

Consensus Building Technique Based on Structured Requirements

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Although the importance of upstream processes in system development has been talked about for a long time, project failures originating in the requirements definition process show no sign of decreasing. The increasing difficulty of the requirements definition process itself due, for example, to current conditions and changes in the business environment certainly plays a part in these failures, but there is a more fundamental problem in requirements definition unrelated to those factors. In this paper, we introduce a technique for building consensus and achieving traceability in requirements definition on the basis of a layered structure of stakeholders and the continuity of demands. This new requirements definition technique addresses the three mutually related issues of clarifying the roles and responsibilities of all stakeholders, ensuring the validity and sufficiency of requirements by confirming their continuity, and providing for management participation and control in requirements definition. It increases the settlement power in requirements definition and improves consensus building, so it should minimize the need for revisions during the system development process.

1. Introduction

Many arguments and proposals have been made over the years with regard to the importance of requirements definition in system development. A questionnaire (1241 parameters)¹⁾ given to visitors at the 2005 Software Development Expo (SODEC) sponsored by the Software Engineering Center of Japan's Information-technology Promotion Agency (IPA/SEC)²⁾ included the question: "What do you feel hinders the project development process?" The top two replies, as in the past, were "proceeding while customer requirements are still unclear" and "customer requirements that are far from settled". Such a situation poses a direct threat to quality and productivity in a system-development project, but it poses an even graver threat to the fulfillment of the primary objective of achieving business requirements. In other words,

inadequately defined requirements can easily lead to a proliferation of unusable systems that do not promote efficient operations or strategic use of information as demanded by managers and the user divisions. In the face of such threats, Fujitsu has been researching ways of improving the content quality (validity, compatibility with objectives, feasibility, etc.) of requirements.

In this paper, with the aim of raising the accuracy of requirements definition and achieving system development in line with primary objectives, we survey current problems in the requirements definition process and introduce a technique for building consensus and achieving traceability on the basis of a layered structure of stakeholders and the continuity of demands. In the following discussion, the terms demand, requirement, and specification are defined as follows.

- Demand: a vague desire or expectation, as in “I’d like to have it like this” or “That would be good.” It is an ambiguous state that has yet to be defined.
- Requirement: the state in which the conditions necessary for achieving a demand are defined. At this point, however, there are still various means of achieving the requirement.
- Specification: the state in which a means of achieving the requirement has been selected.

2. Issues

The following three points can be offered as examples of how current conditions are making requirements definition difficult:

- 1) The range of system stakeholders has expanded, making consensus building difficult.
- 2) System development based on the simple conversion of manual tasks (described in operating-rule specifications, etc.) is now virtually finished, and the creation of new business operations themselves has become necessary.
- 3) System development has been forced to keep up with changes in the business environment, resulting in less time available for requirements definition.

In addition to the above, corporate information technology (IT) systems divisions have come to devote considerable resources to the operation and maintenance of existing systems, which take up 60–70% of IT investment, resulting in an environment in which satisfactory requirements definition cannot be performed.

Against this background, we can list the following problems related to requirements definition as commonly heard in today’s IT systems divisions.

- 1) Ambiguity in the purpose of demands prevents priority from being assigned to the large number of demands made. As a result,

the business division comes to dominate and the scale of development expands.

- 2) Lack of clarity about who is responsible for which requirements prevents decisions from being made and makes it easy for changes to occur.
- 3) The business division comes to say that “the system is hard to use” while management comes to say that “system contribution to operations is low”.

In short, we can regard the above problems as originating in insufficient “settlement power” in relation to requirements definition. Thus, one might think that assigning a persuasive, domineering person capable of making decisions to the job of coordinating requirements would solve the problem. However, that is not the case because such an approach cannot ensure that the primary objectives will be met.

The root of these problems is thought to be the ambiguity over who takes on what roles and responsibilities in requirements definition, no sense of purpose in developing the target system, and inability of management to decide on “what we need to do” from a corporate perspective between the business division’s “what we want” and the IT systems division’s “what we can do”. To eliminate these problems, we must address the following three issues.

- 1) Clarify the roles and responsibilities of all stakeholders
- 2) Ensure the validity and sufficiency of requirements by confirming their continuity
- 3) Provide for management participation and control in requirements definition

These issues and their resolution by Fujitsu’s new requirements definition technique are described in detail below.

2.1 Roles and responsibilities of stakeholders

In our new requirements definition technique, the structure of requirements can be thought of as a matrix with the vertical axis

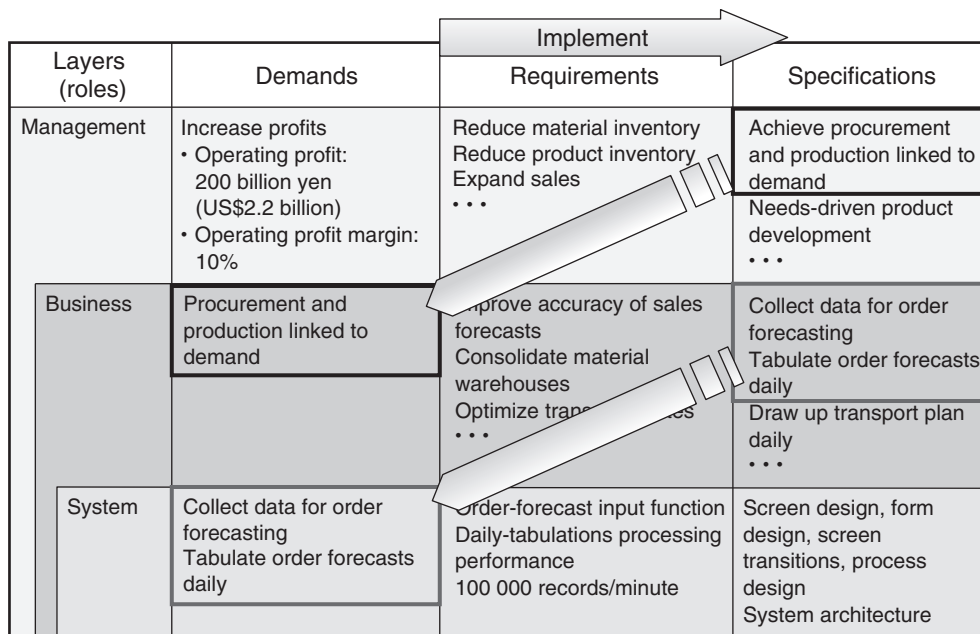


Figure 1
Structure of requirements.

corresponding to roles and the horizontal axis corresponding to the implementation of demands (**Figure 1**). In other words, the management layer in charge of corporate operations, the business layer in charge of business operations, and the system layer in charge of corporate IT systems each work to clarify the requirements and specifications associated with specific demands. The idea behind this matrix is that specifications in the management layer become demands in the business layer, while specifications in the business layer become demands in the system layer. The sharing of this structure helps to clarify the range of responsibility for defining requirements and those elements that link different roles.

The model of a requirements management structure supported by the new requirements definition technique is shown in **Figure 2**. It is a simplification of the requirements structure shown in Figure 1. Here, requirements that should be defined on the management level correspond to Management Objectives and Measures, requirements that should be defined

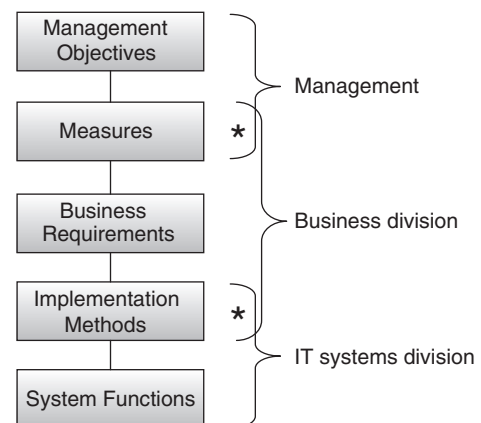


Figure 2
Structure of requirements management.

on the business level correspond to Measures, Business Requirements, and Implementation Methods, and requirements that should be defined on the system level correspond to Implementation Methods and System Functions. The responsibility for defining requirements that overlap two adjacent layers (marked by * in the figure) generally falls on the upper layer, but a more realistic approach is to define those

requirements in agreement with the lower layer. Defining a non-overlapping requirement is the responsibility of the layer in question. Allocating requirements on the basis of this model can demarcate the responsibility of each stakeholder and prevent procrastination in requirements definition.

2.2 Validity and sufficiency of requirements

Recognizing the above requirements-breakdown structure from the upper to lower layers is important for clarifying where the responsibility for requirements lies; however, in reality, requirements are not always defined in such a top-down manner. Indeed, there are many cases in which demands for improvement come directly from the field. Therefore, the relationships between requirements must be closely watched and evaluated and the priority level of a requirement that does not agree with the objectives must be lowered. In this process, examining a requirement to see whether it is firmly linked to an upper-level requirement (i.e., checking whether the upper-level requirement is the reason that requirement is needed) is called a “validity” judgment, and examining a requirement to see whether it is firmly linked to a lower-level requirement (i.e., checking whether the lower-level requirement can contribute to achieving that requirement) is called a “sufficiency” judgment. The value of a requirement’s existence cannot be confirmed until its validity and sufficiency have been ensured. This approach, which examines the relationships between upper- and lower-level requirements from the perspective of compatibility with objectives, is an analysis technique that falls into the category of goal-oriented requirement analysis.³⁾⁻⁵⁾ There have been many reports on related techniques.⁶⁾

Fujitsu’s new requirements definition technique makes an original enhancement to goal-oriented requirement analysis. Here, the relationships between requirements on the five

levels of the management-structure model shown in Figure 2 can be expressed as an analysis view (Figure 3). This view lets one easily check for the existence of validity and sufficiency for requirements at a glance. It makes it easier to revise the priority of a requirement when there are broken links in the upward direction and to take appropriate countermeasures for broken links in the downward direction such as defining the Implementation Methods in a more concrete manner. It provides the analyst with a comprehensive view of the overall requirements picture as it should be.

2.3 Management participation and control in requirements definition

Even if the roles and responsibilities of stakeholders and the relationships between individual requirements can be clarified, complications can still arise among the stakeholders with regard to requirements definition for various reasons. Such entanglements should be thought of as viewpoint-based differences that can make it impossible to say which stakeholder is right. For example, during the definition of the Implementation Methods layer in Figure 2, ill feelings may arise between the business division and IT systems division as the former professes that a certain requirement is absolutely needed for business purposes while the latter claims that there is no budget for implementing it.

In the face of such a standoff, a solution can be sought through a representative council system, but in this case, the missions of the two divisions are bound to clash, resulting in a futile resolution dictated by the most domineering party. At this time, management’s voice of authority can demonstrate its power. Of course, this does not mean arbitrary, off-the-cuff decisions made by individual managers. Rather, it means weighing the business division’s “what we want” against the IT systems division’s “what we can do” to decide “what we need to do” from a

Management Objectives	Measures	Business Requirements	Implementation Methods			System Functions
To be satisfied 3 ←	To be satisfied 2 ←	To be satisfied 1 ←	Object ID	Content	Demand state	← To be satisfied 1
F10 Management Objectives PU4 Procurement and production in line with demand •Procure materials and produce products based on demand forecasts. •Forecast demand on a daily cycle.	F20 Measures BR3 Improve accuracy of sales forecasts from order forecasting •Work to improve accuracy of sales forecasts. •Enable previously collected order-forecasting data and forecasted data to be tabulated.	F30 Business Requirements SR6 Enable tabulation of order-forecasting data. •Enable previously collected order-forecasting data and forecasted data to be tabulated on a daily cycle.	SR7	1. Enable order-forecasting data to be tabulated within 10 min. Enable daily tabulation of order-forecasting data to be completed within 10 min after collection cutoff. Assume up to 100 000 records on peak day.	Demand	F40 System Functions SF7 Performance of batch-processing server is XXX.
Valid			Valid			Sufficient
Purpose of Implementation Methods is unclear.			SR11	2. Enable check of cancelled orders. Once an order-cancellation has been input, the user must be able to check whether the cancellation process has been completed.	Requirement	F40 System Functions SF10 •Check for completion of order cancellation. •Check whether order cancellation process has been completed. (completion of all shipping plans must be updated.)
Valid			Valid			Sufficient
F10 Management Objectives PU8 Lead-time reduction •Shorten lead time from order receipt to shipping.	F20 Measures BR10 Streamlining and automation of processes •Streamline and automate processes to reduce overall time.	F20 Business Requirements BR11 Automatic customer notification (order received, order status) •The customer must be notified of all events, such as order creation, order modification, order cancellation, and order status changes.	SR12	3. Customer is to be notified of order cancellation.	Requirement	
Valid			Valid			System Functions for implementing Implementation Methods are undefined.

Figure 3
Example of analysis view.

corporate perspective (Figure 4).⁷⁾

To enable management to contribute to the decision-making process in this way, our new requirements definition technique not only provides an analysis view for deciding validity (as described in Section 2.2), but also defines the “degree of contribution” and the “load for achieving (expense, time)” for evaluating a requirement with respect to an upper-level requirement. By referring to these indices, managers can make a final decision from a management perspective.

3. Effect and future issues

First, to gauge actual conditions in the management of requirements in the field, we analyzed case studies using requirements management documents from 11 projects.

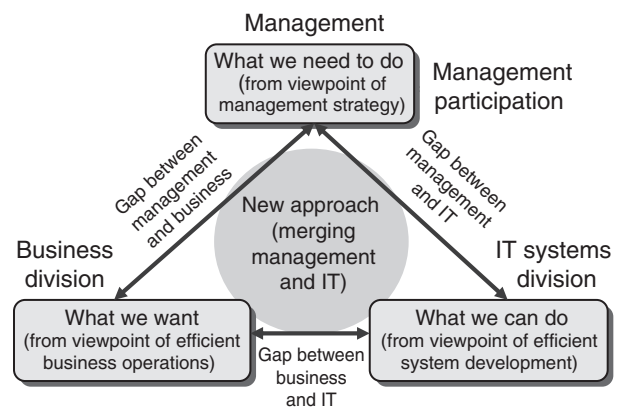


Figure 4
Significance of management participation.

For all these case studies, we found that the relationship between upper-level requirements (such as the project’s “objectives”) and lower-level

requirements (such as system requirements) was hardly managed and that there was no structure for comprehending the validity and sufficiency of requirements.

Next, we examined the results of actually applying the new requirements definition technique to determine its effect on system development. An example of using the new requirements definition technique to analyze requirements-definition documents created by a certain user company for system development is shown in **Figure 5**.

The left half of Figure 5 depicts requirements-definition documents. At first glance, these documents appear to be well organized. The descriptions of system functions in these documents are written at a level of detail that enables the number of processes to be understood and the level of complexity to be deduced. Making a rough estimate on the basis of these documents does not appear to be a problem.

The right half of the figure shows a conceptual diagram depicting some of the results of analyzing the documents on the left using the new requirements definition technique. Here, requirements that are scattered throughout the requirements-definition documents are organized according to the layers of the management structure model for requirements shown in Figure 2. (The upper part of Figure 5 depicts the division of roles (responsibilities) as shown in the requirements management structure of Figure 2.)

Now, when we use this diagram to check for validity and sufficiency in requirements read in from the requirements-definition documents, we find that only those requirements with straight lines drawn between them can be said to be mutually related while the others are in a state in which their relationship to other requirements is unknown. In short, one glance at this diagram reveals that many of the requirements do not have an obvious purpose or means of execution.

For example, the reason for existence is unclear for 10 of the 11 System Functions, which means that the degree of consensus among stakeholders with regard to those requirements and the effects of those requirements are not known.

We think that the reason for this is that upper-level Management Objectives and Measures and lower-level System Functions are created by the stakeholders at each level according to their own frame of mind. Thus, a system whose image is very different among the various stakeholders gets drawn from early on. As a result, there is a high probability that the estimated cost and scale of the system will be significantly different from the actual cost and scale since many changes to specifications can be expected. We think that such problems can be prevented from occurring in the first place if requirements are defined in accordance with the requirements structure advocated by the new requirements definition technique.

Using the new requirements definition technique in this way enables one to visualize deficiencies in requirements validity and sufficiency and the roles and responsibilities of each stakeholder. This technique should enable the person in charge of coordinating requirements to gain a good foothold in exercising settlement power and to be involved in the following ways:

- 1) Propose to delete from the list of requirements any Implementation Methods or System Functions for which no validity or purpose can be found.
- 2) Organize and clarify the roles having responsibilities for requirements (among the management level, business division, and IT systems division) using the requirements management structure and encourage the taking of responsibility among the various roles for requirements whose validity is unclear.
- 3) Once the relationships between System Functions and Implementation Methods on the lower level and Business Requirements

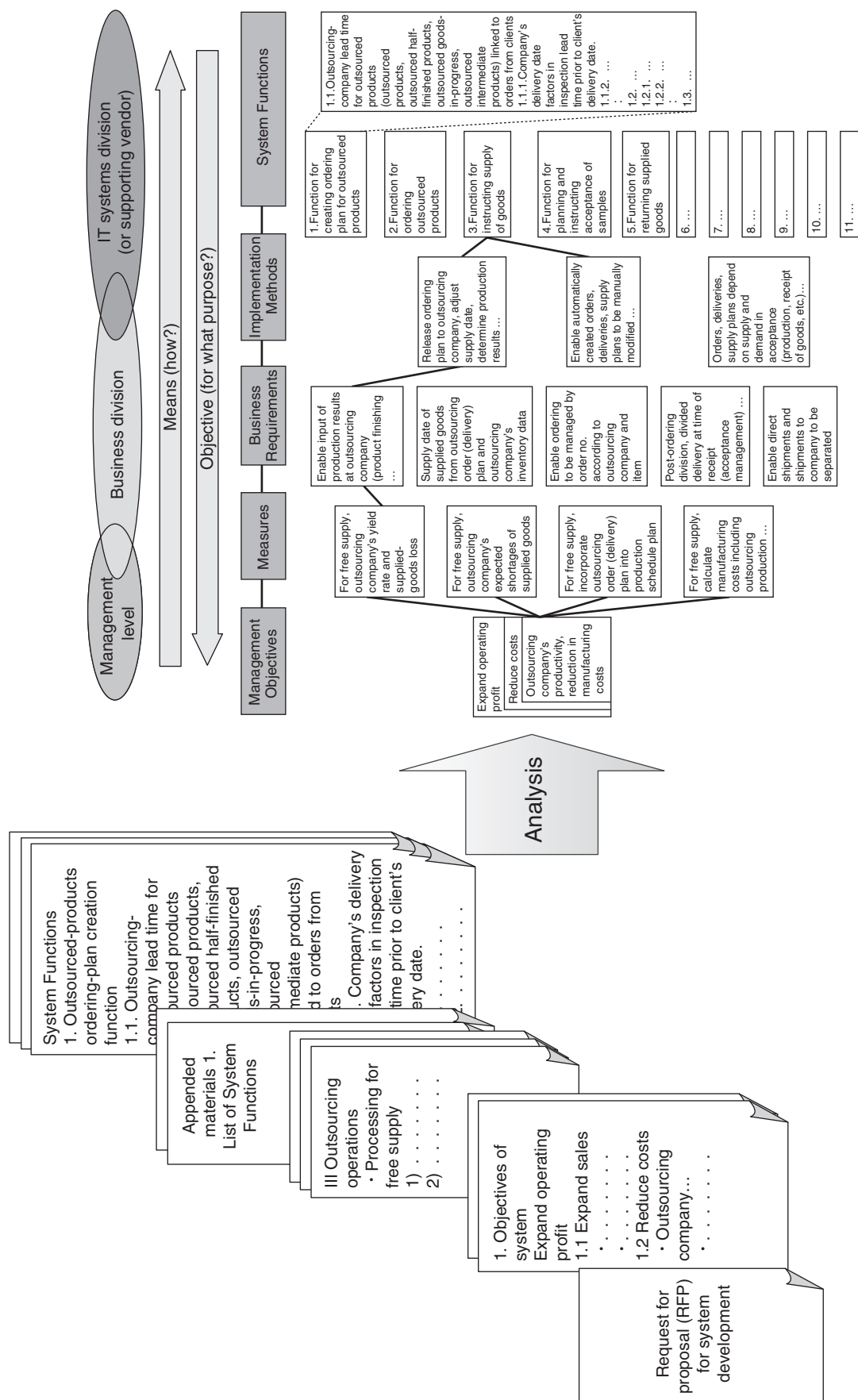


Figure 5 Document examples and analytical results (partial).

and Management Objectives on the higher level have been clarified, the likelihood of alternative proposals is high. Nevertheless, for a function whose purpose is not understood, the IT systems division or other stakeholders will not be allowed to make alternate proposals.

- 4) For those requirements that cannot be specified by the stakeholders, request management to make a decision from a management perspective. In such a case, reference can be made to the “degree of contribution” and “load for achieving (expense, time)” indices described in Section 2.3.
- 5) If a change is needed, even for a requirement for which consensus has already been obtained, the range of impact of that change can be visualized by tracking it on the requirements management structure (= requirement traceability).

In addition to verifying the above effects, this case-study analysis also revealed two problems in methodology that need to be addressed.

- 1) It is sometimes difficult to assign the requirements described in documents to the management structure of Figure 2. This may be due to the type of target document or the person doing the analysis, but another aspect to this difficulty is simply indecision about which level to place a certain requirement on or what degree of granularity to give requirements at each level. To alleviate this problem, we are currently compiling decision-making know-how in the form of a manual based on trial results obtained from an actual project now in progress.
- 2) Viewpoints for evaluating requirement quality are limited. The new technique focuses on validity and sufficiency in a goal-oriented way based on the relationships between requirements. In addition to validity and sufficiency, other viewpoints

like feasibility, technical consistency, and degree of consensus could be considered for evaluating requirement quality. In this regard, we plan to incorporate requirement maturity as a requirement attribute in future research.

4. Conclusion

The new requirements definition technique described in this paper improves the accuracy of requirements definition and consensus building among stakeholders while also enabling traceability in the event of changes made after requirement consensus has been achieved. However, it is no more than an auxiliary methodology for improving accuracy in requirements definition and is not a “silver bullet”.⁸⁾ Effective application of this technique assumes that stakeholders, including management, are aware of each other’s roles and that they will work together toward successful system development. Our aim with this new technique is to get projects with this level of consciousness off to a good start with true requirements definition.

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