Chapter 1
The engineering profession

Terms like *profession, professional* and *professionalism* carry a whole variety of meanings; in some contexts they are simply descriptive (e.g. a professional writer), in some they are commendatory (a professional piece of work), and in some they are pejorative (a professional foul). Furthermore, there is a subtle difference between the activities included in the term *the professions,* which is [1] usually taken to include a rather limited range of employments in the Church of England, the law, medicine and the armed forces, and the use of the term *profession* in phrases such as "the engineering profession" or "the medical profession". In this chapter we shall try to give a precise meaning to this latter usage, particularly in the context of the engineering profession.

The legal (and social) status of the engineering profession is markedly different in different countries. In particular, the position in the USA is very different from that in the UK and the changes now in progress there will have the effect of integrating software engineering into the legal framework governing the engineering profession as a whole. Accordingly, Section 1.5 is devoted to a description of the situation in the USA.

We shall also discuss the obligations and privileges which membership of a profession carries and the way in which individuals qualify for membership; in particular, we shall consider some of the ethical issues that arise in software engineering and the ways in which these may be addressed.

1.1 What makes a profession?

Chambers 20th Century Dictionary defines profession, in the sense in which we are interested, as:

> …an employment not mechanical and requiring some degree of learning; a calling, habitual employment; the collective body of persons engaged in any profession;…

1. Or was: the term is falling out of favour, probably because the idea is no longer felt to be a useful one.

Parts of this definition are clearly too wide: grave digging may be regarded as an habitual employment for some people but anyone who described it as a profession would be in danger of being suspected of irony.

To come closer to characterizing what is meant by profession in normal usage, we may take the last part of the definition *(the collective body...)* and ask what it is that those bodies which are commonly thought of as professional have in common. At least within

the UK, three characteristics become apparent:

- the collective body controls entry to the profession;
- the collective body is self governing and self regulatory, in the sense that it establishes and enforces a code of conduct on its members;
- the collective body is established either by a Royal Charter or by statute (Act of Parliament) which defines the extent of its authority and requires it to undertake certain duties and responsibilities.

If we take these characteristics as defining a profession, we see that solicitors, barristers, doctors, dentists, accountants, surveyors, architects, engineers and many others fall within the definition; so too do one or two less obvious groups such as physicists.

An interesting case is that of school teachers. Most school teachers consider their calling a profession but, until very recently, it fell outside the definition given above; entry to school teaching depended on recognition by the Department of Education and Science, a government body, rather than by an independent chartered body and there was no independent body which laid down a code of conduct—this was largely a matter for the teachers' employers. This is about to change. The Teaching and Higher Education Act 1998 provided for the establishment of a General Teaching Council for each of England, Wales, and Northern Ireland. (Such a council has existed in Scotland since 1965.) The councils will be responsible for setting up and maintaining a register of teachers, for promulgating a code of conduct, and for removing from the register teachers who seriously breach the code or who are demonstrably incompetent; the councils will also have a significant influence over the training of teachers. With a few minor exceptions, registration with the appropriate council will be essential for any practising school teacher. The General Teaching Council for England will come into being in September 2000. It will be made up of 25 elected teachers, nine teachers appointed by organizations representing teachers, 16 members appointed by other interested bodies, such as the Commission for Racial Equality and the Confederation of British Industry, and 13 members appointed by the Secretary of State for Education and Employment, two at least of whom must represent parents' interests. This will put teachers in the same position as doctors and dentists, as a profession subject to statutory control, i.e., control laid down by Act of Parliament.

In contrast to the councils governing professions subject to statutory control, a professional body must already be in existence before it can seek recognition through a Royal Charter. The decision to grant a Royal Charter to a professional body is taken primarily on the grounds of the public interest—is it in the public interest that the activities of the group of practitioners which the body represents should be regulated and, if so, is the professional body a fit, proper and appropriate instrument to do this? This raises subsidiary questions about how representative of practitioners in the field the body is, and the extent to which its members can claim to be a coherent group. A Royal Charter is only granted after extensive investigations; although it confers some privileges, it imposes many responsibilities which the body must be willing and able to accept.

There are some important but subtle differences between the professions. It is a criminal offence, for example, to claim to be a medical doctor, a veterinary surgeon, a dentist, an optician, a solicitor, or an insurance broker without being registered with the

appropriate statutory body. If anyone is found to be committing this offence, the police will normally take action and the Crown Prosecution Service will prosecute. On the other hand, while you are not, for example, allowed to claim to be a Chartered Engineer or a Member of the British Computer Society unless you are, it is up to the Engineering Council or the BCS, as the case may be, to take action in the courts; they cannot rely on the authorities to take action. (This is a practical difference between a profession established by statute and one established by Royal Charter.) And there is nothing to stop you claiming merely to be an engineer or physicist—even if you have no qualifications whatsoever [2] ! In such a case, you might commit an offence by claiming to be an engineer in order to commit a fraud but not by claiming to be an engineer merely to enhance your standing with your neighbours.

The previous paragraph concerns the protection of professional *titles;* this is quite separate from the question of *licence to practise*. Some, but not all, of the activities of some of the professions mentioned above can only be carried out by registered members of the profession. Thus no person may practise dentistry unless registered with the General Dental Council and no unqualified person may act as a solicitor or prepare certain specified documents. Perhaps surprisingly, however, unqualified persons are not debarred from practising medicine as such, although there are a number of activities, such as supplying prescription-only drugs, that they are not allowed to carry out and certain appointments, in particular in the National Health Service, that they cannot hold. There is no statutory control of the right to practise as an engineer in Britain.

2. This is the position in the UK. In the USA and some European countries, it is a criminal offence to call oneself an engineer without possession of the appropriate qualifications. See Section 1.5.

1.2 Structure of the engineering profession

The engineering profession has a two-tier structure. At the first level, there are the engineering institutions, that is, the chartered professional bodies, each of which covers a single or several closely related engineering disciplines. Examples are the Institution of Electrical Engineers, the Institution of Mechanical Engineers and the British Computer Society. Each institution has its own rules regarding membership and its own codes of practice and conduct.

The British Computer Society (BCS) is the engineering institution which is the most natural one for software engineers to join. However, the Institution of Electrical Engineers (IEE) also welcomes software engineers, particularly those whose interests incline towards safety critical systems or control systems, and offers an extensive programme of relevant professional activities. The BCS and the IEE collaborate in many areas, for example the publication of the *IEE Proceedings-Software,* the leading European journal in the field of software engineering.

Individual institutions represent the interests of engineers practising in their field and are frequently consulted by Government as a source of expert and impartial advice. The BCS, for example, is consulted on such issues as safety critical systems, the legal protection of software, data protection, and the law relating to misuse of computers.

Institutions' public activities are not, of course, limited to responding to requests for advice. Their charters impose a variety of duties on them, including the advancement of knowledge in their field, the maintenance and improvement of standards of practice, and the advancement of education.

The second-level body in engineering is the Engineering Council, a chartered body which recognizes certain engineering institutions as its "Nominated Bodies". This means that the Engineering Council is satisfied that their standards of membership meet its requirements. In this way, the Engineering Council acts as an "umbrella" body and represents the interests of the engineering profession as a whole. It is consulted on matters which affect the entire profession, such as the organization of engineering education.

An important function of the Engineering Council is to maintain, through the Board for Engineers' Registration, the national register of qualified engineers and technicians [3] , which currently contains some 290,000 names. The register is divided into three sections: Chartered Engineers, Incorporated Engineers, and Engineering Technicians. Chartered Engineers are considered

3. The Engineering Council and many of the professional engineering institutions feel that the use of the term *engineer* instead of *technician* (as in "we're waiting for an engineer to mend the washing machine") has much to do with the low status that engineers enjoy in the UK. It is ironic, therefore, that the Board of Engineers' Registration should be responsible for the registration of technicians.

to be qualified to develop new technology, to apply existing technology in novel ways and to take responsibility for large, high-risk projects. They are currently expected to be educated to honours degree level, as well as having appropriate professional experience. With a few exceptions, any full or "corporate" member of an engineering institution is entitled to be registered as a Chartered Engineer and thus to use the designatory letters CEng. There are two other registers, one for Incorporated Engineers and one for Engineering Technicians, entitled to use the letters IEng or Eng Tech, as appropriate. The minimum educational qualification required for IEng is that of a BTEC Higher National Certificate and for Eng Tech a BTEC National Certificate. For those entering higher education in 1999 or later, these requirements have been strengthened; see Section 1.4.1 below.

Registration as a Chartered Engineer is the ultimate recognition of professional engineering status; in particular, it generally allows the engineer to be recognized as qualified to practise elsewhere in Europe. This done through FEANI (*Fédération Européene d'Associations Nationales d'Ingénieurs,* European Federation of National Engineering Associations), an umbrella organization which, amongst other activities, maintains a register of European Engineers, who are entitled to use the title Eur Ing (as a prefix, in continental style, rather than as a suffix as would be normal in Britain). Chartered Engineers are normally entitled to register as European Engineers with FEANI.

The European Directive 89/48/EEC regulates the mutual recognition of professional qualifications within the European Union; it came into force in 1991. It provides, in general, that engineers (and other professionals) who wish to have their qualifications

recognized by a member state other than that in which they obtained the qualifications may be required either to serve a period of adaptation or to sit an examination (called an aptitude test). However, in answer to a question asked by a Member of the European Parliament to the European Commission, it has been formally stated that the Commission considers that "an engineer who has obtained the title of Eur Ing should not normally be required to undertake an adaptation period or sit an aptitude test". This means effectively that, subject to registration with FEANI, possession of Chartered Engineer status guarantees recognition elsewhere within the European Union. Twenty countries belong to FEANI and the Eur Ing title indicates recognition of professional status by the professional bodies in all of them; legal recognition, however, applies only in the countries of the European Union. In many of these countries, there is statutory protection of the title of engineer and in some it confers a licence to practise.

1.3 Development of the engineering profession

The term "engineer" was first used in the sense of a military engineer, concerned with the building of engines of war and other military construction. It was in the eighteenth century that the term "civil engineer" began to be used to distinguish engineers who were concerned with civil rather than military construction. It was also in the eighteenth century that the first formal groupings of engineers began to appear. The first was the French *Corps des Ponts et Chaussées* (Group for Bridges and Roads), founded in Paris in 1716; a society of civil engineers was formed in England later in the century. It was also in Britain that the first engineering grouping that aimed to represent the profession, and thus to be a professional body in the modern sense, was formed. The Institution of Civil Engineers was founded in 1818; it was fortunate in persuading the doyen of British civil engineers, Thomas Telford, to become its first president and it was as a result of his efforts that the institution received its royal charter in 1828. The Institution of Mechanical Engineers was founded in 1847, the Royal Institution of Naval Architects in 1860, the Institution of Gas Engineers in 1863, and the Institution of Electrical Engineers in 1871. Many others followed—there are now 42 chartered engineering institutions. The British Computer Society was founded in 1957 and received its Royal Charter in 1984. Like most of the institutions, it started life as a learned society, seeing itself primarily as a vehicle for the exchange of views and the dissemination of knowledge among people with a shared interest in computing; it subsequently developed the concern for education and the promulgation of good practice which characterizes a professional institution.

The large number of engineering institutions did not make it easy for the engineering profession to formulate and promulgate views on matters affecting the profession as a whole. There was no uniformity in the requirements for membership of the different institutions, and employers, to whom the issue of qualifications might be expected to be important, had no say in institutional qualification procedures, except through any personal membership of an institution that they might have. It was to address these problems that 13 of the largest chartered institutions began a long process of negotiation which led, in 1962, to the formation of the Engineering Institutions Joint Council. This body itself gained a Royal Charter in 1965 and changed its name to the Council of

Engineering Institutions (CEI).

The CEI achieved much. In particular, it established the three tiers of engineering qualifications and the registration mechanisms for them and gained acceptance of these from all the institutions. However, it failed to make the qualifications respected by the general public or by employers, and it failed to get itself recognized as the voice of the engineering profession. In 1977, the then Labour government announced the setting up of a committee of enquiry into the engineering profession, chaired by Sir Monty Finniston, a distinguished engineer and industrialist. Its terms of reference were wide and it was asked to review and make recommendations about the requirement for engineers in industry, the role of the engineering institutions, and the advantages and disadvantages of statutory registration and licensing of engineers; it was specifically asked to review the arrangements in other major industrial countries. The committee reported in 1979, by which time a Conservative government was in power. The report of the committee is universally known as the Finniston Report [4] .

The Finniston Committee visited Canada, the United States, Japan, France, West Germany (as it then was), Denmark, Sweden and the Netherlands; its report contains the statement:

> In every overseas country at which we looked the status of engineers and engineering was high; it attracted high quality entrants and was accorded a priority in social and industrial affairs that is generally lacking in the UK.

The position has not changed substantially in the 20 years since the committee reported and similar comments continue to be made.

Finniston found that, in all the countries visited, the mechanism for registering engineers involved the state and, in most cases, there was provision for organized input from employers. It was only in the UK that this process was left entirely to the profession. However, the committee concluded:

> On balance we take the view that the priority and status given to engineering in other countries depends largely on deep-seated cultural factors. Registration may serve to institutionalize and confirm these factors but it cannot of itself fundamentally alter them.

In other words, whatever changes may be made to the registration procedures, much more is needed if engineers and engineering are to achieve in the UK the status and prestige that they enjoy elsewhere.

The Finniston Report came out in favour of statutory registration of engineers through the establishment of a *statutory* Engineering Authority (i.e. a body established by Act of Parliament); the authority would have had powers which included maintenance of the registers of qualified engineers, membership of which would be open to everyone who satisfied its requirements, without any requirement for membership of one of the professional institutions. It did not recommend statutory licensing of engineers, except in areas where safety was involved. It recommended the introduction of the BEng and MEng degrees, although under significantly different conditions to those under which they were finally introduced.

Although the Finniston Report was accepted by the government, many of its 80 recommendations were ignored and others were adopted only in a modified form. (Many of them were in the form of general exhortations to

4. *Engineering our future,* Report of the Committee of Inquiry into the Engineering Profession, Cmnd 7794 (HMSO, January 1980).

employers and to schools and were, in fact, incapable of being given real government backing.) The government was not disposed to introduce legislation to establish a statutory authority and the individual institutions, for obvious reasons, strongly opposed the proposal that institutional membership should not be necessary for registration. The result was the Engineering Council, established by Royal Charter, not by Act of Parliament, and with a continuing requirement for membership of a professional engineering institution in order to be registered.

The Engineering Council has proved a more effective body than the CEI. In collaboration with the institutions, it has developed initiatives to promote the profession among young people; it has contributed to the development of the teaching of technology in schools; it has launched its own code of conduct and a codes of professional practice on risk and on engineers and the environment; it has established a much more uniform standard of professional competence for engineers throughout the profession; and it has contributed in a wide variety of ways to engineering education. Not surprisingly, however, given the weakness that was built into it from the start, it has not succeeded in overcoming the fragmentation of the profession. There are still 42 engineering institutions recognized by the Council; there is a lot of waste and duplication; and there is still much mutual distrust among the individual institutions.

Recognizing these problems, the Council of Presidents of all the institutions set up, in January 1992, a steering group under the chairmanship of Sir John Fairclough, Chairman of the Engineering Council, on the unification of the engineering profession. The steering group produced its first report [5] in April 1993. The report foresaw the eventual merging of the institutions into a single body but, in the short to medium term, envisaged a new relationship between the Engineering Council and the institutions. This new relationship would involve grouping the institutions into a small number of “colleges” and more democratic elections to the governing body of the Engineering Council. These proposals have now been adopted but we are still a long way from having a single institution.

Brief mention should be made of the Royal Academy of Engineering. This is an élite body, made up of distinguished engineers, who are entitled to use the designatory letters FEng. It is intended to be comparable with the Royal Society and the British Academy. Like them, it receives some government funding to encourage high-quality research in engineering and to support certain other initiatives. By its very nature, however, it has little impact on the practising engineer. Its establishment is, however, one more

5. *Engineering into the millennium* (The Engineering Council, 10 Maltravers Street, London WC2R 3ER, 1993).

element in the struggle to enhance the prestige of engineering in the United Kingdom.

1.4 Professional qualifications

Entry to almost all professions requires an appropriate educational qualification followed by appropriate professional experience. Within this basic pattern there is a great deal of diversity. In some cases, the educational qualification must be gained from an accredited academic course (see below); in some cases, it can be gained wholly from such a course or partly from such a course and partly from examinations run by the professional body; and in some cases the final qualification must come from the examinations run by the professional body.

Most candidates for membership of the engineering institutions have graduated from accredited courses and the qualification resulting from successful completion of the course fulfils the educational requirement for membership; accredited courses must be of honours degree standard (but see Section 1.4.1 below). However, for candidates who have not been able to qualify by this route, the Engineering Council itself runs examinations covering a very wide range of engineering topics; it is then open to the individual institutions to state their requirements for membership in terms of papers to be taken and grades to be attained.

At this point, it is as well to clarify what is meant by membership of a professional body. There are usually several grades of member but these can be divided into two categories, professional and non-professional grades. The professional or corporate grades (typically Member and Fellow) are occupied solely by members who have met the body's educational requirements and have satisfied its requirement for professional experience; to a very large extent the members in these grades run the institution and its constitution requires that all positions of authority are occupied by such members. The non-corporate grades (Associate, Licentiate, Affiliate, Student, etc.) may be occupied by people from a variety of categories, such as:

- students on accredited courses;
- graduates who are in the course of completing their period of qualifying experience;
- professionals from other disciplines whose work is related to that of the institution;
- persons with approved qualifications and experience at a lower level than is required for professional membership.

The last of the above categories is particularly important in some branches of engineering where many technicians are highly qualified although not at graduate level. As already mentioned, the Engineering Council recognizes this by the two levels of registration below CEng. It should be remarked that not all corporate members of, for example, the British Computer Society necessarily qualify as Chartered Engineers; they must also satisfy the Engineering Council's definition of what constitutes an engineer.

1.4.1 Course accreditation

The normal procedure by which an engineering institution accredits a degree course starts with a written submission from the department offering the course to the Institution. Among other things, this submission describes the objectives of the course, the syllabus,

the entry requirements, the methods of assessment, the facilities available and the qualifications of the staff teaching the course.

If the written submission is *prima facie* acceptable, then arrangements are made for a party, consisting of academics and industrialists who are professional members of the Institution, to visit the department to discuss the course with both staff and students and to inspect the facilities and student project work. Following this visit, the Accreditation Committee of the Institution receives a report from the visiting party and, on this basis, decides whether accreditation should be granted. The maximum period for which accreditation can be granted is five years but a lesser period may be granted if the course is not felt to be wholly satisfactory; in some cases accreditation may only be granted on condition that certain changes are made, or it may be refused completely.

Although the preparation of the written submission requires a lot of work and the visit is always looked forward to with some trepidation, most departments find that the accreditation process is very valuable. First, the need to review objectives, syllabuses and other aspects of the course at least every five years is a valuable discipline. Secondly, exposing even the best of courses to assessment by group of external experts will always produce valuable comments and suggestions. (Universities are nowadays required to have their own internal course review procedures but these procedures do not necessarily have substantial input from external experts and, as a result, may be concerned more with regulations than with content.)

It was stated earlier that the appropriate educational base for a Chartered Engineer was an accredited honours degree. For students entering higher education at the start of the 1999/2000 academic year or later, the position is different. With the substantial expansion of the numbers entering higher education in the United Kingdom during the 1980s and 1990s, the Engineering Council became concerned about the standards achieved by students awarded honours degrees. A particular concern was that, on entry to such courses, many students had a very limited knowledge of mathematics and physics; the result was that much of the first year was devoted to remedial teaching of such topics and, as a consequence, the level of engineering knowl-edge attained at the end of a three year honours degree course was much less than it had been when the accreditation system had been set up. There was also concern about the general intellectual level of many of the students on the new courses and about the danger of UK engineering qualifications not being recognized internationally. These concerns led the Engineering Council to revise substantially its criteria for accreditation. There are two major changes, which are being phased in over a number of years.

First, only four-year degrees (usually MEng degrees) will normally be accredited as fulfilling the educational requirements for registration as a Chartered Engineer. Three-year degrees may be awarded partial CEng accreditation or may be accredited for Incorporated Engineer status. A person holding such a degree may fulfil the educational requirements for CEng by completing “a matching section”. Precisely what constitutes a matching section is not altogether clear but an appropriate Master’s degree or appropriate training as part of an employer’s scheme would both seem acceptable.

The second change is that, in order for a course to be accredited, the entrants to the course must meet certain standards. Put simply, for full CEng accreditation, 80 per cent of the entrants to the course must have an A-level points score [6] of at least 24; for partial

accreditation, 80 per cent must have an A-level score of at least 18 points.

Other changes include strengthening and formalizing the requirements for initial experience and for the professional review that evaluates this.

These changes to the educational requirements for CEng are matched by corresponding changes to the requirements for IEng. An accredited three-year degree is now required as the basic requirement for registration as an incorporated engineer; an alternative is an HNC or HND with a suitable "matching section".

1.4.2 The engineering applications requirements

The Finniston Report recommended that the education and professional training of a Chartered Engineer should include four essential elements known as Engineering Applications, EA1 to EA4. These are:

6. A-level is the United Kingdom School Leaving Examination. Like the Abitur in Germany and the Baccalauréat in France, it is a public examination, centrally administered; there is no comparable system in the United States, although a few individual states do have something similar. It is usually taken in three subjects and the passing grades are A, B, C, D, and E. The points score is computed on the basis of 10 points for an A, 8 for a B, 6 for a C, 4 for a D, and 2 for an E, although these weights are expected to change in the near future. The Engineering Council's concern is more readily appreciated when it is realized that the average points score for many accredited engineering degree programmes during the 1990s has been as low as 4 or 5.

EA1 an introduction to the properties, fabrication and use of materials;

EA2 application of engineering principles to the solution of practical problems based upon engineering systems and processes;

EA3 a structured introduction to industry under supervision and involving a range of practical assignments;

EA4 specific preparation for a first responsible post and a period carrying responsibility in that post with decreasingly close supervision.

This recommendation was adopted by the Engineering Council; EA1 and EA2 are required to be covered by any accredited course, while EA3 and EA4 must be satisfied during the qualifying period of professional experience.

The EA requirements, particularly EA1, are, inevitably, couched in very general terms and individual engineering institutions must interpret them in a way appropriate to their own speciality. The BCS suggests the following interpretation of EA1, for example,

> An introduction to good engineering practice and to the representation, meaning, modelling and processing of data by means of programs and the machines which execute them.

Provided that it is undertaken in a suitable engineering context, the major individual project which normally forms part of the final year of an honours degree course in engineering is usually seen as being the major element in meeting the EA2 requirement.

1.4.3 The BCS Professional Development Scheme

The assessment of professional experience is much more difficult than the assessment of educational qualifications since the nature of the experience can vary so widely from one individual to another, depending on the environment in which the experience is gained. In the late 1980s, in an effort to provide a framework within which the experience can be recorded and classified, the BCS introduced its Professional Development Scheme (PDS).

Participants in the PDS are issued with a log book when they enter the scheme. This log book is used to record their work experience and training. They are regularly interviewed by a senior colleague who must normally be an MBCS; he or she will sign the log book to confirm the accuracy of the entries made since the last interview and make recommendations for future training and experience designed to develop the participant's career.

An essential part of the PDS is the *industry structure model*. This imposes a matrix structure on employment within the industry. The columns of the matrix represent different *streams* of experience; thus one column represents application programming, another represents telecommunications, and so on. The rows of the matrix represent different levels of work, from trainee upwards. Each entry in the matrix is known as a *cell*. For each cell, there is a description of the experience and training that a person should have had before entering the cell, a description of the work that a person in the cell is expected to carry out and recommendations for training to be received while working in the cell. In principle, and very largely in practice, any job in the industry can be assigned to a cell.

While it would be undesirable to lay down mechanistic criteria (so many months at such and such a level, so many at the next level, etc.) for assessing whether an applicant's professional experience is sufficient to meet the requirements for professional membership, the combination of the log book and the industry structure model provide a useful framework within which an applicant's experience can be assessed. Many large employers have adopted the scheme as a basis for their own career development programmes.

1.4.4 International recognition

We have already mentioned the possibility of registration as a European Engineer and the recognition that this brings in the countries whose national engineering associations are part of FEANI. Following a very substantial exchange of information and detailed examination of procedures and regulations, an important step towards wider international recognition was taken in the late 1980s, when the national engineering associations of Australia, Canada, Ireland, New Zealand, and the United States signed what is known as the Washington Accord.

The signatories to the Accord recognized that the academic requirements for qualifying as a professional engineer are substantially equivalent in all six countries and that their accreditation procedures are comparable. Each signatory therefore agreed to "make every reasonable effort to ensure that the bodies responsible for registering or licensing

professional engineers in its country or territory accept the substantial equivalence of engineering academic programs accredited by the signatories to the agreement." It was not possible for the national engineering associations to guarantee this acceptance because, in some countries, as we shall see below, this acceptance depends on statutory licensing boards.

It is important to realize that the Washington Accord applies only to the *academic* requirements for qualifying as a professional engineer. Thus an accredited degree from Britain should be sufficient to exempt you from the educational requirements in the other countries but this does not mean that the possession of CEng will exempt you from the other requirements, of professional experience or public examinations, for example, that may be necessary to become a fully qualified professional engineer there. Efforts are proceeding to try to extend the Washington Accord to cover mutual recognition of professional registration and to widen the group of signatories. (Hong Kong has recently been added to the original group of six countries.) This is likely to be a long process.

1.5 The engineering profession in the United States

The engineering profession is much more highly regarded in the USA than in the United Kingdom and is subject to strict statutory legislation, going further than what the Finniston Report recommended. The title of engineer is protected and the practice of engineering is restricted. Very similar legislation exists in Canada.

1.5.1 Licensing of engineers

In the first quarter of the 20th century almost all states of the Union enacted legislation to restrict the practice of engineering and the use of the title "engineer" to persons who were licensed by a state engineering licensing board. These boards were set up with a statutory duty to regulate admission to the engineering profession by licensing professional engineers who meet specific criteria. The declared aim was to safeguard life, health and property and to promote the public welfare. The details differ from state to state but are substantially similar; the same statutes usually cover land surveyors and often architects.

Typically, a state's statutes define what is meant by practising as a professional engineer in very broad terms, so as to include both the use of the term engineer, either alone or qualified by terms such as "professional" or "consulting", and carrying out or offering to carry out engineering activities. The flavour of these definitions is shown by the following extract from the statutes of the State of Missouri:

> Statute 327.181 Practice as professional engineer defined
>
> Any person practices *[sic]* in Missouri as a professional engineer who renders or offers to render or holds himself out as willing or able to render any service or creative work, the adequate performance of which requires engineering education, training and experience in the application of special knowledge of the mathematical, physical, and engineering sciences to such services or creative work as consultation, investigation, evaluation, planning and design of

> engineering works and systems, engineering teaching of advanced engineering subjects or courses related thereto, engineering surveys, and the inspection of construction for the purpose of assuring compliance with drawings and specifications, any of which embraces such service or work either public or private, in connection with any utilities, structures, buildings, machines, equipment, processes, work systems, or projects and includ-ing such architectural work as is incidental to the practice of engineering; or who uses the title "professional engineer" or "consulting engineer" or the word "engineer" alone or preceded by any word indicating or implying that such person is or holds himself out to be a professional engineer, or who shall use any word or words, letters, figures, degrees, or titles or other description indicating or implying that such a person is a professional engineer or is willing or able to practice engineering.

As is often the case, the desire to avoid loopholes and ambiguity has led to such complexity that it is very difficult to tease out the meaning of this excessively long sentence. Furthermore, there is an element of circularity in it (an engineer is someone who practises engineering). Nevertheless, it is clear that those who drafted the statute were trying to cast their net as wide as possible—it clearly implies, for example, that those teaching engineering in higher education are regarded as practising engineering. The last part of the sentence makes it clear that that those who choose to call themselves software engineers will be regarded as practising engineering. What is less clear is whether the same applies to those who call themselves programmers or, say, system designers and who are doing precisely the same sort of jobs as those who call themselves software engineers. In other words, the *title* of software engineer is reserved but it is not clear whether the *function* is reserved.

Following a definition of engineering, the statutes typically provide that no one may practise as a professional engineer unless they are registered and that a company offering engineering services to the public must do so through the medium of a registered professional engineer. Further, no company may use the word engineer or engineering in its name unless it employs at least one registered professional engineer. Anyone breaking these provisions is guilty of a criminal offence.

The statutes then lay down the criteria for registration. These normally include successful completion of an accredited degree course of at least four years duration, passing eight-hour examinations (fortunately split into two four-hour sessions!) in the fundamentals of engineering and in the principles and practice of engineering, and four years of approved experience. The examination in the fundamentals of engineering is normally taken at around the same time as the degree is completed and that in the principles and practice of engineering at the end of the period of professional experience. The syllabuses and examination procedures are co-ordinated by the National Council of Examiners for Engineering and Surveying, so that uniform standards and quality are maintained across the whole of the USA. (Canadian licences are not accepted in the USA precisely because registration in Canada does not involve passing the examination in the principles and practices of engineering.)

The engineering licensing boards are statutory bodies with strictly limited functions

and are thus very different from the professional engineering institutions in the UK.

1.5.2 The position of software engineering

The definitions of engineering enshrined in the statutes of the various states cannot be taken to include software engineering unless they are stretched well beyond what is reasonable. The examination in the principles and practices of engineering can be taken in 36 different branches of engineering but software engineering is not one of these. On the other hand, the restrictions on the use of the words "engineer" and "engineering" are quite clear. The resulting position is absurd: the only people who are formally allowed to describe themselves as software engineers are those who are licensed in some other branch of the discipline and a company can only describe itself as a software engineering company if it employs at least one professional engineer licensed in another branch.

The use of the term "software engineering" had become widespread by the mid-1990s; the situation was further complicated by the fact that suppliers such as Sun Microsystems and Microsoft were awarding qualifications with titles like "certified systems engineer" or "network engineer" to those who could demonstrate suitable skills and knowledge in the use of their equipment. Initially, the licensing boards attempted seriously to oppose the use of the term software engineering. According to Capers Jones [7], Tennessee actively prohibits the use of the term in business literature and advertising, while Texas forced universities to stop offering degrees in software engineering. In such circumstances, however, the licensing boards cannot resist the tide of usage. It was therefore inevitable that, rather than try to prevent the use of the term "software engineering", the licensing boards should seek to regulate it.

The Texas Board of Professional Engineers was the first licensing board to approve the registration of software engineers, in June 1998. At that point there were no appropriate examinations in fundamentals of engineering and principles and practices of engineering available for them to take. Because Texas, uniquely amongst the states of the Union, allows the examination requirements to be waived in the case of practitioners of sufficient experience, it has been possible for some software engineers to be registered more or less immediately. The National Council of Examiners for Engineering and Surveying is planning to offer licensing examinations. It can be expected that, as soon as the exams are available, most other states will follow Texas in approving the registration of software engineers.

7. Capers Jones, "Legal status of software engineering", *IEEE Computer,* May, 98–99, 1995.

The Texas decision was not an isolated event. Rather, it was the natural consequence of several years of discussion and activity within and among the relevant professional bodies.

1.5.3 Professional bodies and accreditation in the USA

The United States possesses a range of professional engineering societies comparable to that in the UK. In particular, there are two organizations that carry out many of the

functions performed by the IEE and the BCS in the UK. The Association for Computing Machinery (ACM) may be thought of as comparable to the BCS, while the Institution of Electrical and Electronic Engineers (IEEE) compares loosely with the IEE, its Computer Society corresponding to the IEE's Informatics Division. Both the IEEE and the ACM publish a range of journals covering theory and practice in all aspects of IT; they are the most prestigious and the most widely read of academic and professional publications in the field. The IEEE Computer Society and the ACM collaborate extensively on matters connected with the software engineering profession, through joint committees and task forces, such as the one that produced the Software Engineering Code of Ethics that will be discussed later. The IEEE-ACM Joint Steering Committee for the Establishment of Software Engineering as a Profession, meeting from 1993 to 1998, was the primary force that led to the Texas board's decision to register software engineers.

Accreditation of engineering courses in the United States is only indirectly a matter for professional bodies. Instead, it is undertaken by a body called the Accreditation Board for Engineering and Technology (ABET). ABET is a federation of 28 professional engineering and technical societies. So long as software engineering was not regarded as an engineering discipline from the point of view of registration, it was not considered to fall within ABET's remit. Instead, courses in computer science and software engineering were considered by the Computer Sciences Accreditation Board (CSAB); this is a body set up jointly by the ACM and the IEEE Computer Society. In 1998, an agreement was reached between ABET and CSAB, leading to the ACM and the IEEE Computer Society becoming part of the ABET federation and to the CSAB becoming a constituent part of ABET.

American licensing and accreditation practice in engineering requires the definition of a "body of knowledge" that registered practitioners must possess. The IEEE-CS and the ACM are also working together to produce a definition of this [8] .

8. A preliminary version can be found at the web site http://www.lrgl.uqam.ca.

1.5.4 Certification of engineering artefacts

One of the duties that is reserved for registered engineers is the certification of engineering products. Wherever an engineering project could potentially affect public safety, it must be certified at various stages by a registered engineer. Thus, for example, a dam would need to be certified at the end of the design stage to ensure that all proper issues have been addressed in producing the design and that the design is safe; on completion, a registered engineer would need to certify that it had been constructed correctly in accordance with the design; and a registered engineer would need to inspect it at regular intervals during its life and certify that it is still safe.

The licensing of software engineers means that this same requirement for certification can now be imposed on the software element of safety critical systems. The issue of what it means to certify software is a matter of increasingly active debate. The topic is discussed further in Chapter 10.

1.6 Ethics and software engineering

Ethics is the study of right and wrong in relation to human actions. **It** includes *meta-ethics,* that is, study of the general principles from which ethical systems can be built; *moral theory,* that is, the ethical systems themselves, consisting of the criteria and procedures that can be applied to decide whether individual actions are right or wrong; and *practical ethics* or *applied ethics,* that is, the application of ethical systems to the analysis of particular situations, including such specialized areas as business ethics and medical ethics.

There are few, if any, ethical issues that are peculiar to software engineering. Nevertheless, the availability of technology and its speed and effectiveness mean that many ethical questions present themselves in a particularly acute form. The obligation to keep an individual's medical records confidential has long been recognized and accepted; we would criticize the management of a hospital that allowed the key to the room containing all the manual records to hang on a convenient hook outside the door when no staff were on duty. When a bank president who serves on a medical commission uses technology to identify all sufferers from cancer who hold loans from his bank and then forecloses on those loans, he is clearly in breach of the obligation of confidentiality [9] . However, it is information technology that has made the offence possible. What concerns us, then, is not the issue of confidentiality

9. "RMs need to safeguard patient records to protect hospitals", *Hospital Risk Management,* September, 129–140, 1993. Cited by Ross Anderson in his report "Security in clinical information systems", published by the British Medical Association in January 1996. The whole of this report is worth reading as it shows well the subtle interplay of ethical and technical issues. It is available on the World-Wide Web at http://www.cl.cam.uk/users/rja14/#med.

of medical records but the moral responsibility of the system developers who have left the metaphorical key hanging outside the door, that is, who developed a medical records system that did not contain access controls to make such an action impossible.

There is an important difference between morality and law. Not everything that is wrong needs to be made illegal, nor is everything that is illegal necessarily immoral. Not infrequently, it happens that some real or imaginary problem associated with IT (the London Ambulance System [10] , pornography on the Internet, software theft, hacking, etc.) gets taken up by the media and generates a sort of crisis. It is important that IT professionals should be capable of thinking clearly about such situations, since they are the people who understand them and know what is and is not possible. There is often pressure for legislation that is hard to resist even though it may be unnecessary or ill-advised.

1.7 Strands in ethical thinking

Ethics has been studied for many thousands of years and there are written records of what

people have thought and argued about for much of this period. This material does not become obsolete. What was written in Greece 2,500 years ago or in China 5,000 years ago can be just as relevant to our ethical dilemmas as what was written last year. This means that an ethical debate about issues that seem essentially modern often turns out to depend on fundamental attitudes that have been the subject of discussion since the start of recorded history. In this section, we shall, very briefly and simplistically, review some of the important ideas of meta-ethics that seem particularly relevant to the ethical problems facing the software engineer.

1.7.1 Rules and consequences

One view of morality that has been popular at many times in the past, although it is somewhat out of favour at present, is that bad actions can be avoided and good actions ensured simply by following a set of rules. The most widely known such set of rules is probably the Ten Commandments, found in the Old Testament, which form part of the common heritage of Christianity, Judaism and Islam.

10. This was a *cause célèbre* in the early 1990s. In commissioning its command and control system, the London Ambulance Service ignored more or less every canon of good management and good procurement practice. The prime contractor was ignorant of the difficulties of systems of this type. The system failed catastrophically within three days of being brought into service, with the result that the ambulance service was very badly disrupted. The disaster is discussed further in Section 10.4.

If we leave aside the Commandments that are specifically religious, we see that the rest constitute a set of rules that are not a bad basis for behaviour in a fairly simple society. However, it is difficult to see what they contribute to the debate about employers reading employees' e-mail or, indeed, to debate about many other contemporary issues. Through two millennia Christian theologians have tried to build ethical systems based on Christian teaching that are appropriate to the needs of the society they live in. As society evolves, each generation has to reconsider its moral teaching. This leads inevitably to tension and conflict between progressives and conservatives and is as evident in Judaism and Islam as it is in Christianity.

Naïve popular moralists and preachers often try to reduce morality to a single simple rule such as *Do as you would be done by is the surest method that I know of pleasing* [11]. In more modern language we might express this as: *Treat others in the way you would like to be treated*. While superficially attractive, it fails even on the level of interpersonal relationships. *Love thy neighbour as thyself* is a more sophisticated expression of this idea and has much to commend it on the level of interpersonal relationships but it is still manifestly incapable, by itself, of resolving ethical problems at the level of society as a whole.

The problem with rule-based morality is that, in an ethically difficult situation, there are usually several different possible actions that might be taken and each of them breaks one or more rules or is otherwise undesirable.

An alternative to a rule-based morality is *consequentialism*. Consequentialists believe that general rules are not specific enough to guide actions and that the primary factor in

judging an action must be its consequences. This means, of course, that we must have some mechanism for deciding whether the consequences are good or bad. Such a mechanism is often provided by *utilitarianism*. This doctrine was first enunciated by Francis Hutcheson (1694–1746) in the form: *That action is best, which procures the greatest happiness for the greatest numbers* [12] . In this form, it falls down, if in no other way, on the unavoidable mathematical fact that you cannot, in general, maximize two functions at the same time. (Politics provides many good topical examples.) A more defensible statement was given by John Stuart Mill (1806–1873) in the form: *Actions are right in proportion as they tend to promote pleasure or happiness* [13] .

If the doctrine of consequentialism is to be useful, we must not try to see too far ahead. Essentially, we should only concern ourselves with consequences that are reasonably foreseeable. Otherwise, the network of cause and effect becomes so complex that everyone is responsible for everything and the notion of moral responsibility becomes so diluted as to be meaningless.

11. Usually attributed to the Earl of Chesterfield (1694–1773).
12. More usually cited in the words of Jeremy Bentham (1748–1832) who wrote "The greatest happiness of the greatest number is the foundation of morals and legislation".
13. J.S.Mill, *Utilitarianism,* 1863.

(For rather similar reasons, it is customary to rule out or, at least, limit the amount of consequential damages payable if one party to a contract fails to fulfil its duties under the contract. If a new payroll system is three months late, it is reasonable to expect the supplier to pay the additional costs associated with having to retain the old system. It is not reasonable to expect him to pay the damages awarded to the employee who was injured when the old line printer fell on her, even though this would not have happened if the new system had been delivered on time.)

Consequentialism and rule-based morality can be regarded as in some ways complementary. It is quite possible to accept that the foreseeable consequences of an action are often an important element in judging it, without accepting that they must always be the primary factor. And one can accept rules on the grounds that complying with them is the best way of achieving good consequences. Thus it is perfectly possible for a consequentialist to accept that rules regarding human rights should always be obeyed, because the consequences of universal obedience to them will be good, even though the rules themselves are not intrinsically "right". Equally, it is possible to accept a set of rules governing behaviour but to judge on the basis of their foreseeable consequences those actions that are not covered by the rules.

In practice, most of us accept this latter position, that is, there are some rules we are not prepared to break but, within those constraints, we consider the potential consequences of our actions before deciding what to do.

To the extent that our behaviour is governed by rules, these rules may have several origins. They may come from our own moral convictions, which may derive from the culture in which we have been raised, or they may derive from the rules promulgated by a religious organization to which we belong; such rules are likely to be the ones that we regard as most important and are the ones we are least likely to break. They will apply to

the whole of our lives, not just to our professional activities.

Secondly, there are rules that relate to our professional lives; these may be rules laid down and enforced by our employers or they may be contained in a code of conduct established by a professional body of which we are a member. Our attitude to these will depend partly on how far they correspond to our own moral convictions, partly on how widely respected and observed they are by our peers, and partly on the consequences of breaking them.

Thirdly, there are rules that we accept, more or less willingly, because they make social or professional life easier or because the consequences of breaking them might be unfortunate. "Drive on the left" is an excellent example of such a rule. It is one that we obey, not from any moral conviction or authoritative teaching, but because the consequences of breaking it would be unfortunate. Furthermore, it is clearly relative in that it varies from country to country (and even sometimes from time to time in the same country). While the nature of such rules is not a matter for ethical debate, our attitude to them is; if we ignore them, we may prejudice the well-being of other people and that is an ethical matter.

1.7.2 Sources of moral authority

Some people believe that moral authority lies with the individual, who by reflection and self-analysis develops a set of rules. Others believe that moral authority must be located in larger units—the organization or society, the body politic *or the profession*. If authority lies with a larger unit, it may be collective, in the sense that it reflects a consensus among the members of that unit, or it may be authoritarian, that is, it may lie with a leader or a small group of leaders. All three possibilities have weaknesses. If moral authority lies with the individual's conscience, then what moral basis can the law have. If it is collective, there is a risk that it will never progress; in the absence of strong leadership, democratic bodies are notoriously conservative and the impetus for reform—whether it is the abolition of the slave trade or the legalization of homosexuality—has come more often from the promptings of individual consciences than from the actions of established moral collectives. An authoritarian approach is too dependent on the individual exercising the authority.

The authoritarian approach is typical of totalitarian regimes, both communist and fascist. Within Christianity, the Roman Catholic church takes an authoritarian approach. In other words, the Pope lays down moral teaching and the Church insists that its members accept it. The approach of the Protestant churches has generally been more collectivist in that moral teaching has been the subject of widespread formal and informal debate within a particular denomination (or, sometimes, within an individual church) before being formally adopted. Further, the Protestant churches have commonly, though by no means universally, acknowledged the importance of the individual conscience.

The collectivist approach is implicit in the idea of a professional code of conduct. The profession has decided collectively that its members must abide by certain rules and, by electing to join the profession, members accept this. There is still, of course, some room for individual judgement in interpreting the rules in particular cases.

But the conflict between individual and collective responsibility is at its strongest when

individual beliefs clash with an organization's behaviour. This leads to a set of related questions of which the following are typical:

- How far can individuals be held responsible for the behaviour of organizations of which they are part?
- What should individuals do to dissociate themselves from organizations to which they belong but of whose behaviour in some respects they disapprove?

There are no easy answers to these questions. It is clear that a receptionist cannot be held responsible for the fact that the company is collecting medical data ostensibly for research purposes but is selling it to private investigation agencies. Equally, however, it is difficult to hold the chief executive of the company responsible for the fact that the receptionist has a hidden racist streak that reveals itself only in unpleasant behaviour, when unobserved, to low-status visitors. It is tempting to say that individuals should only be held responsible for those aspects of an organization's behaviour over which they have control, but this can easily lead to the situation in which no one appears to be accountable for an organization's misdeeds. Note that we are talking about moral responsibility here. The company itself and its officers may well have a legal responsibility for actions such as those described above but moral responsibility may lie elsewhere [14] . See Section 9.7 for a discussion of some of the legal issues.

The second question is perhaps more widely relevant than the first. Should I resign from my job as manager of the telecommunications division because the chief accountant practises racial discrimination in making appointments in his office? Or should I stay in the hope that pressure from me and from other people like me will change his behaviour or cause the company to fire him? If, to my horror, I find the company I have just joined writes safety-critical avionics software in C, should I resign immediately or should I stay and try to show my new colleagues the error of their ways?

1.7.3 Absolutism v relativism

Absolutists believe that ethics and moral laws are the same at all times, in all places, and in all societies. Relativists believe that they depend on time, place and circumstances.

Relativists are concerned to avoid two evils—or, at least, two attitudes that are now widely accepted as evil—intolerance and chauvinism. In this context, intolerance manifests itself as the desire to impose all aspects of one's own morality on everyone and chauvinism as refusing to accept that any beliefs other than one's own can be valid. Logically, however, there is no difficulty in reconciling absolutism with the avoidance of intolerance and chauvinism. One can tolerate other ethical systems while believing nonetheless that there is only one "right" system. And one can believe that there exists, in the abstract, the perfect ethical system, without believing that one's own or anyone else's system achieves such perfection.

14. There is some debate amongst ethical theorists about the extent to which a company can be said to be morally responsible.

As with consequentialism, most of us in practice, adopt a half-and-half position over

relativism. We accept the absolute validity of certain rules but recognize that many others depend on the society in which we find ourselves.

Lack of historical and geographical perspective often means that we fail to realize how much morality changes from time to time and from place to place. Attitudes to human rights and to animal welfare illustrate this very clearly.

1.7.4 The doctrine of double effect

One difficulty that arises with rule-based systems is conflict between different rules. It is easy to imagine examples in which the requirement to act in the public interest is in conflict with the duty of fidelity towards an employer or client. Moral theory offers a way of handling this, through the *doctrine of double effect*. According to this doctrine, the foreseeable effects of an action can be divided into those that are intended and those that are merely foreseen but not intended. It is, in certain circumstances, permissible to carry out an action whose intended effects are good even if some of the consequences that are foreseen as possible but that are not intended are bad. Obviously the good effects of the intended consequences of the action must, in some sense, outweigh the possible bad effects that are foreseen.

Notice that the doctrine of double effect is intended to overcome problems in rule-based ethics. Consequentialists have no need of the doctrine because they cannot accept a prohibition against any action.

1.8 Professional codes of conduct

Professional codes of conduct are, by their very nature, collectivist and rule-based. Nevertheless, rule-based ethical systems always seem too rigid and restricted to handle complicated situations on their own and they are incapable of handling situations in which rules conflict or several different actions are possible but all in some way violate the rules. The interpretation of the rules and their application to specific situations may therefore involve individual, consequential reasoning. Although the individual codes themselves have an absolutist tone, the difficulty of establishing international codes has led professional bodies collectively to accept a moral relativism and to decline, for example, to insist that all professional codes demand that members respect human rights.

1.8.1 Codes of ethics and codes of conduct

At the start of this chapter we noted that it is a characteristic of professions that the professional body establishes and enforces a code of conduct on its members. If the professional body is to be effective in regulating the profession, membership must confer some advantages on its members, whether it is a licence to carry out certain activities or simply enhanced prestige. If the body takes seriously its responsibility for the conduct of its members, gross infringements of the code of conduct must lead to disciplinary action, with the possibility of expulsion. The expulsion will deprive the member of the advantages of membership and may thus be open to challenge in the courts. It is

important, therefore, that the code of conduct can stand up to such a challenge. In practice, it will probably need to satisfy the following criteria:

1. Its provisions must be in the public interest and not be inconsistent with the law of the land.
2. Its provisions must be generally acceptable to members of the profession.
3. It must be precise, in the sense that it should be possible to establish convincingly whether or not an act violates the code.
4. Its scope should be limited to professional conduct.
5. It should be accurately worded.

It will also need to be demonstrated that the code is applied consistently and that the disciplinary procedures that enforce it are fair.

The terms "code of conduct" and "code of ethics" are both used. It is not altogether clear what distinction is intended. On the whole it appears that a code of ethics is seen as being more aspirational and less regulatory than a code of conduct. The codes that are described as codes of conduct generally come closer to satisfying the rules given above than do those described as codes of ethics. Both codes of conduct and codes of ethics are distinct from *codes of practice,* which are concerned with good practice in doing the job [15] ; it is very rare to get expelled from a profession simply for doing the job badly. Codes of practice are discussed in Section 10.2.3.

Professional codes of conduct are particularly valuable in addressing conduct which can be seen as an abuse of the professional status. Doctors can be struck off, that is, deprived of their registration, for entering into sexual relationships with their patients or for drug taking. These clauses are not there because doctors are more sexually active than other members of the population or because they are more inclined to take drugs. Rather, they are there because it would be easy for doctors to take advantage of their professional position to seduce patients or to acquire drugs for non-therapeutic purposes. In the same way, solicitors often find themselves in the position of having custody of clients' money; there is an obvious temptation to use such

15. Confusingly, the IEEE-CS/ACM code is entitled *Software engineering code of ethics and professional practice*. It is not in any normal sense a code of practice.

money either to overcome short-term liquidity problems in the practice or to finance speculative investments; they are therefore required to hold clients' money in a separate account. Traditionally, such abuse of professional status has been dealt with severely.

The oldest known example of a code of professional conduct is the Hippocratic Oath. It bears the name of Hippocrates, the Greek student of medicine, who lived from around 460 to 377 BC, although scholarly opinion is unanimous in asserting that he did not write it. It takes the form of an oath, sworn by new doctors, and is still used in a modified form today.

1.8.2 Software engineering codes and their weaknesses

Most codes of conduct affecting software engineers have undergone major revisions

during the 1990s. In the United States, the IEEE adopted a revised Code of Ethics in 1990 and the ACM adopted a revised Code of Ethics and Professional Conduct in 1992 [16] . As far as software engineering is concerned, these have recently been replaced by a code developed jointly by the ACM and the IEEE Computer Society [17] (referred to as the IEEE-CS/ ACM code).

The BCS revised its Code of Conduct completely in 1992. Since this is the code likely to be most relevant to the majority of the readers of this book and is also perhaps the one that best meets the criteria listed in the previous section, it has, with the permission of the Society, been included as an appendix.

The ACM 1992 Code of Ethics is very clearly an aspirational code. It begins with a section entitled "General Moral Imperatives". The first three of these imperatives state that

> *As an ACM member I will…*
> 1.1 Contribute to society and human well-being;
> 1.2 Avoid harm to others;
> 1.3 Be honest and trustworthy.

The introduction to the Code makes it clear that these imperatives are intended to apply to conduct as a computing professional. Nevertheless, their scope is both so wide and so imprecise that it is difficult to extract real meaning from them. In comparison, the first rule in the BCS Code:

16. Anderson R. *et al.,* "Using the new ACM code of ethics in decision making", *Communications of the ACM,* 36(2), 98–107, January 1993.
17. The web site http://www.computer.org/tab/seprof contains this code as well as much discussion of it.

> Members shall in their professional practice safeguard public health and safety and have regard to the protection of the environment

is more limited but more precise.

A major weakness of the codes is poor drafting, so that, in the end, they do not mean what they were intended to mean. Because this is so widespread and so insidious in robbing codes of conduct of their usefulness, we shall give three examples of it.

1. Clause 6.05 of the IEEE-CS/ACM code states "[Software engineers shall] not promote their own interest at the expense of the profession, client or employer". This sounds reasonable until you realize that, if you are doing a good job, then changing jobs probably amounts to promoting your own interests at the expense of your employer.
2. As a second example, consider clause 8.01 of the IEEE-CS/ACM code: "[Software engineers shall] not give unfair treatment to anyone because of any irrelevant prejudice." There are two problems here. Surely a software engineer should not treat anyone unfairly, for whatever reason? The second problem is the word *irrelevant*. As the clause is worded, I am allowed to refuse to employ a 50-year-old as a programmer if I believe that only young people make good programmers, because this is clearly a

relevant prejudice. However, I must not refuse to employ a member of a religious sect of which I disapprove, because this is an irrelevant prejudice. It is not likely that this was the intention of those who drafted this clause. The wording of clause 8 of the IEEE Code of Ethics (1990) expresses much better what was presumably intended:

> treat fairly all persons regardless of such factors as race, religion, gender [18] , disability, age, or national origin.

3. The Code of Ethics of the American Society of Mechanical Engineers contains, as the second of its "fundamental canons", the statement "Engineers shall perform services only in the area of their competence". On the face of it, this is reasonable but a little thought shows that, if it is interpreted strictly, it will either stifle technological innovation or ensure that technological innovation is carried out only by non-engineers. Clause 20 of the BCS Code of Conduct is better in this respect; it states "Members shall only offer to do work or provide service which is within their professional competence and shall not lay claim to any

18. There was apparently some disagreement over the use of this term, doubtless because some members of the working group that produced it shared this author's view that *gender* is a grammatical term and does not have the same meaning as *sex,* which is what is meant here.

> level of competence which they do not possess,…". The essential point is surely that of not claiming competence that one does not possess.

A second weakness is lack of precision. Clause 4 of the BCS Code of Conduct requires members to "avoid any actions that adversely affect basic human rights." When the clause was written, there was no reference to human rights in the law of the United Kingdom. This did not come until the Human Rights Act 1998 which incorporated the European Convention on Human Rights into British Law [19] . However, the United Nations Charter contains a Universal Declaration of Human Rights, which differs from the European Convention on Human Rights in many ways [20] , and there are other declarations on human rights that differ from both. Neither the Universal Declaration, the European Convention, nor the 1998 Act, defines *basic* human rights, which are presumably a subset of the totality.

These are not simply legalistic quibbles. The Universal Declaration on Human Rights declares that everyone has the right to freedom of movement and residence within the borders of each state. The European Convention and the British Human Rights Act say nothing about this. If members of the BCS work on a system for issuing internal passports for a country that restricts internal movement, are they contravening the BCS Code? Clearly their work is adversely affecting a human right defined in the Universal Declaration but is it a *basic* human right? Anyway, they could argue that it is not a human right at all since it is not included in the Human Rights Act nor in the European Convention.

In clause 1.07, the IEEE-CS/ACM Code states that

> [Software engineers shall, as appropriate,] consider issues of physical

> disabilities, allocation of resources, economic disadvantage and other factors that can diminish access to the benefits of software.

This clause is very widely drawn and is idealistic. It reflects a political view that will not command universal acceptance, even among ACM members. It is difficult to see how it could be effectively enforced.

The 1984 version of the BCS Code of Conduct contained a lengthy section on the code as applied to the consultant. This was removed from the 1992 version in the interests of simplicity. In 1988, the Computer Society of South Africa (CSSA) adopted a code very similar to the BCS (1984) one. However,

19. Indeed, although the Act was passed in 1998, at the time of writing (late 1999) it has still not come into effect.
20. The Universal Declaration is very much broader and asserts a much larger set of rights than the European Convention. However, there is no mechanism for enforcing the Universal Declaration while the European Convention establishes the European Court of Human Rights specifically to provide a final enforcement mechanism.

in addition to the section on the code as applied to a consultant, a section was added on the code as applied to salespersons. This contains a number of explicit interpretations of the main code that will seem very relevant to anyone who has experience of selling in the computer industry. To give the flavour, we cite three out of the fifteen:

- Members shall accept only such work as they believe the organization can produce and deliver.
- Members should not denigrate the honesty or competence of a fellow professional in order to gain unfair advantage.
- Members should avoid illegal "informal" price fixing and market sharing arrangements tending to falsify the process of tendering and open competition.

While one may quibble about some of the wording here, it seems a pity that other societies have not chosen to address the conduct of sales people. Selling is perhaps the area of the profession in which the temptations to act unethically are greatest.

1.8.3 International initiatives

The International Federation for Information Processing (IFIP) has made some attempts to develop an international code. The difficulties that this process encountered serve to point up the extent to which ethical approaches differ from culture to culture. To quote Worthington, writing in 1993 [21] , the IFIP work "was attacked as biased, being written by rich males, with a western European cultural background. It was claimed to not include the issues relevant to females and those with a non-western outlook and with poor third world countries." Without knowing the details of the debate, we can guess that three of the topics that were felt to be influenced by the "western European cultural background" of the writers were human rights, bribery and corruption, and conflict of interest. Most codes coming from professional bodies "with a western European cultural background" refer to these issues; most of those from elsewhere do not. Quite what is meant by "the

issues relevant to females" is not clear.

Worthington goes on to say

> It may not be possible to have a detailed code of ethics which [is] standardised across the world. The best might be to require IT professionals to work within the norms of the society they are part of. When working in a different cultural area they must adjust their actions to suit. If they

21. Available at URL http://www.peg.apc.org/tomw/virtths.htm on 21 August 1999.

> cannot adjust they must decline the work. The alternative is a form of technical cultural imperialism. Imposing alien values in the name of technical advancement.

This is an extreme instance of the relativist position. It would, for example, allow British software engineers to work in other countries on control systems for gas chambers or record systems intended to ensure that all female children were circumcised. They would not be subject to censure by the BCS because they would be working in a different cultural area and so "they adjusted their actions to suit". One does not have to be an ethical absolutist to find this approach distasteful and few would claim that condemning mass killings was cultural imperialism.

Since the members of IFIP are, for the most part, national professional societies, IFIP has now taken the view that it is not appropriate for it to produce a code of conduct. Instead it recommends that national societies should do so and provides a list of issues that they should consider.

Both CEPIS (Council of European Professional Information Societies) and SEARCC (South East Asia Regional Computer Confederation) have produced guidelines to assist member societies in preparation of codes of ethics. The major difference is that the CEPIS guidelines include reference to human rights and to the offering of inducements or bribes, while the SEARCC ones do not.

1.8.4 Contentious issues

Because the social consequences of developments in computing are perceived as being profound, ubiquitous, and long-lasting, several codes of ethics or conduct have tried to make software engineers responsible for the social and economic consequences of their actions. There is a danger here. Predicting the social and economic consequences of any major development may require professional skills in the social sciences that few software engineers possess. If a code of conduct demands that software engineers take responsibility for these matters, it is inviting them to form judgements, and presumably promulgate them, in areas outside their competence, something which is expressly forbidden elsewhere in most codes. Furthermore, their technical competence in software engineering may give their pronouncements an authority they do not merit.

The issue of moral relativism has significant commercial consequences. If country X has a strict code of professional conduct, which is vigorously enforced, there will be some types of work in other countries for which companies from country X cannot bid.

This will place companies from country X at a significant competitive disadvantage *vis-à-vis* companies from country Y, which has no such strict code. The arguments here are similar to those concerning arms sales and ethical foreign policy.

The boundary between ethics and politics is a fuzzy one. Some codes of ethics are largely concerned with personal conduct, while others seem to seek to impose political views on members.

Some of these issues relate to a more fundamental conflict. Whom do professional engineers serve? Is it the public, their employer, the profession—or even themselves? In practice, of course, compromises are necessary and most engineers will accept that they have obligations to each of these four groups.

1.9 Applying codes of conduct

The examples that follow are all based on real situations of which the author has direct personal knowledge; in some cases, however, they have been simplified to make the essential point clearer and to prevent the protagonists being identified. Although the examples are discussed largely in the context of the BCS Code of Conduct, none of them led to disciplinary proceedings; indeed, in most cases, the party who might be considered to have breached the Code was not a member of the Society.

1.9.1 Sales proposals

Your company has successfully completed several large high-integrity systems in the field of on-line banking. As a result of these successes, the team responsible for them has left your company to set up on its own. Your company has been asked to bid for another similar system, by an overseas bank that is probably unaware that the team has left. You write a proposal that makes much of your company's experience in the field but fails to say that the team which worked on those contracts has now left. You believe that the company is still fully competent to carry out the work and that this justifies the omission.

Rule 10 is the most relevant to this situation:

> Members shall not misrepresent or withhold information on the capabilities of products, systems or services with which they are concerned or take advantage of the lack of knowledge or inexperience of others.

The example quoted would be a clear case of withholding information on the capabilities of services and (at least if successful) taking advantage of the inexperience of a client who does not think of asking to meet some of the senior staff who worked on the previous projects.

The assumption that the company is still capable of carrying out the work raises another question, addressed by rule 20:

> Members shall only offer to do work or provide service which is within their professional competence and shall not lay claim to any level of competence which they do not possess…

This situation is not, however, straightforward. It is fairly widely accepted that advertisements, for example, while not containing statements that are false, need not contain information detrimental to the image of the product, unless, as in the case of tobacco, there is a legal obligation to do so.

Rule 20 is concerned with individual members claiming competence. It is generally straightforward although, in practice, there may be a problem of individuals not realizing their own lack of competence. This problem becomes much more serious when it is a company that fails to realize its lack of competence. This seems to have been the case with the London Ambulance System, where the company writing the software had no previous experience of such systems and quoted a totally unrealistic price, which was accepted although it was only a fraction of the price estimated by experienced consultants. It would be unrealistic to assume that all professional members of the BCS are able to judge satisfactorily their or their company's competence to tackle an unfamiliar job. See Chapter 10 for further discussion of this issue.

1.9.2 Integrity and professional status

A consultant employed by a software house is advising a company about a new large-scale hardware procurement. She is recommending a switch from the present multinational supplier to a smaller supplier on the grounds that its prices are substantially lower and it offers better service. She receives a phone call from a senior manager in the multinational supplier saying that, if she persists with the recommendation, he will ensure that her managing director receives reports from several sources of her incompetence and lack of professionalism. Furthermore, he will ensure that her company never again receives any business from his company [22] .

Rule 16 covers this situation:

> Members shall act with integrity towards fellow members and to members of other professions with whom they are concerned in a professional capacity and shall avoid engaging in any activity that is incompatible with professional status.

22. In the real-life scenario on which this example is based, the final threat was a fairly empty one, since the software house had never won any business from the multinational.

The wording is a little strange. One would expect that members should be required to act with integrity towards everyone with whom they are concerned in a professional capacity, not simply fellow members and members of other professions. The manager from the multinational is clearly not behaving with integrity towards the consultant. Even if she is neither a fellow member of the BCS nor considered to be a member of another profession, to threaten someone in this way is surely incompatible with professional status.

1.9.3 Political and social considerations

Suppose that you are asked to work on a system for a country of whose political and social system you disapprove. What should be your attitude in the following cases?

1. The system records inoculations and is intended to improve the protection of the poorest section of society.
2. The system is for government use and clearly implements the country's tradition of sexual or racial discrimination.
3. The system will maintain intelligence for the country's notoriously brutal secret police.
4. The system will control the flow of gas into the gas chambers that are being used to eliminate racial minorities in the country.

While there would seem to be no generally accepted moral objection to the first of these, some software engineers would have refused to work on such a system for South Africa during the period of boycotts aimed at removing the apartheid regime.

The second case poses in perhaps the most acute form the conflict between the absolutist and the relativist positions. It is also one where the influence of the mass media and of single-issue politics is important. There are countries that practise racial and sexual discrimination on an institutional scale that would be abhorrent to very many people in the UK and elsewhere. Because this has not been widely reported and there is no organization pushing to bring the matter to public attention, the situation is not widely known. However, many countries (including our own) have policies of which some of us may disapprove. It is easy to argue oneself into the position where almost no work is morally acceptable.

Only clause 4, with its reference to basic human rights, offers any help in these situations. If the term "basic human rights" is to have any meaning, it must surely include the right not to be murdered or arbitrarily imprisoned. This should prevent a member of the BCS working on systems 3 and 4. The position regarding system 2 is less clear. The apparent weakness of the Code in these areas probably reflects the lack of a consensus among the Society's members.

On the more general question, the concept of proportionality may be of some help. If you are opposed to nuclear weapons and their production is the main part of the business of the company for which you work, you will surely feel that you are unlikely to be able to change the company and that you should not continue to work for it. However, if you disapprove of the policies of the government of Pontevedro and you find that the large telecommunications company for which you work is supplying 5,000 of its latest telephone hand sets to the Pontevedrian Ministry of Health, you may well feel that this is a minor matter and that resignation would be a disproportionate reaction. Furthermore, you might be able to persuade the company not to look for further business in Pontevedro.

1.9.4 Public health and safety

Suppose that you are a database expert and have been asked to write software that

maintains records of radiation dosages to which employees at a nuclear installation have been exposed. The input comes from the radiation badges that employees are required by law to wear and the purpose of the software is to flag any employee who is approaching the maximum dosage in a given period. You have been asked to write the software in such a way that the recorded dosage is never shown as reaching the threshold. If you do this, will you be in breach of the BCS Code of Conduct?

The most relevant clauses are clause 1:

> Members shall in their professional practice safeguard public health and safety and have regard to the protection of the environment.

and clause 3:

> Members shall ensure that within their chosen fields they have the knowledge and understanding of relevant legislation, regulations and standards and that they comply with such requirements.

Unfortunately, neither of these clauses quite fits the case. Although it is in the public interest that employers should not behave in this way, it is not a matter of *public* health and safety but of the health and safety of the employees of one organization; clause 1 is not precisely applicable, therefore. Neither, unfortunately, is clause 3. As a database expert, you may well be complying with all legislation, regulations and standards relevant to your chosen field while breaking the regulations relevant to nuclear installations. This may seem like casuistry but these are arguments that might be put in an attempt to prevent the Society from expelling the member concerned.

In this case, the IEEE-CS/ACM code is much clearer. Clause 6.06 says "obey all laws governing their work, unless, in exceptional circumstances, such compliance is inconsistent with the public interest".

There remains the question of what you should do if you find yourself placed in this situation. Assuming that voicing your concerns to your manager has failed to produce any useful result, you might think of approaching a trade union representative on the organization's Health and Safety Committee. If you do this, you will be in breach of clause 8 of the BCS Code, which requires you to keep information confidential unless your employer gives permission or a court orders you to disclose it. Again the IEEE-CS/ACM Code is more helpful; it requires you to keep the information confidential, "where such confidentiality is in the public interest". The BCS member would have to invoke the doctrine of double effect in order to justify the breach of confidence involved.

Applying the doctrine of double effect to "whistle-blowing" leads to the common sense conclusion that denouncing one's client or employer to a regulatory body is justified if there is a serious breach of the regulatory provisions that threatens the public interest and that cannot be dealt with in another way, because the good effects can be expected to outweigh the bad effects of the foreseen but "unintended" breach of fidelity. If the breach of regulations was merely minor and technical, the good effects intended might well not outweigh bad effects of the breach of fidelity. This again is a matter of proportionality, as mentioned in the previous section.

An appeal to the doctrine of double effect in a case like this would probably be

sufficient to convince a professional body that a member should not be disciplined. The legal position has been changed and is now governed by the Public Interest Disclosure Act 1998; a detailed discussion will be found in Section 6.1.5.

1.9.5 Conflicts of interest

Peter is advising a government agency on the introduction of a new and comprehensive computer system to automate many of its operations. He advises the purchase of a package costing several million pounds to handle certain specialized communications requirements. He fails to mention that his wife, Ann, is the sales director of the company that markets the package.

Two of the BCS rules directly address this situation, perhaps because situations like the one described are more common than they should be. Rule 12 says that

> Members shall not purport to exercise independent judgement on behalf of a client on any product or service in which they knowingly have any interest, financial or otherwise

and rule 22 states

> Members shall avoid any situation that may give rise to a conflict of interest between themselves and their client and shall make full and immediate disclosure to the client if any such conflict should occur.

Rule 12 goes much further than rule 22 in that it forbids a consultant from claiming to exercise independent judgement even if he has disclosed his interest. Rule 22, however, covers a wider range of situations, for example, where a management consultant is advising a company on its organizational structure and takes the opportunity to recommend the promotion of her second cousin.

In the scenario described, Peter is clearly in breach of both rule 12 and rule 22 and should have informed his client immediately there was any possibility of his considering software marketed by Ann's company. The sort of things you should disclose under rule 22 include:

- a directorship or a major financial interest in any business that is in competition with your client;
- a financial interest (except a small share holding in a public company) in any goods or services you are recommending to your client;
- a personal relationship with someone in either of the above categories;
- a personal relationship with any person working for the client who might influence, or be directly affected by, your advice.

It is difficult to be precise about how close the personal relationships have to be. Family relationships can cause a particular problem. In some families second cousins may be ignorant of each other and never have met; in other families, a third cousin once removed is regarded as a close relative who should be helped if at all possible. The essential point is that if an outsider might reasonably think that your advice or recommendations could

be influenced by the relationship, you should declare it.

A particular problem may arise when a personal relationship develops during the course of a professional relationship. In one case, such a relationship developed between the contractor's project manager and the client's project manager. In order to be able to maintain the relationship, they prolonged the work far beyond the length of time it should have taken. This is clearly a conflict of interest but the wording of rule 22 is perhaps not clear enough. The contract between the two organizations said that all communication had to pass through the project managers; thus the "client" was well aware of the situation. A requirement to make full and immediate disclosure to "client management and to the member's own management" might perhaps be clearer.

1.10 Further reading

The engineering profession, as opposed to the discipline, is not well served by books. The Finniston Report:

Engineering our future , Report of the Committee of Inquiry into the Engineering Profession, Cmnd 7794 (HMSO, January 1980)

is readily available in academic and other large libraries. It describes the context within which the Engineering Council was founded and the issues that were occupying the profession at the time. Despite its age, it is perhaps the best single document covering the engineering profession in the UK and much of what it has to say is still valid today.

SARTOR:

Standards and routes to registration (SARTOR) , 3rd edn (The Engineering Council, Canberra House, Maltravers Street, London WC2R 3ER, 1997)

describes the current structure of the profession.

The current position regarding licensing of software engineers in the USA is discussed in

Bagert, D.J. 1999. "Taking the lead in licensing software engineers", *Communications of the ACM ,* **42**(4).

The best and most convenient source of up-to-date information on the topics discussed in Sections 1.1 to 1.5 of this chapter is the World-Wide Web. The following is a list of sites used as sources for the material in those sections

The Engineering Council http://www.engc.org.uk (There is a summary of SARTOR available at this site.)

The British Computer Society http://www.bcs.org.uk

The Institution of Civil Engineers http://www.ics.org.uk

The Institution of Electrical Engineers http://www.iee.org.uk

The General Teaching Council for England http://www.dfee.gov.uk/gtcreg (This is a consultation paper. The regulations setting up the Council are contained in Statutory Instrument 1999 No. 1726, which can be accessed through the HMSO site: http://www.hmso.gov.uk.)

FEANI http://www.feani.org

Accreditation Board for Engineering and Technology (ABET) http://www.abct.org

Computing Sciences Accreditation Board (CSAB) http://www.csab.org

The National Council of Examiners for Engineering and Surveying (NCEES) http://www.ncees.org

General Statutes of North Carolina http://www.ncbels.org/generalstatues *[sic]*

(Chapter 89C of the statutes contains the provisions relating to engineering and can be taken as fairly typical of the position in most states of the USA.)

Sections 1.6 to 1.9 are better served by books. For a modern and readable introduction to ethics, we can recommend

P.Benn, 1998. *Ethics* . London: UCL Press. (In the series *Fundamentals of Philosophy*.) ISBN 1–85728–453–4.

More extensive discussion of professional codes of conduct, along with discussion of other and wider aspects of professionalism will be found in:

Myers, C., T.Hall & D.Pitt (eds) 1997. *The responsible software engineer: selected readings in IT Professionalism* . London: Springer-Verlag. ISBN 3–540–76041–5.

The following article covers much the same material as this chapter, although from a rather different point of view:

K.C.Laudon, "Ethical concepts and information technology", *Communications of the ACM* **38**(12), 33–39, December 1995.

The work of the IFIP Ethics Task Group was published as

Berleur & K.Brunnstein (eds), *Ethics of computing: codes, spaces for discussion and law* . (London: Chapman and Hall, 1996). ISBN 0–412–72620–3.

This book is a valuable source of material for anyone seriously interested in the ethics of the computer profession. It includes a number of discussion papers and the draft international code of ethics that led to the controversy referred to in 1.8.3. It reproduces over 30 codes of ethics or conduct and contains a comparative analysis of them. Unfortunately, this analysis is rather naïve. The book is also beginning to date a little.

Finally, the Web allows many codes of conduct to be consulted. We have already indicated the sites at which the codes of conduct referred to can be found.