

Chapter 1

Introduction

Life constantly confronts us with problems ranging from the trivial to the serious. We solve problems by drawing on knowledge, skill and experience. We educate our young to solve problems, first offering them examples to which we already know the answers, later challenging them with problems of an open-ended nature. We hope that, as they grow into adulthood, our children will be ready to face new problems with confidence, and will join the ranks of problem solvers.

In everyday life we solve simpler problems by instinct and the harder ones by past knowledge. In professional practice every new problem may call for its own novel solution. This does not mean that every problem solver is, and remains, a novice. Fortunately it is possible to classify problems by discovering in them common patterns. Such patterns reveal inherent similarities between problems which at first sight appear very different. Problem solvers exploit this: they accumulate and pool experience and classify problems according to frequently occurring patterns; they distil the principles of the subject and define its basic concepts; they formulate methods which embody good practice. As the subject develops and matures, its scientific foundations are identified, are set out in theories, and are taught to newcomers to the field. Skilled and experienced practitioners get together to form a professional community, and define requirements of professional qualification.

The aims, principles, concepts, theories, scientific foundations, methods and problem solving strategies collectively form the 'methodological foundations' of a discipline. Experts are practitioners of a discipline, competent in solving a particular class of problems.

Our highly developed society relies on the expertise of professional practitioners of mature disciplines. Such mature disciplines

include the various branches of medicine, law, science and engineering. Each expert of a mature discipline is specialist in a particular class of problems. But what happens if a problem is beyond the scope of any of the established mature disciplines? And what if momentous problems keep arising, each beyond the scope of any mature discipline? What if the lack of suitable expertise keeps leading to failed projects, loss of time, loss of resources, and sometimes even loss of life?

These days we often find ourselves in just such situations. Technological advances of recent decades facilitate international trade and worldwide communication, challenging us to undertake projects of global significance. Such projects may arise from any part of the world and from any sphere: public health or housing, education or transportation, ecology or care of the elderly, industrial relations or a combination of these and others. To tackle problems of wide concern and great complexity, deep understanding and effective communication must exist between the 'owners' of the problem and those undertaking the solution. The team of problem solvers would usually be large, involving experts of many different specialist disciplines: financiers and architects, mechanical, chemical, electrical and software engineers, network specialists, psychologists and others. To bring the shared project to success, it is essential that these experts should understand each other and cooperate effectively.

A new discipline is needed, particularly suited to the solution of complex problems which may arise from any field, and may call for any blend of specialist expertise.

Solving problems by use of general principles, concepts, methods and strategies is termed systems approach. All systems approaches rely on organized common sense, and some underpin this by firm methodological foundations. This book is an introduction to the methodological foundations of a systems approach, and is a practical guide to problem solving.

This introductory chapter presents a background to the study of systems. It outlines the systems approach, shows the importance of communication in problem solving, and introduces the Product/process (P/p) methodology: an aid to solving complex problems, based on a systems approach.

1.1 Systems approach to problem solving

Problems arise from unsatisfactory situations which need resolution, or from a desire for improvement. The ‘problem owner’ is the customer: an individual, representative of the group of people who identified the problem and seek its solution. The person who undertakes to develop and deliver the solution is the ‘supplier’. Negotiation between the two parties leads to a ‘contract’.

The contract

The obligations of the customer and the supplier are set out in a contract between the two parties. The contract may be an informal verbal agreement, or it may be a simple document stating the name and address of the contracting parties, the date of the transaction, the key features of the deliverable, and the recompense to be paid by the customer to the supplier. The contract may also be a formal document including the specification of the deliverable, together with such details as the time scale of the project, the process of developing the solution, the means of achieving the solution, and the payment or other form of ‘consideration’ to be provided by the customer.

Figure 1.1 shows a contract as four interrelated elements: the customer, the supplier, the deliverable and the consideration.

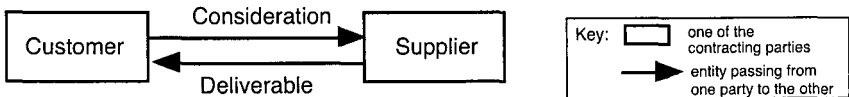


Figure 1.1: Diagram outlining the contract

The customer

The customer – one of the contracting parties – is frequently the representative of some organization: a company or a group of businesses, a local authority or a branch of Government, a pressure group or a political organization. The problem affects many or all members of the customer’s organization, and the solution may concern them all; thus, although some may not be actively involved, all are ‘stakeholders’ in the project. The project and its outcome may also have consequences for

people outside the customer's organization: it may increase or reduce employment opportunities of the community, cause or diminish pollution, result in new buildings or infrastructure which improves or damages the built environment.

The supplier

Similarly to the customer, the supplier of a project may be the representative of a wide constituency: the employees and shareholders of the supplier's organization, the subcontractor who may become engaged in the project, and members of the local community who may be affected by the problem, the solution, and the project which leads to the solution. To be successful, the project must meet the requirements of them all.

The problem solvers

Complex problems usually demand contributions from members of a large team drawn from the supplier's organization, complemented by numerous external subcontractors and a diverse collection of specialist experts. As a matter of principle, the supplier carries responsibility for the complete project, and is accountable for the work carried out by all internal and external contributors. How is the supplier to discharge such a responsibility?

Acting as project manager, the supplier may be guided by the systems approach: seek similarities beyond superficial differences.

One of the prime tasks of the project manager is to partition the project into a set of interrelated subprojects, and decide which of these to subcontract and which to undertake internally. It is easy to see that the relationship between the supplier and a subcontractor is similar to that between customer and supplier, as is shown in figure 1.2.

In the relationship with a subcontractor, the supplier of the original contract is now acting as the customer, with the subcontractor filling the role of supplier. Good customer/supplier practices established in the original contract may be codified into general procedures and used in successfully managing each subcontract. In each case the contract would specify the deliverable, the completion date, the payment (or other form of consideration) owed by the supplier to the subcontractor, and any other relevant detail of the procedures to be followed.

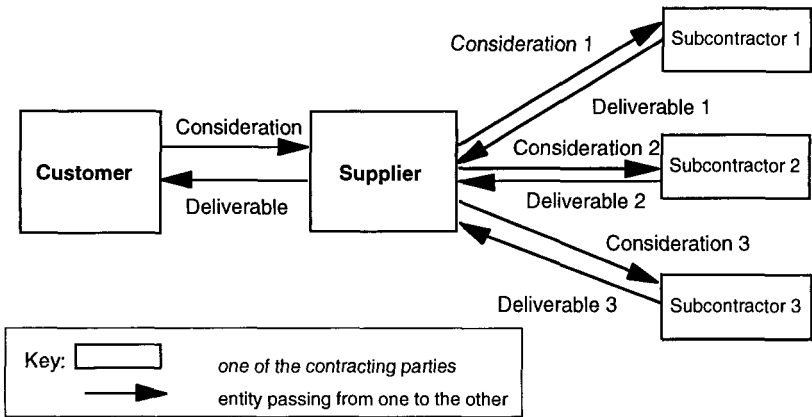


Figure 1.2: Enlarging the scope of contract to subcontractors

What about the work carried out internally, within the supplier's organization?

The systems approach alerts the project manager to look for a general pattern: consider the internal activity as a collection of related subprojects and regard the manager of each subproject as an 'internal subcontractor'. The relationship between an employee and his/her superior is essentially the same as that between customer and supplier (and between supplier and subcontractor!). Just as in those other cases, there will be a 'contract' between the two parties of the internal subcontract, including the specification of the task, the date by which the job has to be done, and details of the procedures to be followed. Codes of good practice established in the original contract and in the management of external subcontracts may be used in successfully managing each internal subcontract. But what about the 'consideration' to be extended to the internal subcontractor?

In internal 'subcontracting', the consideration is unlikely to be a direct payment from the project manager to the manager of a subproject: the employee draws a salary which is usually paid even if the job is not done well, or is not completed in time. However, the project manager's appreciation should be reflected in promotions, salary increments, annual bonuses, or, in case of non-fulfillment of the internal contract, in sanctions, and ultimately in termination of employment.

It is now a simple step to generalize: extend the notion of contract to all those involved with the project throughout the supplier's

organization, including the management of the external or internal specialist experts and any groups of specialists under their command. While the project manager may not be directly involved in drawing up each of the contracts and overseeing each of the deliverables and considerations, he/she is ultimately responsible for them all, and can require the messages in these contracts to take a form comprehensible to all concerned.

Thus, using a systems approach, any complex project will amount to a clearly defined multilevel hierarchy of manageable internal contributors and external subcontractors of diverse expertise, tied together by a network of clearly understandable contracts. As we shall show in this book, the principles, concepts, methods and strategies used in building and managing such a workforce will be used in managing all other aspects of problem solving.

1.2 Systems approach to communication

Communication is a basic human need. From its very first few days a new baby establishes contact with its mother, learns to interpret her signals, and starts generating those of its own. Communication is at the root of our civilization: society began with communication between individuals. This book is a communication between the authors and the readers. At first the communication is one way, but feedback from you, the reader, establishes a channel for two-way communication, and the exchange of ideas will help the evolution of concepts.

In the early stages of development the needs of society were amply met by communication in a primitive form of the natural language. The simple language was then adapted, expanded and refined to suit local circumstances and serve the changing needs of users. As an example, in English we have a single word for 'snow', but societies whose whole environment is surrounded by snow will have refined the concept and have created many words to distinguish different types of snow. In English a single word may suffice for 'camel' or 'sand', but in a desert-based society these concepts are diversified, and several words are needed to represent different varieties.

These days we face an explosion of new concepts relating to rapid social change and technological development. New notions call for the creation of new words to describe them, but the development of the language may not always be fast enough to meet the needs.

Misinformation and misunderstanding can arise from vagueness – doubtful borderline cases –, ambiguity – a single term carrying more than one meaning –, and cultural differences among those concerned. Many conflicts, accidents and failed endeavours may be traced to faulty communication.

Lest you think we are exaggerating the dangers of defective communication, consider the following examples. If you fail to spot the fault in the communication, console yourself with the fact that you are not alone, and consult the notes in exercise 3 at the end of the chapter.

Example 1.1 (from a cookery book)

Peel six oranges, cut into strips and boil for 7 minutes.

Example 1.2 (from a transatlantic committee meeting)

UK member: ‘What a good idea! Let’s table the motion’.

USA member: ‘What a curious thing to say.’

Example 1.3 Sign in a greengrocer’s shop: ‘Organic vegetables’

The customer – a research chemist – is amused.

Example 1.4 Sign in the shop window of a jeweler selling paste set in brass:

‘Money back if unsatisfactory!’

Communication allows members of society to live together harmoniously and resolve problems effectively, to mutual benefit. Language, the tool of communication, allows us to record observations, to classify and order them, to exchange our perception of phenomena and deepen our understanding. We use language to pass on our learning, to share our knowledge and cooperate with others.

Communication in problem solving

To solve problems effectively, each profession formulates precise concepts over its own specialist domain. In the past the tendency has been for each discipline to designate its concepts by its own distinct vocabulary. The specialist’s vocabulary allows effective communication within the expert group but excludes laymen and members of other groups.

As we noted before, the magnitude and complexity of today’s problems is such that each problem may cover many specialist fields of expertise. This means that the individual problem solver or the specialist

problem solving team of the past is replaced by an interdisciplinary team. Members of such a team, among them, must explore the problem, define it, specify the solution and propose options, identify the most appropriate solution among possible alternatives, and then design and implement the chosen solution effectively, within constraints of time and budget.

We have also noted previously that successful solutions call for cooperation among members of the team, and cooperation requires clear, concise and precise communication. Since each field has its own professional language in which its experts can express their ideas, this ‘Babel’ of different professional languages can cause chaos in large interdisciplinary problem solving teams.

While communication among members of a problem solving team is necessary for the success of any project, even more important is understanding between the customer – the person with the problem – and the supplier – the individual in charge of the team providing the solution. If customer/supplier communication is faulty, if the customer’s needs are imperfectly captured, if requirements are poorly expressed or misunderstood, then even the smartest team of cooperating experts will fail: at best, they will provide the right solution to the wrong problem.

Communication in and around a project

In problem solving, communication takes place:

- between customer and supplier; this usually calls for passing messages between businessmen and professionals,
- within the team of problem solvers: a large team of experts belonging to a variety of specialist professions,
- between customer and the wider community of interested parties; this demands passing accurate messages between businessmen and laymen.

In all cases, the language of communication must suit the topic, must be understandable to the communicating parties, and must have the necessary precision to ensure that the message is stated, clearly, unambiguously, and with adequate detail.

Let us examine the communication problem from the viewpoint of the problem solver. The requirements of the communication between customer and supplier differ from that within the multidisciplinary problem solving team. Members of the team are professionals, accustomed to precise forms of communication, whereas the customer,

while having the right to be informed, may be bemused by overly technical language. The question is: must the problem solver establish different languages to suit each individual problem and subproblem, each customer and each specialist discipline in the multidisciplinary team of experts, or can the systems approach assist in identifying some common pattern among the limitless variety of problems, customer needs and solution expertise? Could a systems approach establish a generic means of communication to suit all requirements?

As we have seen, a systems approach enables the project manager to view all professional relationships within the project as contracts between pairs of parties, and recognize that these relationships are essentially the same as the relationship between customer and supplier. This means that the core of the messages passing within the team is the terms of contracts between the parties, although the contents of such messages will differ in their detail. The question is: can the systems approach also guide us to recognize a common pattern in the contents of a boundless variety of contracts among any customer present or future, any supplier, any subcontractor and any other contributor to the efforts of any possible problem solving team?

The message

Contracts represent the most important messages linking those concerned with projects. Using figure 1.1 and guided by the systems approach, consider again the terms and conditions common to all good contracts.

The four elements of figure 1.1 show that contracts must cover four kinds of entities: the customer, the supplier, the deliverable and the consideration. Looking for patterns, those living by a systems approach will immediately recognize in the figure the symmetry between customer and supplier, and between deliverable and consideration. The contents of the contract must reflect this symmetry.

Contracts must identify the customer. We shall see in chapter 5 that this calls for designating the customer by a unique nominal measure: a name, supplemented by other characteristics which exclude ambiguity and vagueness of identity.

Similarly, the supplier must be identified by a unique nominal measure.

The contract will specify the deliverable – a new factory to satisfy a market or relieve unemployment in your area, a new design for a

manufactured item to gain or retain markets for your company, a new bus route to ease traffic congestion in your city, a new computer system to speed up payment of pensions and benefits, or whatever. A contract worth the name will list and define the key characteristics of the deliverable, and assign a measure to each. In the P/p methodology such a representation is called a 'product'. The measures characterizing the product will make it clear to the customer what to expect from the supplier, and tell the supplier what criteria to meet at the time of delivery: it is against these objective measures that the deliverable will be tested at the acceptance trials.

The contract may require the supplier to follow certain procedures in developing the deliverable, and the contract will specify these. Quite often the customer will want to examine the project in progress, and this means that the contract must include the project plan with appropriate milestones and specifications of part-results given in measurable terms. In the P/p methodology procedures and activities are represented as 'processes'.

Similarly to the deliverable, the contract must provide details about the consideration, in the form of product measures.

If the contract calls for stage payments then these would usually be conditional upon part-fulfillment of the project plan, and will be shown in the process model of the project.

Without timing, contracts have no meaning. The P/p methodology demands explicit timing of products and processes, and this includes the contract itself, viewed as a product.

Conveying the message

Experts use technical language of their profession to convey ideas with precision and reason about them closely. Systems professionals – experts of the systems approach – need precise technical language as much as do members of other professions. However, communication with lay customers and with other professionals is an essential part of the expertise of the systems professional; thus, defining a language which is clear, concise, precise and comprehensible to all is an integral part of the P/p methodology.

Say it in words

Good communication demands that the message be understandable to all concerned. This advocates the use of natural language, but as professional problem solvers we must be guarded against the inherent vagueness and ambiguity of natural language. To serve its users, the language of the P/p methodology includes natural language, but supplements it with more formal means of communication.

The P/p methodology also protects its users in another way. Built on a systems approach, the language can be frugal: systems concepts are general and powerful, hence a small number of carefully selected and well defined key concepts can convey a wide range of messages. To ensure that concepts are well defined, definitions are quality assured.

In the interest of understandability the language of the P/p methodology is free of jargon.

Say it in pictures

There is an Andy Kapp cartoon in which the eponymous character says: “We know as much as the expert but the expert says it with diagrams”. The well-worn saying that “a picture is worth a thousand words” conveys the same idea.

The P/p methodology employs a graphical language whose symbols are few and well defined. The graphical language is complemented by tabulated information about the elements of the graph, backed by the definitions of the textual language.

Say it in mathematics

Mathematics ensures precision and supports reasoning. To take advantage of these desirable features, the elements of the graphical language of the P/p methodology are formally defined, supplementing the verbal and graphical expression of messages.

Say it with measures

In everyday life, just as in science and engineering, measures are the means of characterizing problems, recording facts, setting goals, supporting decisions, registering progress. Measures are the lingua

franca of precise multidisciplinary communication: a powerful instrument in the hands of the professional problem solver.

The language of the P/p methodology

This book presents the textual, graphical and measurement-based language of the P/p methodology, but only touches on its mathematical foundations. A deeper and more detailed treatment of the subject, together with rigorous definitions, is given in another book by the same authors [¹].

1.3 The P/p methodology

As a first introduction, let us present the key concepts of the P/p methodology in the form of a ‘story’.

The systems approach postulates a generic concept embracing any entity of interest in the real world. This generic notion of any item of reality is termed the referent.

To discuss the referent and reason about it, we need to represent it in some form. The systems approach demands us to draw a clear distinction between reality and its representation.

- The systems approach requires us to represent any referent as a system.
- The representation of the referent as a system involves us in two kinds of choices:
 - 1 Should we regard the referent as a whole, or should we consider it to be an assembly of parts?

If we wish to regard the referent as a whole then we must represent it as a black box system. If we need to represent the referent as an assembly of parts then we must have a structural system (or structure, for short).

The black box system represents the referent by its attributes which are given, wherever possible, by means of measures.

¹ A Kaposi, M Myers: “Systems for All”. Imperial College Press, 2001.

The structural representation of the referent demands viewing it as a collection of interrelated parts, each part being represented as a black box or as a structure.

- 2 Should we take a snapshot of the referent at a particular time instant, or should we view its operation over a time period?

The snapshot yields the representation of the referent as a product.

Observation of the operation of the referent over a time period results in its representation as a process.

- Any referent, including the problem, the solution, the process of obtaining the solution, and the team of problem solvers, may be represented in a P/p graph: a structure made up of products and processes.

1.4 This book

This book introduces the P/p methodology as an aid to problem solving, based on the systems approach. The structure of the book follows the 'story' just told.

Chapter 2 outlines the key concepts of the P/p methodology.

Chapter 3 is devoted to modelling: the activity of obtaining a representation of the referent.

Chapter 4 deals with the concept of system.

Chapter 5 focuses on attributes and their measures.

Chapter 6 and its companion chapter 7 discuss black box systems and structural systems, respectively.

Products and processes are the subject of chapter 8 and its companion chapter 9.

P/p graphs are introduced early in the book and are referred to throughout. Chapter 10 demonstrates the uses of P/p graphs on some case studies.

1.5 Summary

This chapter explains the need for a systems approach in solving today's complex problems. Looking for deep similarities in apparently different problems is one of the guiding principles of the systems approach, and this chapter demonstrates this on a network of contracts linking all participants of problem solving: customer, main supplier, subcontractors, employees and the public, all involved in some way with defining the problem, implementing the solution, and living with the solution. To solve problems effectively, we need clear, concise, unambiguous communication between laymen and professionals as well as among cooperating professionals of different disciplines.

The Product/process methodology is claimed to be a simple yet rigorous aid to problem solving, offering a way of defining and analyzing problematical situations, constructing specifications, composing, verifying and managing solutions, and communicating information about the project in a way comprehensible to layman and professional alike. In this chapter the methodology is introduced as a story linking the key systems concepts of the Product/process methodology. These concepts are then to be discussed and illustrated in later chapters.

1.6 Exercises

1. Describe a situation involving you in a contract as a customer. Describe a situation involving you in a contract as a supplier. Name some distinctive and some common features of each of these contracts.
2. You, as a builder, have contracted to construct a house for a customer according to the architect's drawings. You need to subcontract part of the work. Give examples of the type of subcontractors you may use, and draft a contract between you and one of the subcontractors. How would your contract with the subcontractor affect your contract with the client?
3. Examine examples 1.1 to 1.4 given in the text. Can you spot the reasons why they were chosen? If not, the following hints may help:
 - Example 1.1: One of the authors cut the orange flesh into strips and wondered why the recipe did not succeed.
 - Example 1.2: The term 'tabling a motion' may have different meanings in different English-speaking countries.
 - Example 1.3: To a chemist, what is the opposite of 'organic'?
 - Example 1.4: Unsatisfactory *what?*

4. Identify:
- a problem you can solve yourself,
 - a problem where you need the help of one expert,
 - a problem which would need a team of experts.
5. What is your present notion of the meaning of the word 'system'?
How would you define the notion for one of your colleagues?
How would you explain it to a (bright) young child?
What examples would you use in each case to support your definition?
6. Define the meaning of the word 'bug' as it may be used in computing, in zoology and in the world of espionage.
How many other kinds of uses can you find for the word?
7. Mark the following as true (T), partially true (PT) or false (F).
If you think that a statement is partially true, write one or more questions to cover the same ground such that you could give conclusive true or false answers.
- At least two parties are necessary for a contract. _____
 - At least two parties are necessary for communication to take place. _____
 - A contract is a written document. _____
 - A message is a written communication. _____
 - 'Ambiguity' and 'vagueness' are synonyms. _____
 - Ambiguity is caused by a careless attitude. _____
 - Ambiguity and vagueness cause confusion and must always be avoided. _____
8. Examine the following statements:
- Fruit flies like a banana.
 - He had a ball.
 - I saw the man on the hill with a telescope [²].
- Are these statements ambiguous, vague or both? Replace each sentence by two or more others such that the meaning should be clear.
Do the examples 1.1 to 1.4 contain ambiguity, vagueness, or both?

² T Winograd: "Language as a Cognitive Process", Addison Wesley 1983.