly to the first viewpoint.</i>	Different terms have been used for the same concept. Need to find out which to use when. <i>Example: "borrow" and "issue" apply to the same action. A borrower is more likely to use the former term, and a librarian the latter.</i>	
Interpretations are not wholly consistent and if both are to be used, some resolution is required. <i>Example: The "shelve" action is not wholly consistent with the second viewpoint as "available" does not quite correspond to "on shelf".</i>	Designs can be combined but interfere and the direct combination may not be the ideal resolution. <i>Example: A reserve collection could be added to the first viewpoint by splitting the "on shelf" state to indicate the type of shelf.</i>	The same verbs have been used for similar concepts. The differences need to be resolved. <i>Example: "Out of circulation" and "At binders". The latter is more specific, and implies that these books will eventually return.</i>	
Interpretations totally contradict one another and cannot be used in conjunction. <i>Example: There is no "return" action for recalled books in the second viewpoint, contradicting the notion of a returned book stack.</i>	Designs are completely incompatible or tend to negate one another when combined.	The same verbs have been used for different concepts and so distinguishing terms are needed. <i>Example: The "return" from "at binders" is indistinguishable from the "return" from "lent". These might be completely different actions.</i>	

Table 1: Different types and severities of conflict, and for each a description of the kind of situation covered, and an example from the library books conflict.

Proposals might also recommend that one interpretation should be discarded in which case the issues raised by the discarded description need to be satisfied in other ways

3.4.1. Relating Options to Issues

The first task is to relate the suggested resolutions to the issues underlying the conflict. This may be done by taking each option in turn and selecting the issues that it satisfies, or by taking each issue in turn and deciding which options would satisfy it. Both approaches have merit in that either may reveal additional issues missed in the other. Satisfaction of issues is measured using the criteria attached to the

The links between options and issues vary in the extent to which the option satisfies the criteria. Also, the relationship may be either positive or negative, where the former indicates the option contributes to the satisfaction of the issue, and the latter indicates it frustrates the issue. Unfortunately, the complex relationship between options and issues cannot be satisfactorily expressed using a simple numeric scale. Instead, a qualitative scale is used, along with explanatory notes. Participants may attach one of five values to each combination of option and issue. The values are fully satisfies, partially satisfies, no effect, partially frustrates, and totally frustrates. The system attaches the value "no effect" by default. If the satisfaction of frustration is partial, an explanatory note is attached. These values will later be used to compare the options which contribute towards each issue.

3.4.2. Relating Options to One Another

The individual resolution options may interact in interesting ways. Some might usefully be combined to produce a resolution which satisfies more issues than either individually. For example, the suggestion of adding a missing state to the first viewpoint, and the suggestion of renaming the arrow from both this state and the state at binders state to restock might be combined to give a more complete solution. For other options, combination will negate some of the benefits. For example, the suggestion of adding a reserve correction to the first viewpoint is not compatible with the suggestion of maintaining two types of state information, whereabouts and loan status. The range of interactions between options is analogous to the possible interactions between the parts of the original viewpoints, as shown in figure 1, which were evaluated using a scale of severity.

Where two or more options can be combined, the combination is recorded as a new option. In creating the combination, the way in which the combination satisfies the issues may need to be reconsidered. In most cases, the combination will satisfy all the issues that the individual options satisfied. However, this is not always the case, and in particular, it is not clear how options with differing strengths link with an issue might be combined. This information needs to be elicited from the participants. Additionally, the combination might only be possible under certain circumstances, which need to be recorded as conditions for the new combined option.

3.4.3. Choosing a Resolution

Once the options have been linked to the issues and to each other, the only remaining problem is to select the best option or combination of options as a final resolution. In many cases, an agreed resolution will have emerged during the process, making much of the evaluation phase redundant. However, in cases where there is no obvious resolution, the options need to be compared. If there is an option or combination which satisfies all the issues, then this is a viable candidate. If any participants are unhappy with such a resolution, their reasons need to be elicited; these are likely to indicate issues that were missed in the exploration phase.

To a certain extent, if there is still no clear resolution at this stage, this can be seen as a failure of the negotiation process. The aim of the entire process is to explore the conflict and educate participants about each other's viewpoint; if this is successful, a resolution should emerge from the process, or the conflict should disappear. In the last resort, the participants might either agree some decision-making procedure, or agree to leave the conflict unresolved. In the case of the former, the procedure will depend on the perceived importance of the conflict. An unimportant conflict might be resolved by an arbitrary method, while a more important conflict may require a process of ranking the issues, to select the option that best satisfies the most important issues.

The chosen resolution is represented as a new viewpoint which can be used instead of the original conflicting descriptions. Here the conflict involved only a part of the original viewpoints; the viewpoints can now inherit the relevant section from the resolution viewpoint. The original descriptions are retained as part of the record of the resolution process. The conflict map is recorded as a rationale for the resolution viewpoint, so that it is available for later re-examination if necessary.

3.4.4. Support for the Evaluation Phase

Linking issues to options is a straightforward interactive activity. Two approaches can be used: an option is displayed and the user asked to select those issues which it addresses, or an issue is displayed and the user asked to select the options which address it. The user can switch between these two approaches. In either case the procedure is the same: the option or issue is displayed alongside a list of the titles of the issues or options to which it may be linked. The full details for any title can be displayed by clicking on it. The user selects the relevant titles, and for each is prompted for the strength of the link, which is then indicated by flagging the title with one of the symbols: \bullet representing totally satisfies, \circ partially satisfies, \square partially frustrates, and \times totally frustrates respectively. The links can have explanatory notes attached to the

For the process of linking options to one another, the user may select a group of options to link together from a list, or may as *Synoptic* to suggest a possible combination. In the latter case, combinations are chosen to maximise the number of issues satisfied, and may not always be sensible. The chosen combination is recorded as a new option, for which the process of linking to issues is repeated, as described above, with the links already fixed in where possible. Here the link cannot be calculated automatically, for instance because one of the combination frustrates an issue which another satisfies; a question mark is displayed to remind the user to fix in the information.

Support for the final stage, selecting a resolution, is provided for the reasons set out in the previous section. An option is available to attach a numerical importance to each issue, so that the system can calculate a numerical score for each resolution option. The mechanics of this are very simple: the user is presented with each issue in turn and asked to select an importance value. These values are then combined with the values on the links between options and issues to generate a score for each option. The system does not allow for disagreement between participants over the importance measures. No attempt is made to support any other type of decision procedure.

4 SUMMARY

This paper has described a mode of conflict resolution which can be used to integrate conflicting domain descriptions. This forms part of a larger mode of requirements engineering based on the representation of multiple viewpoints, as described in Easterbrook. In recognition of the fact that carefully managed conflict can help eliminate errors and improve the quality of the requirements specification, the mode encourages the expression of conflict by allowing participants to describe their viewpoints separately. Expression of conflict needs to be balanced with productive resolution methods, to encourage collaboration and to ensure that conflicts do not become counter-productive. The mode described in this chapter was designed with this aim in mind.

The mode consists of three phases: exploration of the participants' perspectives, the generation of suggestions for resolving the conflict, and the evaluation of these suggestions. During the exploration phase, the initial conflict is broken down into its components, represented as specific correspondences and differences between items in the viewpoint descriptions. These are annotated with comments describing any assumptions they make and issues they raise. These links and annotations act as a map of the conflict to guide the later stages. Resolution takes the form of designing novel ways of satisfying the issues. In the final phase, the ideas generated are then

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