**Brian S. Collins and Robin Mansell**

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## Book section

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# Chapter 2 Cyber trust and crime prevention

Brian S. Collins and Robin Mansell[1]

## 2.1 INTRODUCTION

Cyberspace is global in its reach. In the UK and elsewhere, many solutions for crime prevention could be introduced through public or private initiatives. Many of these solutions, however, require internationally coordinated action if they are to be effective. In the UK the science and engineering base is strong in key technical areas as well as with respect to problems and issues that are the concerns of the legal profession, the social sciences and the humanities. This provides a strong basis for leadership internationally.

The evolution of cyberspace is a subject of great controversy. There are divergent views about whether the UK has a competitive advantage in developing technologies that will be trusted by the majority of their users and whether there is a need for government initiatives to ensure the development of trustworthy technologies. There are similarly divergent views about the need to constrain cyberspace developments in order to limit the potential for destructive attack, strengthen collective security and limit privacy invading intrusions. The scientific evidence base cannot be applied to resolve all of these controversies. However, it can be applied to clarify how the human and technical components of cyberspace relate to each other. Our synthesis of the chapters in this volume is designed to suggest how the interventions in cyberspace of different actors are likely to reverberate throughout the social and technical system.

In the UK, Foresight projects are designed to produce challenging visions of the future with the aim of ensuring that the strategies of today are effective. The Cyber Trust and Crime Prevention project explored the application and implications of new generations of information and communications technologies (ICTs) in a variety of areas that will present opportunities and challenges for crime prevention in the future. These areas included identity and authenticity, system robustness and dependability, security and information assurance, and privacy and surveillance. All of these raise crucial issues for our understanding of how risk is perceived and trust is fostered within complex social and technical systems. The synthesis in this chapter emphasizes key interrelationships between the human and technical components of cyberspace.

The material in this chapter is based on the state-of-the-art science reviews commissioned for the Cyber Trust and Crime Prevention project. The ten major reviews of current work in Parts 2 and 3 of this volume provide authoritative reference material and a foundation for further research and debate.[2] Each of these chapters highlights the current state of knowledge in selected areas as well as research that is needed to clarify and build an improved knowledge base in the future. In Part 4, we include three short notes by experts who were invited to comment on a specific topic.[3]

Section 2.2 provides a brief discussion of the technologies of cyberspace. In Section 2.3 we consider how those who design computer-based systems understand the processes involved in constructing them as well as the processes of, and mechanisms for, identifying and authenticating users. Important issues of the usability of these mechanisms, the role of cyber-security and risk management, and the future prospects for the trustworthiness of cyberspace are also considered in this section.

The construction and use of cyberspace systems requires many assumptions about the experience and perceptions of trust and risk, as cyberspace tools and applications are developed. In Section 2.4 we examine theories and empirical evidence from a variety of disciplinary perspectives. These help to shed light on trust and risk management and on the appropriate models for understanding trust in offline and online environments. We examine the ethical issues and stances that inform divergent and deeply held commitments to the need for a more dependable cyberspace.

The discussion in Sections 2.3 and 2.4 is principally concerned with general trends that apply broadly across the components of the human and technical cyberspace system. In Section 2.5 we examine how various models of trust are being applied in two important areas of technical development – software agent-based systems and knowledge technologies and the semantic web. We also consider the available, albeit limited, empirical evidence on the way cyberspace users think about trust.

In Section 2.6 we examine the economic features and likely dynamics of the evolution of future cyberspace technology and service markets and the interaction of these features with policy measures and the legislative environment. Finally, in Section 2.7 we reflect on the lessons that can be drawn from existing research about the future context in which crime prevention strategies will evolve. This section highlights areas where measures could be taken to develop more trustworthy cyberspace systems that may help to strengthen crime prevention strategies. The overriding concern is to minimize the potential for cyberspace to develop in ways that create new opportunities for physical and cyber crime to occur.

## 2.2 THE TECHNOLOGIES OF CYBERSPACE

We briefly introduce the hardware, software and human systems that comprise cyberspace in this section. ‘Technology’ may refer to the components of cyberspace, such as its hardware and software, or it may refer to the social values, norms, practices and institutions of cyberspace. ‘Cyberspace’ refers to interconnected networks or the spaces within which electronic communications take place and this term has become synonymous with the Internet and the World Wide Web and their use by the public (Skibell 2002).[4] Those who invent, design and implement the ICTs that underpin cyberspace, generally agree that much needs to be done to build confidence both in people and in the ‘mechanics’ of cyberspace.

Analyses of the technical and possible market developments in the field of pervasive computing and trustworthy ICT systems show that some of the technologies are relatively mature and well-understood, but still evolving. Other technologies are immature, but reasonably predictable in their evolution, and still others are in the ‘blue-skies’ research phase (Sharpe 2003; Sharpe and Zaba 2004). The technologies range from those used for pattern recognition and cognitive modelling to those supporting network connectivity and broadband access. They include various kinds of software, service platforms and service functionalities.

In this chapter, we focus particularly on the development of complex software systems and the technologies used to establish identity and to authenticate users of cyberspace. We look specifically at developments in software agent-based computing and knowledge technologies and the semantic web. All of these technologies play a crucial role in the emergence of ‘pervasive’ or ‘ubiquitous’ computing and the spread of networks of ‘ambient intelligence’ (see Box 2.1). And these technologies play a major role in the extent to which issues of risk, trust, privacy and security and also ethical issues become important in crime prevention strategies.

As suggested in Box 2.1, the majority of current users of cyberspace do not have a good understanding of today’s security requirements. As the European Commission’s Advisory Group on Information Society Technologies (IST) has suggested, the solutions for improving cyber trust and crime prevention in a pervasive computing or ambient intelligence environment are likely to be quite different from those in use today.

*Box 2.1 Ambient intelligence and the security paradigm*

'In the ISTAG [Information Society Technologies Advisory Group] concept of Ambient Intelligence, intelligence is pervasive and unobtrusive in the environment. The environment is sensitive to the presence of living people in it, and supports their activities. People, physical entities, and their agents and services share this new space, which encompasses both the physical and virtual worlds – the Ambient Intelligent Space – or AmI Space.

Security in this space will require solutions very different from those of today's systems which are predicated on relatively stable, well-defined, consistent configurations, contexts, and participants to the security arrangements. … This new paradigm will be characterized by 'conformable' security, in which the degree and nature of security associated with any particular type of action will change over time and with changing circumstances and with changing available information so as to suit the context. … within the existing security paradigm there are significant outstanding problems that inhibit development of information society markets. The majority of potential users of services and products have, at best, a poor understanding of security, which leads to caution and, at worst, severe distrust. They need comprehensible mechanisms in which they can have confidence…' (European Commission, IST Advisory Group 2002, pp. 3-4).

The commercial setting in which ICT evolution is occurring is subject to the dynamics of the interactions between the players (governments, citizens and consumers, civil society organizations of many kinds, and businesses) and the choices made with respect to regulations, standards and the role of the market. These, in turn, are strongly influenced by changes in the motivations and actions of those that seek to minimize criminal opportunities through crime prevention and those that seek to exploit emerging technologies to support existing and new forms of criminal activity. In an emergent evolutionary system, such as cyberspace where there is an "arms-race' between offenders and crime preventers, a key strategic issue is 'how to live with it and how to ensure that the balance is tilted as far as possible, for as much of the time as possible, in favour of preventers" (Ekblom 1999, p. 47).

Crime prevention in the context of cyberspace means reducing the risk of the occurrence of crime and the potential seriousness of crime and disorder events that may occur either in the online or offline world (Ekblom 2002, 2003). To achieve this, it is necessary to identify the problems and their causes. Given the relatively recent and rapid development of cyberspace it is not surprising that there are very substantial uncertainties about what future problems will emerge and how they can be tackled. It is clear, however, that cyberspace entails new opportunities for crime because its reliance on networks and communication is such that criminal events may be distributed across geographical space and through time in many new ways. It enables new computer systems and data capture methods that may be vulnerable to attack and, at the same time, offer innovative means of responding to criminal activity. Just as the cyberspace system design itself is evolving and adaptive, giving rise to new forms of criminal opportunity, so also are the potential offenders' tactics and strategies (Ekblom 1997). The solutions to the evolutionary arms-race involving cyberspace technologies will undoubtedly lead to new technical design considerations, but their feasibility, in turn, will depend on changing social, cultural, political and economic priorities as well as on a number of crucial ethical considerations.

In a dynamic socio-technical system of this kind, the components of cyberspace often acquire a self-reinforcing structure. The motivations of the different players in society will resolve themselves in particular ways, such that as new ICTs are implemented, parts of the system may become quite stable for a period of time. The significance of this is that the future use of ICTs will be inextricably bound up with systems that coordinate a large number of technologies within agreed interfaces and standards, which themselves will experience periods of transient stability. These evolve from generation to generation, as the technology shifts and the players act in various ways that change their respective motivations and actions.

The range of technologies – technical and social – that is central to the emergent properties of cyberspace is vast.[5] In this chapter, emphasis is given to those areas and developments that were regarded as being the most important by those consulted during the Cyber Trust and Crime Prevention project. Many of the problems that give rise to perceptions of risk and the insecurity of cyberspace are not new, but crime prevention in the light of cyberspace developments does have some new dimensions. This is particularly so in areas such as the management of digital identities, the processes and tools used to enable reciprocity in cyberspace, and the properties that are required to enable humans to place trust in technology systems, that is, in part, the trustworthiness of such systems.

The scope of the issues examined in this chapter is informed by an analysis of previous studies in closely related areas. Although trust, assurance, security and dependability as aspects of cyberspace developments, have been mentioned in previous works, crime prevention itself has not been a explicit focus. In addition, there are differences in the focus of studies of cyberspace-related developments conducted in the US and in Europe as suggested by the following extract.

> The US studies tended to be more focused on technological and managerial solutions to the challenges. European studies addressed these issues but discussed more extensively the societal context and had more explicit visions of the desired societal end-state. This perhaps reflects a US focus on managing the risks consequent on market led developments compared to the European attempt to direct and shape these developments. It may also reflect an embedded US view that ICT developments (mainly US-led) are broadly positive, compared to a more sceptical European view that is more concerned about the economic, social and

political changes they will entail (Cremonini et al. 2003, p. 8).

The European emphasis on the economic, social and political implications of cyberspace technologies is reflected in the state-of-the-art science reviews that follow this chapter. Pervasive computing will give rise to the need for new paradigms for managing uncertainty, the perceived and actual risks of cyberspace, and the trustworthiness of the cyberspace system.

The technical and human components of cyberspace form a complex emergent system that is subject to periods of instability and stability. Historically, studies of innovation and techno-economic change demonstrate periods of instability and stability as technical and human or social systems interact in new ways. There is no reason to expect the cyberspace system to be different in this respect (Freeman and Louça 2001; Perez 2002). Addressing questions about cyber trust and crime prevention within existing paradigms will not suffice to alleviate concerns about threats in this environment. The contributors to this volume call for a stronger cross-disciplinary research effort that will build a better foundation for understanding key facets of the technical and human dimensions of cyberspace.[6]

## 2.3 CONSTRUCTING AND USING CYBERSPACE SYSTEMS

Technological innovations could affect many elements of the web of interacting and mutually dependent aspects of cyber trust and crime prevention. The dependability of pervasive and complex computing systems has a clear impact on security and on risk. User identification and authentication mechanisms also have an impact on security and, in addition, are tightly bound to tokens, passwords, encryption and the usability of these mechanisms by human agents. We highlight in this section recent thinking about the way large-scale pervasive computing systems are being developed. Software development practices that favour the construction of more dependable systems are examined together with issues of identity and authentication. Research in these areas emphasizes technical and human issues and the importance of managing risk and trust in cyberspace.

### 2.3.1 Towards Trustworthy Pervasive Computer Systems

The UK is not alone in becoming ever more dependent on large networked computer systems yet the dependability of such systems is by no means always satisfactory (Royal Academy of Engineering and British Computer

Society 2004). The techniques and tools available today make it possible to produce complex computer systems that are adequately dependable. However, there is a huge ‘deployment gap’, with many organizations attempting to produce complex systems and, in particular, software (which is where the complexity of such systems mainly, and appropriately, resides) using technical and management methods that are far from ‘best practice’. Even with today’s technology we seem to be unable to adapt the methods and techniques available to us to deploy reliable systems. In the future, as we invent even more complex systems, unless there is a major and disruptive change in the way in which we go about deploying systems, the trustworthiness of the underlying infrastructure and of the applications that run on it will degrade (see Ch. 3 in this volume). Major or radical innovations in technology often require equally major or disruptive changes in practices of system design and implementation.

### 2.3.2 Dependability Technologies

Dependability (sometimes and not always usefully termed ‘trustworthiness’) is the ability to avoid computer system failures that are more frequent or more severe and outage durations that are longer than is acceptable. The causes of any such failures are termed faults. It is not feasible to escape the need to accept some level of failure. What is at issue is the level of failure that comes to be seen as being unacceptable. This is a complex mix of socio-technical issues that is worthy of further analysis and study. Overstressing the need for a high dependability level when members of society will accept or tolerate a lower one, especially to make a system more useable, is a very important driver for the design and construction of a complex computer system. It is clear, however, that system failures should be prevented at some level. There are four basic dependability technologies – fault prevention, fault removal and fault tolerance (whose effective combination is crucial), and fault forecasting. These provide the means of assessing progress towards achieving adequate dependability (see Ch. 3).

A variety of fault prevention and fault removal techniques are currently in use, in some cases as part of a formal (mathematically-based) design method. However, there is a need to make such methods and their tools easier to use. Fault tolerance is very effectively used for hardware faults and, in some arenas, for software faults. Fault forecasting currently has limitations with regard to large systems and extremely high dependability targets.

The problem of deliberate attacks on networked computer systems and, via them, on other major infrastructures, by amateur and professional hackers, criminals or well-resourced terrorist groups is already serious and seems certain to grow as systems become more pervasive. Detecting the onset of such attacks is insufficient to ensure system dependability. Means are also needed for maintaining satisfactory service despite such attacks, and for reliably gathering evidence of the attacks if subsequent judicial processes are to be successful.

Because systems are all pervasive, they are being and increasingly will be used in the design and testing of new systems and in the support of the operation of 'transactional' systems that the 'end-user' experiences. The reliability or trustworthiness of these other uses is just as important to the 'end-user' systems as the one he or she experiences, and particularly those used for testing. Those used for evidence gathering in support of judicial processes must be at least as provably trustworthy as the end-user system, if not more so. The development of complex software relies on state-of-the-art in the software engineering process including the way projects are managed and the choices of technology.

*2.3.2.1 Complex software projects and software engineering processes*

Complex software projects have certain unique properties that are derived from the fact that they are not governed by physical laws in the way that civil and mechanical engineering projects are. However, complex mechanical and civil engineering projects have a number of properties in common, such as the need to share constraints and dependencies between members of the project team (Collins 2004). The management processes that traditionally are applied to software projects involve breaking the total project activity into lines of activity within which there are close interdependencies. These lines of activity are broken down further into sets of tasks that run sequentially. The interdependencies between lines of activity are then also established. This historical approach to the development of software has not been completely successful and there is a need for a fundamental review of the nature of the problem of software engineering and its architecture to develop a more radical approach to new ways of managing this complex set of activities to achieve greater dependability (Collins 2004; and see Ch. 3).

In the organization of software projects, teams of people pursue particular lines of activity that are coordinated by an overall project manager. However, as Brooks (1995) has pointed out in his seminal book, *The Mythical Man-Month*, the balance between creative work carried out by an individual in pursuit of the task that has been allocated to him or her, and the sharing of information about the work with others dependent on this individual becomes an unmanageable process once the team size involved in a line of activity exceeds some 35 to 50 people. In this area, technology itself may be able to provide more sophisticated environments for developers to work in, such that the load placed upon them for sharing can be diminished so as to rebalance the time that is available to them to carry out creative work (Collins 2004).

Leadership in software engineering centres on the project manager's ability to maintain strong discipline and the sense of direction for the activities involved in the face of demands for unstructured change, movement of team members and reallocation of financial resources. Such leadership qualities arise from a mix of experience in carrying out a range of tasks within the general field of software engineering and an understanding of the overall activity in a holistic sense. Without strong, sustained and high-quality leadership, complex software projects are almost doomed to failure and possibly should never even begin.

A complex software project will be undertaken in order to meet the business needs of the organization or within a contract to be delivered to an external customer. It is vital not only that the customer is engaged in the development process from its inception to its completion, but also that the project team has well-defined mechanisms that allow the customer to be involved in the project and add value during its lifetime. The way in which the customer engages with the project may be divisive or incoherent such that the quality of the product is diminished to an unacceptable extent. It is a common experience that project management methodologies with well-defined processes for customer engagement are not always invested in or trusted by customers.

*2.3.2.2 Technical choices and software requirements*

In large-scale software projects, there are significant technical choices to be made about how to capture requirements in a systematic way and how to interpret those requirements in such a way that they can be validated against the users' perceptions, and in the concepts of how the software will function when it is installed and operating. In addition, choices must be made as to the design language that is used to interpret the requirements in a form from which the programmer can develop code that delivers the functionality that the user requires. There is also a choice to be made about the programming language. This must be compatible with the functionality of the project, but also with the functionality that is either concurrently developed in other projects or with legacy code with which it has to interoperate, and all have to be compatible with the target platform of both hardware and operating system software, on which functionality will eventually reside. Between the development of the code and operation there is a further level of complexity connected with the testing, validation and verification of the code that has been delivered to show that it does indeed meet the requirements of both the user and the system developer (Collins 2004) (see Box 2.2).

This level of complex interdependent processes and tools is not unique to software engineering. Large software projects are not unusual in having changes imposed upon them by external factors beyond the project control and frequently the basic assumptions on which the projects are based will not be examined. In such cases it may be necessary to stop the whole project or re-design to accommodate these new developments.

*Box 2.2 Validating technical choices throughout the product lifecycle*

These complex choices have been written here as if they are linear choices to be taken sequentially. In fact they all should be taken at the start of the project in such a way that an integrated environment for the whole project is defined at the outset. If any major changes are made to the assumptions concerning any of these factors such that, for instance, a different programming languages is chosen or a new approach to testing is selected, then at least conceptually a return to the beginning should be taken in order to re-verify that the assumptions that were made up to that time, supporting the original choices that were made, are still valid (Collins 2004).

This example of applying a professional discipline is an essential part of a successful complex software project. Ideally, buyers of such projects should insist on these disciplines being implemented as appropriate. To achieve this, the use of educated and experienced people in the design and implementation of large software projects is an essential contribution to minimizing the risk.

#### *2.3.2.3 Dependability and cross-disciplinary research*

Present trends indicate that as ICTs are embedded into almost everything, huge networked computer systems are likely to become pervasive and richly interconnected and required to function essentially continuously. Even today's best practice, which is not used to good effect, will not suffice for the development and operation of such systems. The problems of producing dependable large complex distributed systems to match their specifications within time and budget constraints, and the problems of actually achieving adequate operational dependability from such systems when they are deployed, are critical components of ongoing research programmes that will remain important for some time. New means of governance will be essential. Consideration could be given to developing auditing procedures so that large-scale software projects could be certified as having been carried out by appropriately qualified employees, in line with agreed standards.

### 2.3.3 Identification and Authentication in Cyberspace

As the automation of business and the use of electronic forms of communication increase, individuals in society are challenged with finding equivalents to such basic security and crime prevention features as face-to-face recognition and hand-written signatures. Although the technology is changing rapidly, when two people communicate electronically, for instance, by email, they have usually lost the important facility of face-to-face recognition and need some other means of identifying each other. Similarly, while shoppers in the high street have confidence in the authenticity of the identities of the major stores that they frequent, it is not so easy for Internet shoppers to have confidence in the authenticity of a store's web site (see Ch. 4 in this volume).

### *2.3.3.1 Identifying people, devices and data*

Identification and authentication in cyberspace involves primary objects whether these are people, devices or digital data. The problems associated with identification and authentication in the electronic world need to be considered in the light of the limitations of the techniques used in the pre-electronic age, some of which are highlighted in Box 2.3.

> *Box 2.3 Authenticating primary objects*
>
> Suppose, for instance, that you look up someone's telephone number in a directory and dial it. If someone answers and claims to be that person then can you be sure that they are the person you wish to contact? The realistic answer is 'yes, almost certainly'. However, it is worthwhile to stress the assumptions you are making. The first is that your contact is the only person likely to pick up the phone and claim to be them. This, of course, may not be true. Even if the number is correct there may be two people at the same address with identical names, for example, mother and daughter. The phone call may have been re-routed by a criminal to an impostor who is deliberately impersonating the person you wish to contact. The second assumption is that the number in the directory is accurate. This is almost certainly true if you are relying on a paper version of the directory that has been published by, for instance, the telephone company and it would certainly be difficult for fraudsters to change people's entries. However, the same may not be true if you are relying on an electronic copy of the directory where obtaining assurance that the information has not been altered might be much more difficult (see Ch. 4).

There are three classic ways for users to authenticate themselves to a system, which may be a computer, a network or another individual: (i) something they own; (ii) something they know; or (iii) something they are, that is, a personal characteristic. Use of combinations of at least two is common. Typically, the 'something owned' might be a token. If that token, for example, a smartcard, has some form of processing capability, then the something known might be a password to activate the device. The personal characteristic is likely to be some form of biometric, such as a fingerprint, which might also be used as an activation process for a smartcard. It is now common for a smartcard to have encryption capabilities and to contain cryptographic keys. The authentication process may involve sophisticated protocols between the card and the authenticating device (see Ch. 4).

Before any of these techniques can be used, there must be an identification of the users to ensure that they have, in fact, been given the correct object or knowledge or that the characteristic being associated with them is, in fact, theirs. Most commonly used authentication techniques assume that there has been an initial, accurate identification and rely on that assumption. Authentication techniques that rely on something owned and/or something known cannot authenticate the individual. All that they do is equate the individual with either the knowledge or possession. If the original identification is not conducted properly then disaster looms. Even if the identification process is correct there is always the danger that impostors may either obtain the knowledge or capture the token. In cyberspace it is necessary to prove our identities to one another using a variety of means.

*Passwords.* The password is the most common form of identification used today. While there are substantial problems with password-based authentication – and these problems mean that passwords are considered a weak form of authentication – it should be noted that passwords are very familiar and convenient and are afforded a wide-degree of acceptability by users. Added to this, administrative safeguards can be used to ensure that user-chosen passwords satisfy certain criteria to help set a minimum level of password acceptability. Users can also be required to change their passwords at regular intervals, and systems often lock-down after a specific number of unsuccessful login attempts (see Ch. 4).

*Box 2.4 One-time password schemes*

In a one-time password scheme, a user's password is only valid for a short time frame, perhaps for 30 seconds or one minute. After this time the password changes. The window of opportunity for an attacker is greatly reduced since an intercepted password is unlikely to be of use in the future. All that is required is that the sequence of passwords should not be easy to predict after witnessing or intercepting a (potentially large) set of past passwords.

A one-time password scheme requires a moderate level of computational complexity, and to provide this, the user typically is provided with a token. One of the largest deployments is probably the RSA SecurID, which can be provided in a variety of forms. The card is issued to a specific user and each card contains a secret, which is also held at the authenticating server. The one-time password is computed as a complex function of the physical time, the unknown secret stored in the card and, optionally, a user-supplied PIN. The password on the token display should then match the password anticipated by the server (see Ch. 4).

A particular form of password is the Personal Identification Number or PIN. We are very familiar with this mechanism from the banking industry, but the PIN is little more than a short, restricted password. The PIN offers very little security, but is typically used in a two-factor authentication system and also is used in conjunction with the bank (or automated teller machine -ATM) card. Fixed passwords have many good attributes – their simplicity and cost of administration – but the risk, in some deployments, of password discovery, interception and/or replay, may be too great. The one-time password is a move towards a stronger means of authentication (see Box 2.4).

The RSA SecurID[7] technology can be deployed in software and it is supported on a variety of platforms including some mobile phones. In this way, the cost of card deployment is mitigated and the mobile phone can be used as a convenient channel for deployment. Despite the improved security offered by the one-time password it is still not classed as strong authentication. Strong authentication requires real-time interaction and the use of cryptographic algorithms.

*Encryption.* Encryption is the basis for stronger forms of authentication. Instead of transferring a password (or a short-lived password) as a means of authentication, the authenticating server and the claimant (typically a card or token) perform some protocol or exchange of messages. In general terms, the server sends a challenge to the token and a cryptographic computation takes place within the card or token. The result is sent back to the server for verification. The cryptographic computation can be based on secret (symmetric) key or public (asymmetric) key techniques (see Ch. 4).

In classical cryptography, the two participants in a cryptographic exchange share the same secret key. Such algorithms are referred to as secret key or symmetric algorithms. Public key or asymmetric cryptography allows two participants in a cryptographic exchange to possess different keys. Such systems are designed so that knowledge of one key (the public key) does not allow an adversary to recover the other (the private key).

*Table 2.1 Cryptographic algorithm classification*

| | Confidentiality | Authentication |
|---|---|---|
| Secret Key (Symmetric) Cryptography | Block ciphers<br>Stream ciphers | Message authentication Codes |
| Public Key (Asymmetric) Cryptography | Public key encryption | Digital signatures |

*Source: Table 4.1, Ch. 4 in this volume.*

Public key techniques can be used to provide what are termed digital signatures. Public key cryptography is not problem-free. In particular, the problem of ensuring the availability of authenticated, valid public keys is significant and has proved to be practically tractable in only a few specific areas of deployment. Such a supporting infrastructure is referred to as a Public Key Infrastructure, or PKI. Cryptographic algorithms are typically classified as shown in Table 2.1.

An alternative to challenge-response protocols based on public key techniques (which are computationally intensive) might be to use what are termed public key based interactive identification protocols but these do not provide public key encryption or digital signatures. Chapter 4, Table 4.2 provides a summary of the different identification (entity-authentication) mechanisms.

People are not the only entity that needs to be identified for cyberspace to be trustworthy. Information in a number of representations (documents, images, sounds, videos), software processes and physical devices (computers, networks, mobile phones, etc.) all have to be identified if a set of trustworthy relationships is to be established between them. At present the main application area is in document authentication, which, in turn, is an important application of cryptographic techniques. In many situations it is the authenticity of information that is far more important than its confidentiality. The term document can be extended to cover the simple electronic representation of physical documents and other forms of digital information, such as that carried on a bank card, executable code downloaded into a device and virtual and dynamic documents that might contain links to temporary resources on the Internet, or might be generated dynamically using temporary data stored on some server (see Ch. 4).

When considering the authentication of a document the complexity of the ‘document’ can have a significant impact. When we sign a standalone electronic document, or some executable code, then it is (reasonably) obvious what we intend the signature to cover and what we intend the signature to mean. However, if a document were to contain links to, or be generated by, other temporary resources, then while the implication behind the signature might be obvious, its execution and continued validity can introduce some significant problems.

How to extend the concept of identity into these complex areas and engineer reliable solutions are as yet poorly understood.

*Biometrics.* The only authentication techniques that attempt to authenticate a user *directly* are biometrics. The term biometrics is derived from the Greek words bio (life) and metric (to measure). The field of biometrics is the measurement and statistical analysis of biological data. Biometric authentication methods cannot be passed on to others and losing them is difficult (and even if the feature is 'lost', it cannot be used by somebody else). However, the possibility of impersonation by forgery may be possible (see Ch. 4).

In a biometric system a personal characteristic, such as a fingerprint, is used and the basic assumption of the authentication process is that a person's fingerprint identifies them uniquely or, more accurately, that the probability of two people having identical fingerprints is so small that it can be safely assumed to be zero. In a typical biometric system, a user will give a number of copies of the chosen biometric, which are converted into bit patterns and stored on a template. When that user wishes to authenticate to the system he or she provides a copy of the chosen biometric and that copy is compared to the template. If the copy provided is 'close enough' to the template then the user is authenticated. A fundamental problem with applying biometrics is the determination of what is acceptable as 'close enough'. The main biometric methods in use today are: fingerprint recognition, hand geometry reading, iris scan, retinal scan, face recognition, signature dynamics and voice recognition (see Ch. 4).

In order to be applicable for authentication, a biometric method must fulfil the general requirements shown in Table 2.2. No current technology is available or will become available that meets all the requirements to the fullest extent because those who seek means of circumvention will continue to do so.

*Table 2.2 General requirements for biometric methods*

| Requirement | Description |
|---|---|
| Universality | Each person should have the characteristic. |
| Uniqueness | No two persons should have the same characteristic. |
| Permanence | The characteristic should neither change nor be altered. |
| Collectability | The characteristic can be measured quantitatively. |
| Performance | The characteristic can be efficiently measured in terms of accuracy, speed, robustness, and resource requirements. |
| Acceptability | The characteristic should be acceptable to the public. |
| Circumvention | There should be no easy way to fool the system. |

*Source: Table 4.3, Ch. 4 in this volume.*

Before a biometric system can be used, the user – identified in some way – has to enrol, providing the system with his/her biometric reference data, which are stored and used to produce a template which is matched with one, in the case of verification, or many, in the case of identification, reference templates. No two biometric templates match 100 per cent and their similarity has to be calculated. In order to make a decision, a certain threshold is defined, which maximizes the acceptance rate for authorized users and minimizes the acceptance rate for impostors. Two types of error are defined to measure the performance of biometric systems (see Ch. 4).

Type 1: The system fails to recognize a valid user (*false rejections*).
Type 2: The system accepts an impostor (*false acceptance*).

While there is not necessarily a precise link between the two error rates, in practice they are typically linked. When the false rejection rate is kept small, the false acceptance rate tends to rise, and vice versa.

The application domains for biometric authentication coincide with the application domains of conventional authentication methods, namely, access control to networks, physical access control to sites, entity identification and time and attendance control among many others (Woodward et al. 2002). Some applications that have attracted attention in the media include passports and identity cards. Many airports now issue smart cards with biometric templates to allow speedy checks at immigration. In the US the biometric used is typically either hand geometry or a fingerprint, while at Heathrow Airport in the UK it is iris recognition (see Ch. 4).

*2.3.3.2 Usability of authentication mechanisms*

Cyberspace is enabling new forms of attack on people and their possessions and the declining cost of technology makes cyberspace attacks less risky for the attackers. Changes in the design of secure technologies and in social practices and cultural norms of information assurance influence whether strategies to reduce criminal acts or threats arising from unintended changes in information handling procedures will be effective.

Although there are many mechanisms for authentication, there is no single mechanism for usable authentication. This is because the answer to the question ‘which is the most usable authentication mechanism?’ is that it depends on the characteristics of the user group, the task and the physical and social context in which users and security mechanisms interact (Schneier 2000, 2003). In addition, the available mechanisms may be hard to use or ineffective because they make unreasonable demands on their users (Checkland 1999; Zurko and Simon 1996; and see Ch. 10). Box 2.5 summarizes research on the usability of alternative means of authentication.

The usability of any authentication mechanism depends crucially on the nature of the task to be performed. A well-designed mechanism needs to maximize the effectiveness and efficiency of task execution. Failure to provide users with the necessary understanding, training and motivation will result in human error. Users are often left to make a choice between complying with security regulations and completing a task.

*Box 2.5 The usability of authentication mechanisms*

The functioning of human memory makes strong passwords difficult to use. Users report that they have an increasing number of passwords to remember and regularly encounter problems with infrequently used passwords (Adams and Sasse 2001; Sasse et al. 2001). In one study, 52 per cent of failed logins were due to users entering the wrong password.

Research on human memory has established that human performance at recognition is far superior to unaided recall; images are processed and stored differently from words and are easier to recall. Graphical passwords authenticate users through recognition of images or features of images. Studies suggest that these perform better than passwords and other forms of infrequently used authentication, but informal reports from commercial trials indicate that this performance advantage disappears rapidly when users have multiple logins using the same type of image or the images/faces are changed, and they can be very slow.

Knowledge-based authentication in the form of passwords and PINs creates unacceptably high costs for users and organizations in terms of stress, low task performance due to failed logins and reduced productivity.

Tokens have been used for remote access by financial institutions, with apparent success, but the high cost of replacing lost tokens and/or lost working time has led companies in other sectors to abandon it. Users may need a collection of tokens, which they will find hard to manage, but a single token carrying multiple credentials raises issues for privacy protection.

Biometrics are not secret and they can be harvested from legitimate users and systems, which then can be attacked. Some users are temporarily or permanently unable to register a particular biometric; five per cent of people are estimated not to have readable fingerprints and blind users cannot register iris images. Temporary inability to register or use a biometric can result from cuts or burns on fingers for fingerprints, or pregnancy or certain types of medication for iris recognition. Biometric authentication raises the question of acceptability among some user groups for religious reasons, because of safety and privacy concerns, and as a result of labour relations concerns about monitoring employees. Many banks in the UK and Germany have ruled out use of biometrics on cash dispensers in the foreseeable future, because of concerns about how customers will respond to false rejection and because the cost of the technology is too high (see Ch. 10).[8]

The selection of a security mechanism and how it is configured should not be left to security experts because their usability depends on the context of business processes and workflow. Empirical studies of users of ICT systems suggest that many users are not motivated to comply with security regulations because they do not believe they are personally at risk or that they will be held accountable (see Ch. 10).

*2.3.3.3 Cyber-security and risk management*

Empirical research has examined the conditions under which end-users of cyberspace systems might begin to offer solutions to many cyberspace security problems (see Ch. 11 in this volume). Studies show that if a 'culture of security' can be fostered, end-users may take on responsibility for monitoring risks and taking appropriate action (Parker 1997; Osborne 1998; von Solms 2001; Wood 1995; and Ch. 11).

The case study in Box 2.6 indicates the importance of appreciating the many subjective understandings of risk and the importance of communicating risks effectively by considering the medium as well as the message.

> *Box 2.6 Security and risk communication*
>
> A case study of an effort to launch an Internet banking product in a top-tier global bank – NIMETBANK -– indicates that individuals and institutions process messages they receive and develop their perceptions of messages according to previous experiences, the social and economic climate, their cultural backgrounds and the trust they place in messages and their sources. Trust was placed in the technologists who had delivered in the past. In order for us to trust a message, we need first to trust the communicator. Credibility of information sources is a key factor in risk communication such that credible sources are those that shape risk and security policies within organizations (Bener 2000; and see Ch. 11).

Internal control systems are crucial to system security as demonstrated in the case described in Box 2.7 where issues of control in decentralized organizations are depicted to show the difficulties of establishing operational norms among different cultures and sub-cultures.

> *Box 2.7 Interpreting security control rules*
>
> The relationship between formal systems and informal organizational norms was investigated in an international bank with branches in London and Bangkok. A relatively flat matrix management system led to security guidelines being ignored in the local branch in Thailand partly because of the absence of a designated bank manager in the branch and the London manager's failure to be responsive to the different cultural context in Thailand. Hofstede (1991) identifies dimensions of the cultural contexts that give rise to 'social risk'. In the Bangkok branch the status of the formal rules was undermined by organizational changes and staff were resorting to personal judgments. The key lesson is that global policies and standardized manuals and procedures of multinational firms are not internalized in the same way in every branch, as had been expected by the management of this bank (Chauvidul 2003; and see Ch. 11).

As corporate experience with the use of PKI shows (see Box 2.8), the technical capacity to interoperate must exist alongside the interoperability of institutions and their policies and practices. One instance of this is particularly evident in the case of standardized directories.

*Box 2.8 Security, ICT system interoperability and identity management*

Standardized directories may be used to avoid interoperability problems where digital certificates and a PKI are in use. A case study examined two global companies in the oil and finance sectors to show why it is so difficult to implement technical standards. The success of PKI in Oilcom was attributed to a campaign to knit it into the organization, but 'islands' of PKI began to emerge for Oilcom's outward-facing trust services. At Bankrecht PKI was less successful because of the absence of a widely accepted institutional order, which led to the proliferation of PKI 'islands'. Both companies were depending on 'circles of trust' in closed trade bodies, rather than on the PKI model's capacity to verify identities (Wamala 2002; and see Ch. 11).

In the light of growing evidence about the importance of behavioural factors in achieving ICT system security, there is a shift in security management from concern about technical devices to management issues. This is evidenced by the success of codes of information security management developed in the UK (BS7799) and by the International Organisation for Standardisation (IS017799). The next phase of security management is likely to focus on the interoperation of management policy for a number of business processes, such as document sharing, collaborative working and online dispute resolution, giving rise to the need for new theoretical frameworks that can be applied to address these issues. At an organizational level, the most immediate change to achieve a 'culture of security' is to integrate security into business processes.[9] Once security aims appropriate to the organization are established, role models are essential to change behaviour and re-build the security culture to make secure behaviour a desirable trait that becomes embedded in professional and ethical norms (see Ch. 10). In addition, ratings service providers, such as Standard and Poor's, and Moody's, are likely to begin offering operational risk ratings for cyberspace services in the future (see Ch. 11).

#### *2.3.3.4 Future prospects for trustworthy cyberspace*

Weaknesses in currently used methods of ICT system development and in identification and authentication mechanisms allow exploitation by criminals. Most solutions are appropriate for certain environments and inappropriate for others. There is progress in securing different aspects of the cyberspace infrastructure, but the issues are complex and, as yet, not well formulated.

Persuasive design techniques offer a means for designing systems that intrigue and, thereby, persuade and reward users for good security behaviour (Fogg 2003). Developing usable security mechanisms is not simply an issue of ‘fixing’ user interfaces to current mechanisms. Appropriate and effective security must be an integral part of the socio-technical system it is supposed to protect. Effective security must take into account the needs and potential conflicts of all stakeholders (see Ch. 10).

Security needs to be integrated into ICT development approaches. It should be part of the software engineering documentation that developers work with. Technical design decisions must consider the mental and physical workloads imposed on system administrators as well as end users. Despite the fact that different authentication methods are frequently adequate for their purpose, they display obvious security limitations. Tokens can be lost or stolen and passwords and PINs can be guessed or copied. The use of biometrics can, at least in theory, remove some of these insecurities. We have reached the situation where some biometric authentication techniques have become quite advanced, but it is not clear that there is yet any reliable consistency in biometric products (see Chs 4 and 10).

System integration is essential even in the case of the use of biometrics because the transmission of biometric data between different system components is one of the main weaknesses of a biometric system. Biometric data are transmitted from the sensor to the feature extractor and then to the matching module and onto the application. There is also a need for alternatives for users who inadvertently fail or are unable to use a given biometric test. The best solution might be to have the reference data (templates) stored on a smartcard or another device that the user can carry.

Matsumoto used sweets called ‘gummy fingers’ to create forged fingerprints and this highlighted the future importance of liveness detection, that is, the biometric template used at both user registration and authentication should be from a live user (Matsumoto 2002). In the future, secondary levels of authenticity and trustworthiness will become very important as will methods of controlling information and metadata (see Ch. 4). As compared to issues of primary object identification and authentication discussed above, issues of secondary authenticity are more subtle and complex.

*Secondary authenticity and trustworthiness.* When we authenticate or identify a human or a computational device we often make the assumption that the supporting infrastructure will be trustworthy and that it will behave as intended. Without this assumption it is difficult to imagine that any solutions will be viable and there is a tendency to acknowledge and then ignore this issue (see Ch. 4). All the security mechanisms discussed above could be compromised simply by a failure in the administration procedure. Many security problems occur when the human being directly interfaces with the digital world. This happens at user registration and when a user is prompted for action by some application. It requires a leap of faith to assume that the whole system will work as intended. As more rights are managed and conferred by digital means – for instance with the use of digital identification cards as a way of providing access to services – the stakes are raised and the illicit gains of fraudulent behaviour are likely to increase. Box 2.9 highlights a few of the issues in this area.

All these developments raise issues for the control of information and metadata in cyberspace.

*Box 2.9 Safeguarding the trustworthiness of infrastructure*

Consumer devices – Personal computers, Personal Digital Assistants (PDAs), and mobile phones can import code that changes their functionality. To help decide between good and potentially malicious code, initiatives such as code-signing are developing that allow a device to digitally verify the authenticity of a particular application.

Smartcard manufacturers spend millions on the best ways to provide additional security features on the cards they produce. The integrity of a smartcard based solution is dependent on the fact that the smartcard offers a secure storage and computation environment.

Secure computing initiatives such as Palladium and Trusted Computing Platform Alliance (TCPA) provide a secure and trusted computing environment.

Good engineering and secure coding practices are being promoted, but it is unclear whether good security implementation practices are being used within deployments (see Ch. 4).

*Controlling information and metadata*. Controlling information is fast becoming the issue of our times. Pervasive computing and *ad hoc* networking are giving rise to the need to authenticate dynamic documents that either point to transitory information or use transitory information in their construction (see Ch. 4). *Metadata* are information that has attached to it additional information serving as a description of its use and functionality. An extension of this concern occupies the minds of executives at companies providing entertainment content, for example, music and videos. The use and potential misuse of this information drives the whole area of Digital Rights Management (DRM) and leads us full circle to the issue of registration of identity or ownership. One DRM solution that is much discussed is effectively to 'register' the devices on which information can be accessed. Unlike the case of human registration where there is no digital interface, registering a device is technically straightforward (despite the formidable privacy and consumer-acceptance issues involved).

In the future, the concept of *ICT system trustworthiness* will need to be broadened to include reliability. Catastrophic system failures are usually fairly easy to detect and, more often than not, to fix. Intermittent problems that lead to degradation rather than to outright service failure are harder to address. For this reason it will be very important to address the continued robustness or dependability of the supporting cyberspace infrastructure. As agent software is used for workflow, middleware and automatic negotiation, the importance of identification and authentication of software and data objects, as well as people, will grow.

Original identification is also likely to become an issue in the future. Consideration will need to be given to people's attitudes to intrusive measures such as taking DNA samples at birth or inserting chips. The likely physical consequences of implanting chips in a person's body for life and the durability of the chip will need to be examined. The general problem of identifying 'the original' is a difficult one that is frequently overlooked (see Ch. 4).

The problems associated with establishing identity are often ignored in discussions relating to the issuance of passports, digital certificates and all the authentication techniques that rely on biometrics. Most of the current methods of establishing identity seem to depend on the fact that a person's identity has already been established somewhere else. Each new process is merely endorsing the old one. There are numerous examples of where the ability to impersonate someone at some point in the registration stage implies the ability to steal that person's identity and impersonate the person for life (see Ch. 4).

*ICT forensics in the future.* ICT Forensics as a branch of Forensic Science is in its infancy. The practice is mainly involved with data held on hard disks in PCs, PDAs and other flash memory devices. These are used by criminals for some activities and when captured, the data on the devices provides evidence of malfeasance. In order to provide such evidence, all entities – documents, computers and disks – concerned with the case have to be identified and authenticated. People are identified using traditional techniques and their use of systems is authenticated via system logs.

The strength of the process of authentication of all entities that are considered valuable for detecting, investigating and prosecuting crime is critical in the case of digital evidence. If a digital image is produced as evidence it needs to be protected from alteration. Furthermore, if the digital image is obtained using a digital camera then it is necessary to verify whether it is the original. If the protection, such as a digital signature, is constructed and attached inside the camera then we need assurances about the tamper-resistance of the camera. If it is applied using another device then we need procedures to ensure that it was not changed before the protection was applied (see Ch. 4).

The general problem of identifying 'the original' for authentication purposes is difficult and frequently overlooked. This topic has a direct bearing on the trustworthiness of cyberspace and our ability to successfully prosecute where digital evidence is used. Similarly, if a document, that is, an email, a transcription of a phone call or an internal memo, is seen to provide evidence of a criminal activity, then some 'proof' that a certain person authored the original and when and on what 'machine' they did it, is essential if the document is to stand up in court. The quality of the proof will rely on not only the raw data and metadata, but also on the veracity and traceability of the process by which these data and metadata are managed between the times they are obtained by the law enforcement agency and by the court.[10]

For the future, however, a number of developments are seen as being either disruptive to current processes or scaling up the problem to such an extent that new ways of dealing with computer forensic investigations will be essential.

Key issues are likely to include:

*Scale of systems*: the volumes needing to be searched in order to find data that might be of interest to a law enforcement agency are growing exponentially. Obtaining specific information to reduce this volume will become more and more problematic as distributed storage, possibly incorporated in a grid architecture, becomes the norm.[11] However, legitimate users will face the same problem. Tools that deal with such scale will be developed, but they may not have the processes of auditability and traceability incorporated in them that will be necessary for evidence gathering unless this is laid down as a requirement at the outset.

*Distribution of data*: data will, all other things being equal, be stored wherever it is most efficient to store them; this may not be in the jurisdiction of the law enforcement agency that needs to investigate an alleged crime or gather evidence about one that has certainly occurred. Unless some form of international code of practice relating to access to such data, perhaps under the umbrella of newly agreed digital principles, is agreed, it will become increasingly difficult for law enforcement agencies to access data to detect crimes and prosecute criminals (see also Ch. 15 in this volume).

*Lack of strong binding between data and suspect*: as the world of electronic commerce and other electronic services spreads geographically and becomes much more pervasive, ensuring the ability to connect the record of any action with an information object such as a document, video or audio record will become more and more complex and potentially expensive. In order to prove in court that there is a connection between an information object and a person, both must be identified *and* a link between them established with appropriate spatial and temporal proofs. The strength of the evidence of this link, usually referred to as the strength of the binding mechanism, will become critical in establishing the proof that will be needed in court. A more relaxed objective could be to establish sufficient strength to allow other physical investigations to be instigated under warrant to gather stronger evidence. In both cases, collaboration between system designers and legal and law enforcement specialists would greatly increase the probability that this issue does not become a major obstacle to crime detection.

*Mass storage devices*: the availability of mobile and transportable miniature mass storage devices will expand enormously over the next decade. The current use of devices, such as i-Pods for music storage, will expand to encompass video and data. From a crime prevention viewpoint these devices have a number of undesirable properties; they store huge volumes of data, which can be protected at the document and device level using strong encryption-based authentication, are only connected to a system when plugged in or connected via a wireless network, and can be very easily concealed and, in extremis, destroyed. Reliance on the analysis of log files to identify when and where specific devices have accessed or are accessing systems and networks and being able to very rapidly and accurately trace subsequent use seems the only opening at present for tracing illegal activities being perpetrated through the use of such devices. This is an extension of what is now possible for mobile telephony, but on a much greater scale, with concomitant expense; the question of whether the public or private sector wishes to bear the costs of very expensive tracking or endure rapidly spreading unprosecutable crime could be urgent subjects for debate.

*High quality encryption*: high quality encryption has been freely available for decades. Little visible use is being made of it as yet by criminals, but most experts in the field consider it is only a matter of time until this happens. If and when it does, another layer of complexity in detection and prosecution will emerge, especially if there is widespread use of encryption for privacy or commercial-value protection. This will cause there to be a greater volume of encrypted material within which the criminal can conceal his or her activities. One mitigating circumstance is that if data can be shown to be encrypted and not legitimate, they could be used to make a case for further investigations under warrant. This would also have to be widely in line with new principles and practices (see Ch. 15).

*Gap between user system developments and forensic tools*: forensic tools are developed by a very small number of academic groups and companies to meet the specific needs of current case work. User system development attracts billions in development investment to provide highly sophisticated user functionality in products such as SAP, MS Office, Oracle and bespoke systems for banks, trading floors, on-line news services and air traffic control. It is inevitable that without some collaboration with such developments, the ability of investigators and computer forensic experts to maintain parity with the environment within which the data under investigation are used and stored, will be limited. Such collaboration, until very recently, has been sporadic. Unless the ability to carry out forensic investigations is seen as being a legitimate requirement of a system or application design, this situation is likely to get worse, and the ability to prosecute e-crime using computer forensics could become largely non-existent.

*Inertia in legal systems*: the rate of change in society associated with the spread of the Internet is probably unprecedented in recent centuries. Legal institutions and procedures are perceived by some to have changed very little as a result of the growing use of online services. This may be unfair criticism, but the gap between fact and perception is an important social phenomenon. The creation of a forum in which dialogue could occur to clarify this situation would be highly beneficial to all concerned. However, for such a forum to be trusted, the fundamental issue is how various stakeholders might react to legal initiatives and ethical discussions and, hence, which type of organization (government, judiciary, parliament, society, commerce, learned society) should initiate it (See Ch. 15).

*The nature of computer forensics*: computer forensics, at present, is largely an activity in support of evidence-gathering by law enforcement agencies. A certain amount of support is given to investigative work, but very little to preventative investigations. Why this is so is unclear. Candidate reasons are too few experts, rapidly changing systems, lack of access to suitable environments or indecision of owners of systems as to whether they 'want to know' in advance of any potential weaknesses. The negative reaction to the Y2K preventative investment after the perceived 'non-event' is indicative that this last may be the dominant reason. However, it is clear that considerable improvements were made in terms of system resilience as a result of the preventative work carried out in relation to Y2K. Hence, consideration could be given to the balance that could be struck between evidential – investigative – preventative computer forensics and the risks and benefits of the options.

*Current research*: research centres around applied activities that are derived from ongoing case work. Tools and techniques are being developed in an attempt to place the law enforcement agency and the investigator in a good position to 'do better next time'. There would appear to be little fundamental work being carried out, especially relating to the difficult problems outlined above with respect to scale, complexity, criminal strategy, legal and constitutional issues, and the impact of new technologies.

### 2.3.4 Lessons for Cyberspace Dependability and Security

A survey carried out by UK Department of Trade and Industry and PricewaterhouseCoopers in April 2004[12] indicated a rapidly growing dependency in British industry and commerce on critical information held in computer systems and an increase in the use of the Internet and the web in business in general. These factors combined to show an increase in security incidents of all types even though there was heightened awareness of the need for good security. This survey indicated the need for improvements across the board if business were to maintain or improve the dependability of services derived from the use of such systems.

Dependable pervasive systems will be constructed out of multiple existing systems and will also need to be highly adaptable. Most will embody human beings as system 'components'. The successful design and deployment of such systems is a major challenge that calls for expertise and socio-technical as well as technical dependability. Cross-disciplinary approaches to research and operation are essential if any inroads are to be made in this field.

Once designed and implemented, pervasive computing systems must incorporate means of identifying users and of authenticating that users are who they claim to be for many purposes and applications in cyberspace. This is giving rise to the need for both human and technical measures to secure cyberspace that are responsive to the needs and behaviour of the users. We have examined a number of identification and authentication techniques. If they are to be trusted then the process of *original identification* must be adequate. Technical research into the security of technology is needed together with research on the effectiveness of the identification processes used for important everyday processes such as passport applications, bank account/credit card applications, including their costs and failure rates (see Ch. 4).

Encryption is, at present, the only ‘strong’ mechanism available and it is now in reasonably widespread use. However, there are situations where it can be subverted or used as a tool for denial of service. An outstanding question is how much ‘security’ or ‘strength’ is appropriate? Procedural approaches and architectural solutions (separation of duties) can be used to reduce significantly the risk of vulnerabilities arising as a result of human behaviour in what might otherwise be ‘trustworthy’ processes.

Education programmes could be used to highlight the need for compliance with local security policies by drawing attention to the relationships between offenders, targets and guardianship using a systematic framework linking risk, information system security, audit, compliance and human relationships. This would avoid the tendency for security systems to be developed in isolated ‘silos’ within organizations.

It is clear that developments in pervasive computing involve important organizational and human behavioural issues. The foregoing discussion clearly indicates the need to examine assumptions about the work organization of software engineering teams and collaborations between developers, and between developers and end-users. In addition, solutions for user identification and authentication depend on their usability and their security, neither of which can be addressed through technical means alone.

## 2.4 EXPERIENCING TRUST AND RISK IN CYBERSPACE

Many assumptions about trust and risk in cyberspace are made by cyberspace technology developers and users. These assumptions are examined next to suggest why there are divergent views about person-to-person, person-to-system and system-to-system trust in cyberspace and to suggest some implications for crime prevention.

The trustworthiness of the ‘space’ implemented by the use of pervasive ICTs will only be enhanced when we have a deeper understanding of how knowledge, the currency of the knowledge society and the economy, can be managed throughout its life cycle, both by people and agents, and interactively and collaboratively, in such a way that outcomes of transactions and interactions are predictable, at least generically, and are perceived as being reasonably safe. To achieve this, it will be necessary for the barriers to criminal or socially unacceptable use of ICTs to be sufficiently high to minimize opportunities for unpredictable interactions associated with behaviours that are not socially valued. The way system components interact dynamically to add value to society and the way critical technologies support social processes that may lead to cyberspace crime prevention, both need to be understood from a variety of perspectives.

We can draw upon research focusing on risk perception and on trust and the nature of trustworthy systems to understand the relationships between risk appraisal, the likelihood of forging trusted relationships in cyberspace and the development of norms and practices that are consistent with crime prevention. The extent to which people are likely to accept government intervention or controls over their behaviour in cyberspace depends upon whether they are informed about the potential risks of cyberspace and whether they perceive themselves to be at risk. It is unclear whether the technical possibility of risk in cyberspace is the same as the reality of the perception and experience of risk. We are in the early stages of creating an evidence base to assess whether people act according to their perceptions of risk or their experience of actual incidents in cyberspace. These factors influence people's willingness to place their trust in cyberspace. As in other areas of technological innovation, cyberspace is being developed in an environment that Beck (1992) and Giddens (1991) have called the 'risk society'.

### 2.4.1 Public Perceptions of Risk – Appraising Uncertainty

Research on public perceptions of risk suggests that the social meaning of a risk influences its salience and how uncertainty is judged. Concerns about risk express underlying values and attitudes to blame, morality and the value placed on the outcome of an event. Public opinion is often contrasted with expert assessments of risk and this is particularly so in the case of crime that is facilitated by cyberspace (Liberatore 2000; Ravetz 1987; and see Ch. 8 in this volume). Disputes about differing conceptions of risk cannot be settled by stipulating definitions for disputed terms because they are systematically linked to 'probabilistic' and 'contextualist' dimensions of risk (see Box 2.10).

*Box 2.10 Probabilistic and contextualist dimensions of risk*

The probabilistic view of risk suggests that it is purely a matter of the probability of an event or its consequences. From a contextualist perspective, risk has no single determining criterion. A risk will always be associated with a number of characteristics. Probability, in this view, is simply one among other risk attributes.

From the strong contextualist perspective, probability estimation may be irrelevant to determining the existence of a risk or for communicating it to others (see Ch. 8).

The way the public sees experts and regulators may influence how risks, such as those perceived or actually experienced, are interpreted. The relative failure of risk communication strategies in relation to technological risks, has given rise to substantial research on the role of trust in risk perception (see Ch. 8). Public anxieties in the UK about GM food, BSE, rail safety, mobile phone transmitter masts and a host of other issues may be explained by a lack of trust or confidence in those responsible and a loss of legitimacy of certain public institutions.[13] However, as O'Neill (2002: 12) suggests, it is important to distinguish between perceptions of trust as reported by participants in empirical studies or in the media and the "practical demands of placing trust". She argues that the relation between perceptions of trust and trustworthiness and placing trust in public institutions, scientific evidence or professional judgement is not straightforward.

> The connection is that those who see their world as a "risk society" often find placing trust problematic: but it does not follow that they do not place trust, or even that they place no trust in those whom they claim to think untrustworthy (O'Neill 2002, p. 12).

This perspective is important when we consider some of the insights from empirical studies in the field of trust and risk perception that are highlighted in Box 2.11.

*Box 2.11 Empirical studies of trust in risk perception*

Empirical research on the role of trust in risk perception includes work by Freudenburg (1993) on the effect of trust on the concerns of local citizens and by Slovic (1993) on the asymmetrical effects of trust building and trust destroying information. Slovic showed that the effect of negative information on trust 'destruction' is much greater than positive information on 'trust building'. Trust is related to beliefs and expectations that some possibly remote institution or actor will act in a particular way in a particular context (Barber 1983; Luhmann 1979). A lack of trust, which leads people to see risks as greater, may be based on expectations about risk managers' competencies. Rather than deducing trustworthiness from direct evidence, people infer it from 'value-bearing narratives' using information shortcuts and images (Earle and Cvetkovitch 1995; Siegrist et al. 2000). Trust may be higher when the narratives or stories told by institutions express salient values that are similar to their own (see Ch. 8).

Douglas (1966, 1992) argues that beliefs about purity, danger and taboo are essentially arbitrary. Once they become fixed, they serve to organize and reinforce social relations according to hierarchies of power. An individual's beliefs about what constitutes an important risk are also indicative of his or her place in society (Rayner 1992). This observation shifts the emphasis away from individual differences or biases in perception of objective risks towards the role of inter-group distinctions. People's conceptions of what constitutes danger or a risk may vary according to the way their social relations are organized. People may identify risks as being important or trivial because this reinforces established social relations within their culture, although they may revise their thinking over time (see Ch. 8).

Insights into the perception of risk and trust can be drawn from theories in cognitive psychology, psychometric research, and studies of the relationship between emotion and risk perception (see Box 2.12). These insights need to be examined in the light of people's perceptions about the riskiness of cyberspace. Their perceptions are likely to be influenced by the signs, symbols and representations they encounter within their social networks and through the media's reporting of cyberspace events. Social meaning must be expected to influence appraisals of a perceived threat or an uncertain event in cyberspace and it places risk objects within a cultural context.

*Box 2.12 Contributions from psychology*

*Cognitive Psychology*

Risk perception can be seen as a matter of judgement about an uncertain event – its likelihood and its consequences. People do not follow the principles of probability theory when judging the likelihood of uncertain events. They employ 'rules of thumb' and theory suggests these include the representativeness of an event and the ease of recalling a similar class of events. The greater the ease of recall, the more numerous such events are likely to seem.

*The Psychometric Paradigm and Risk*

The psychometric approach to the study of risk perception has helped 'to demonstrate that the public's viewpoint must be considered not as error but as an essential datum' (Royal Society for the Prevention of Accidents 1992, p. 91). This approach aims to elicit judgements about risks from individuals who are confronted by hazard stimuli in order to understand quantitative judgements about risks and the subjective dimensions. Personal risk taking activities are seen as less risky and more acceptable.

*Emotion and Risk Perception*

A distinction is drawn between two modes of information processing: formal, logical and numeric reasoning and 'intuitive, automatic, natural, non-verbal, narrative and experiential' reasoning. This approach highlights the interplay between emotion and cognition. A stimulus can evoke images that become tagged with affect, such that the overall affective impression can be more influential than more cognitive assessments. This may increase judgements of riskiness and decrease the perceived level of benefit (see Ch. 8).

Murdock et al. (2003) suggest that the media can amplify or attenuate perceptions of risk if they resonate with public feelings and mood and if the symbols and representations capture existing public concerns and frames of reference. Petts et al. (2001) show how patterns of talk and the structures of accounts of events influence lay interpretations of risk. ‘Risk signatures’ can become grounded in everyday experience and the more they are grounded, the more they are seen as personal and credible threats (Horlick-Jones et al. 2003).

Empirical accounts of the narrative structure of risk communication demonstrate that whereas experts see risks as chains of cause and event, lay people tend to see them in a social context of relationships (Wiedemann et al. 2003; and see Ch. 8). Research is needed to assess the importance of these insights in the context of cyberspace.

### 2.4.2 Trusting in Cyberspace

Trust is a means of alleviating risks, but there is only a weak empirical foundation for assessing the basis upon which people are prepared to trust others in cyberspace or to trust in the trustworthiness of ICT systems. It is clear, however, that growing numbers of interactions are occurring between strangers who have never met ‘in real life’ and exchanges of a social and commercial nature are clearly increasing, indicating that whatever the explanation of the basis for trust, people do act as if they trust ‘virtual’ others in many instances.

For example, in the commercial world, people are buying and selling goods from each other on eBay, spending hours playing computer games and dating via instant messaging. Massively Multiplayer Online Games (MMOGs) involve increasing numbers of people in buying and selling imaginary ‘property’ and avatars. Game players have invented a currency for exchange, the total value of which in 2001 was estimated as equivalent to the GDP of a relatively wealthy country (Tyrrell 2004). More and more government services are being provided online, giving rise to new means of accessing information and of communicating between all the actors in the social system.

These relationships are possible only to the extent that people behave as if they trust in each other and in the systems they use. Issues of trust involve person-to-person, person-to-system and system-to-system trust. The former two are emphasized in this section (the latter was addressed in Section 2.3 above). Box 2.13 highlights questions that are often asked about trusting in cyberspace from the end-user’s point of view.

*Box 2.13 Trusting in cyberspace*

*Trusted connections* between machines: is your computer connecting to the one you have asked it to? Is the connection secure? Is your security being compromised by the other system?

*Trusted, verifiable content*: are you sure that the content you are downloading is real rather than pirated? If you are downloading from a specific site, can you verify that the site is the one you think it is?

*Trusted transactions*: are you confident that any transactions and credit card (or other private) details are secure? Or, at least, are you aware of the level of security that exists?[14]

*2.4.2.1 Cyberspace trust and expectations*

Trust is a critical factor for the acceptance of electronic services including those provided by electronic commerce and e-government service providers. Research in the fields of human-computer interaction (HCI) and computer mediated communication (CMC) focuses on increasing people's trust perceptions, rather than on enabling people to make reasonable decisions about what or whom they may trust in cyberspace (see Ch. 10 in this volume).

The need for a trust framework for understanding online commercial interactions has been recognized in this literature to differentiate between situations requiring different types and levels of trust.[15] In the case of electronic commerce, the trustor may have to wait for days or weeks to take possession of goods and check that they are satisfactory. Interactions in cyberspace may be perceived as being riskier and demanding greater trust than similar interactions in a physical context. Whether people are prepared to engage in a relationship has been found empirically to depend on many factors including the following:

- The number of actors involved in the exchange (ranging from a single pair to potentially millions in public-good dilemmas).
- The actor type (individuals, organizations, technology).
- Whether there is synchronous or asynchronous trust exchange (strategic insecurity).
- Whether the user can identify trust-warranting properties.
- The types of signals employed to communicate trustworthiness (symbols and symptoms of trustworthiness, identity- and property-signals).
- The person potentially placing trust, including propensity to trust, knowledge of the situation, prior experience, potential benefits they expect, and the risk they face (enacted as 'trusting action') (Riegelsberger et al. 2003; and see Ch. 10).

Trust needs to be a core concern in the design and deployment of cyberspace technologies and it is now being acknowledged more widely that technical systems can only work as part of a larger socio-technical system

(Checkland 1999). Trust appears to reduce the need for costly control structures, and makes social systems more adaptable (Uslaner 2002). Information exchanges that are now being mediated by technology or even executed with technology as a transaction partner, put more responsibility for supporting trust on the designers and operators of the technical systems (Reigelsberger et al. 2003).

#### *2.4.2.1 Game theoretic and institutional approaches to trust*

From the vantage point of game theoretic models, trust can be conceived as arising out of expectations. This body of theory indirectly informs much of the thinking about the future role of software agent-based computing in cyberspace. We examine theoretical arguments about trust developed in the economics discipline next.

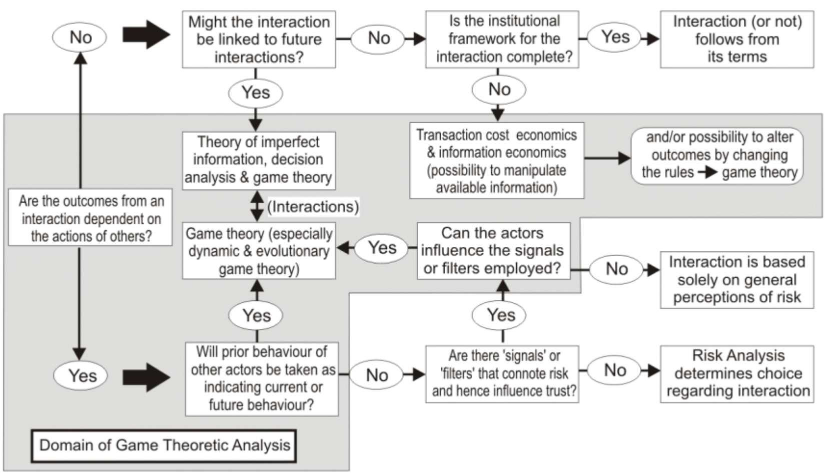
Trust is a matter of expectation – a trusting individual has some opinion about what might happen, some notion as to how likely the various possibilities are and some belief about how these outcomes and their likelihood are affected by his or her choices. Various models of choice that take account of the probabilistic nature of risk may be used to represent these assessments. Trust may also involve more or less consequentialism, that is, it may be bound up with the process as well as the outcomes. For example, an online customer may trust a transaction without distinguishing between the (distinguishable) reliability of the merchant, the payment and/or delivery services, and the legal mechanisms that provide compensation in the event of loss. Trust has been a difficult concept for economists to clarify (Hollis 1998), but its influence is widely acknowledged (see Chs 12 and 13 in this volume). Considerable research focuses on the development of game theoretic approaches (see Box 2.14).

> *Box 2.14 Games and incomplete information*
>
> Decisions to interact with other individuals for gain or loss, for example, buying and selling, employment, cooperation for purposes of mutual gain, etc., are conceived by economists as 'games'. A decision to 'play' in a game, if alternatives are available, in essence, involves trust: one trusts that the interaction is as described, that the other player(s) (actor(s)) will behave as expected. This trust is essentially an expectation – an assessment of what will happen in the future and in different contingencies. When individuals regard other actors as being unresponsive or unpredictably responsive to their choices, the economic analysis of incomplete information is used to analyze the interaction. When individuals see their choices as being interdependent, the appropriate economic approach is *game theoretic* (see Chs 12 and 13).

A basic framework for distinguishing game theoretic from information and institutional economics frameworks is illustrated in Figure 2.1. Game theoretic analysis applies when the institutional framework, including laws, rules, norms and standards, is incomplete because strategic actions will affect the institutional framework. Such analysis is not relevant where interactions cannot be affected by others' actions.

An alternative approach that de-emphasizes the role of game theoretic analysis focuses on the institutional structures – laws, rules, norms, and standards – that are imposed on market players and govern their interactions (Williamson 1975, 2000). The fields of transaction cost economics and 'new' institutional economics both acknowledge that long-term contracts are often incomplete. When parties are mutually dependent on the maintenance of business ties there is a strong incentive not to defect or behave opportunistically. This incentive amounts to what some would call 'trust'. Economists focus on the costs of breaching trust as the principal motive for maintaining it (see Chs 12 and 13). Trust serves as a 'lubricant' in markets, reducing transaction costs and assuring something closer to perfect competition. The institutional framework for cyberspace transactions involves the use of technical methods for user authentication, time-stamping and electronic signatures; and norms or standards, such as indemnification from fraud. These can reduce the costs of transactions and make them more likely to occur.

*Figure 2.1 The domain of game theoretic analysis*




*Source: See Figure 13.1, Ch. 13 in this volume.*

Economists also draw a distinction between *trusting* – whether I should trust another entity (person, group, institution, etc.) and *trustworthiness* – whether another entity should trust me. Despite the normative connotation of the words (relating to a standard or norm), these terms are used to reflect behaviour – one acts as if one is trusting or acts in a way that is consistent with eliciting trusting behaviour from others, that is, trustworthiness. Choices that are made about whom to interact or play with, and whose expectations to fulfil, disappoint or ignore, determine the 'network structure' of the game (see Ch. 12). In game theoretic contexts, it is relevant to consider how the design of the game itself embodies trust, especially where contracts may be incomplete (Bacharach et al. 2001; Bacharach and Gambetta 2001; Bowles and Gintis 2000). Trust is essential to the functioning of the norms and standards that allow markets to function.

Trust in games can be analyzed with reference to all the underlying data of the game: the set of 'players'; their strategies or powers of action; their information; their motivations or pay-offs; and the solution concept used to summarize the information in the game. A common assumption is that the other players engaged in a game act rationally which allows their behaviour to be predicted. Much recent work represents trust as a strategic choice that is influenced by the credibility of information, that is, its provenance, and the degree to which others will believe our own communications, for example, threats and promises (Bowles and Gintis 2000; Guerra and Zizzo 2002; Hardin 1991). Research also suggests that the distribution of trust is a key factor in agent behaviour (see Box 2.15).

*Box 2.15 The distribution of trust*

Trust (trustworthiness and trusting behaviour) is a valuable property of complex interactive systems. From the economic point of view, it is not the level that matters so much as the distribution of trust. How trust is distributed governs expectations and the alignment of information, motivation and the power to act. A simple policy of maximizing trust may be myopic or even counterproductive. For example, customer trust in electronic commerce systems is advantageous, but it does not follow that more trust is better – a higher level of trust increases the possibilities of opportunistic behaviour by those that are trusted (see Ch. 12).

Simple games representing stylized views of trust and their associated equilibria can be used to model agent behaviour as strategic behaviour; as the formation of player networks; and as hybrid games that combine elements of both approaches (see Ch. 12). A basic approach to game theoretic analysis is given by the coordination game in which players choose between high and low trust strategies. In such games, individuals are assumed to choose a single strategy for all their interactions (Axelrod 1984). This framework may be extended to consider a multiple period game in which cooperation or defection is a choice in each period for each player (see Ch. 12).

Games can be used to suggest outcomes in terms of whether high trust or low trust equilibria pertain if all players interact with each other in a fully connected network. Trust is partially a collective property, depending on how individuals are linked, whom they trust and who trusts them. It is feasible to look at the influence of linkages of trust to see whether networks will form that provide optimal trust. These economic approaches to understanding trust or agent expectations are mirrored in the modelling of software agent-based behaviour in cyberspace and the way trustworthiness may be signalled (see Box 2.16 and Ch. 6 in this volume).

When trust and crime are important there are externalities. These can be mitigated by precautions taken by the affected parties. The collective response (in civil, criminal or contract law) to market failure is to align the nature and amount of precaution with the assignment of liability for consequences (Shavell 1987).

Varian (2002) considered the impact of liability on the incentives to offer a public good, such as ICT system reliability or trustworthiness. The results depend on how the provision of the public good relates to individual effort. They also depend on whether decisions to contribute to the provision of this good are taken simultaneously or in sequence. This has implications for the risks associated with computer viruses, spam and harmful or illegal content in cyberspace.

*Box 2.16 Signalling trustworthiness*

Economic theory relating to product safety and reliability distinguishes two strategies to signal trustworthiness. A firm wishing to convince customers of its reliability can provide extensive or minimal warranty protection. In the former case, the signal is credible because the warranty would be too expensive to offer otherwise, providing the assurance is reliable and inexpensive to exercise. The customer does not need to trust the firm, but the firm may need to trust the customer not to make frivolous claims. A well-known firm can credibly signal trustworthiness by providing unusually low levels of protection, since it places its reputation on the line by so doing. Trust in this interpretation is solely about the assessment of risk because the consumer has little control over the allocation of risk. Trustworthiness signalling can influence agent expectations (see Ch. 12).

Precautionary activities, themselves, have externalities. Some have the effect of protecting others, for example, shutting down the offending communication. Some do not affect risk to others, for example, protecting one's own machine. Others may transfer the risk or costs to others, for example, attacking those who appear to have sent offending messages. These issues interact with issues of industrial structure because they influence and are influenced by the degree of monopolization in the market. They also influence the prevalence, adequacy and ownership of standards and the nature of networking among market participants.

In summary, in the economic view of trust, trust serves as a useful lubricant for establishing and maintaining networks of agents involved in activities in which mutual gain is a possibility. Achieving an overall increase in the level of trust is less relevant in achieving efficient outcomes or stable networks than is the *distribution of trust* that supports the setting of priorities for establishing trust relationships and which establishes a structure for negotiating the liabilities arising from interactions. Networks involving trust will tend towards equilibrium involving a high level or a low level of trust and agents will either rely on consistent behaviours or expect opportunistic behaviour. Aligning the institutional rules of cyberspace networks with the tendencies of a network may improve efficiency. The possibility of free riding may reduce the quality of a public good such as system dependability. Because it is possible for the independent actions of one member of a network to compromise the interests of others, cyberspace networks may need stronger rules for exclusion or for imposing sanctions on participants that breach the trust of others.

### 2.4.3 Trust and Social Capital

Trust is a major component of 'social capital' (Fukuyama 1995; Pollitt 2001; Putnam 2000). Bourdieu and Passeron (1977) developed the idea of social capital as a means of modernizing Marxist concepts of class reflecting the relational capital of elites. This concept can be linked to the positive effects expected from networks of trusted agents. The social capital idea has received considerable attention due to the efforts of Putnam (1993, 2000). He sought to explain differences in economic performance between Northern Italy and the mezzogiorno region and between regions within the US as the result of differences in the nature and density of non-economic relational associations in society (see Ch. 13 in this volume).

Although many economists are sceptical of the social capital idea because of the causal ambiguity in the relation between non-economic social relations and economic performance (Sobel 2002), some economists have embraced the idea of exploring 'trust' as a feature of preferences (Glaeser et al. 2000; Knack and Keefer 1997). It can be argued that societies that engender and support a more complex and dense pattern of networked social relations may benefit from lower transaction costs and more robust assumptions about the unlikelihood of opportunistic behaviour. This approach helps understanding about how 'trust' can be extended between parties that are capable of opportunistic behaviour by creating a 'web' or 'network of trust' (Mansell et al. 2000). This would suggest that policies aimed at supporting the development of virtual communities in cyberspace would have a positive payoff in economic performance (Mansell and Steinmueller 2000; and see

Ch. 13).

This view is not uncontested since some would argue that the concepts of contract and trust are antithetical. Others point to a pragmatic inconsistency. Trust in incomplete contracts involves acting on the basis of incomplete information. Many trust-enhancing measures, for example, authentication mechanisms, add information and actually weaken trust. Contracts exist in a specific legal and social context that provides for monitoring, verification and enforcement. Where enforcement involves relationships between actors, hierarchies or other complex structures of trust may emerge, which introduce further complexity into the analysis of trust and economic performance (Eisenstadt and Roniger 1984).

One reason that there are such differing perspectives on trust in cyberspace is related to whether the analysis of behaviour begins from an individualistic or egoistic perspective or a collective or societal perspective. This raises ethical issues, some of which we review in the next section.

### 2.4.4 Ethics and Cyberspace

Technologists sometimes make a distinction between the 'real' world and cyberspace. The spaces and means of access may be quite different, but research increasingly shows that many aspects of human behaviour remain constant (Mansell and Steinmueller 2000).[16] It seems unlikely that the majority of people will alter their basic behaviours, ethical stances and morality when they enter cyberspace. In fact although criminals – or those who seek to exploit others – will think of new forms of attack, most people are likely to find ways of translating conventionally understood norms and practices into cyberspace. When people understand that there are certain ethical and moral requirements, they may be more likely to adopt and demand them. Helping them to acquire that understanding is a key challenge for crime prevention.

For this reason, we need to consider the ethical standpoint from which it is feasible to argue that interventions in cyberspace to improve crime prevention are reasonable. O'Neill argues that a critical approach to practical reason "does not take the expression of the basic norms of a community or of one's own personal commitments as intrinsically rational" (O'Neill 2000, p. 26). Instead, the standards for taking action should be whether the guidance provided to those with a capacity to act can be recommended universally without damage to others and whether they can be understood. Any measures to secure cyberspace through building trust and trustworthy systems raise numerous ethical issues. Standard ethical concepts map onto cyberspace in interesting ways (see Ch. 14 in this volume). This section considers ethical positions with respect to attempts to secure cyberspace.

#### *2.4.4.1 Trust and security*

In earlier sections we have seen that there are many definitions of trust and many perceptions as to likely actions under conditions of uncertainty in cyberspace. An enticing means of reducing uncertainty in cyberspace is to develop and implement security systems, but this raises ethical issues around the spread of a security infrastructure. What avenues will be cut off for those who do not wish to employ it? We have discussed the way security systems require some kind of identity authentication (and see Ch. 4). However, for many users, the charm of the Internet is precisely the ability to get away from, or play with, one's identity. Every extension of power should require a justification and agreement as a result of a dialogue (Ackerman 1980), and the software code of the Internet controls its architecture and what actions are permissible (Lessig 1999).

To question the extension of cyberspace security there needs to be a forum within which the sceptical can table their requirement for justification. However, given the global reach of the Internet enabling security measures to jurisdictions, then enabling a full cross-section of users to debate is very difficult. One strategy may be to place the burden of proof on those who wish to alter the principles upon which the Internet was founded, namely liberty and openness. On the other hand, from an argument based on John Stuart Mill's (1869) work, *On Liberty*, it could be held that liberty and openness are the essentially important values *after* a certain level of cultural development has been achieved. This might imply that it is first of all essential to provide a cyberspace architecture in which privileged activities – selected on the basis of judgement by those with political power – such as science and commerce, can flourish, and only then should liberty become an overriding value.

#### *2.4.4.2 Rationality and value*

In the context of cyberspace, one notion of trust is a utilitarian notion developed by Luhmann (1979; and see Ch. 14 in this volume). This sees trust as a way of reducing complexity, by accepting the *bona fides* of agents rather than investigating them. The second is a moral notion of trust developed by Durkheim (1893/1984), which sees trust as inclusion into a value-laden society; if I trust you, I accept you as one that shares my values. Durkheim's view is optimistic and conservative; Luhmann's is rooted in self-interest. The Luhmann view is that trust is the effect of good behaviour and, therefore, ensuring trust requires providing incentives for good behaviour. The Durkheim view is that trust is the *cause* of good behaviour, and that the best strategy to ensure that people behave well is to trust them and make it clear to them what behaviour is acceptable (see Ch. 14).

This argument mirrors a major ethical debate about the purpose of the Internet and the limits of its regulation. Castells (2001) and others argue that openness is deeply embedded in the architecture of the Internet.[17] They suggest that cyberspace technology is inherently supportive of values such as passion, freedom, social worth, caring and creativity; values that are prevalent within the 'hacker' community. They argue that these values need to be defended in the face of efforts to achieve control for purposes such as crime prevention.

Others, such as O'Siochru and Contanza-Chock (2003) and Surman and Reilly (2003), suggest that the picture is more complicated. While evidence shows that civil society organizations are making much greater use of cyberspace tools, the extent to which such use is dependent upon maintaining all of the original features of the Internet's architecture is unclear. In addition, many uses of the Internet may be associated with actions across the spectrum of values and political aims. The relationships between the spread of the Internet and issues of privacy, vulnerability and security in the broader context of ethical and political considerations, mainly in the US, have been examined (Latham 2003). In the UK and with a more international orientation, empirical work has been undertaken on the use of the Internet for criminal activities, but it tends to focus on near-term developments and technologies rather than on the technological landscape that is likely to emerge in the coming decades (Thomas and Loader 2000; Wall 2001).

Some argue that the governing values of the Internet, liberty and openness, are a stage through which the Internet had to move, but which may be transcended to allow other cyberspace activities such as commerce. Others argue that liberty and openness are essential and non-negotiable. The former group wants to ensure trust by altering cyberspace architectures to make bad behaviour more difficult. The latter wants to be allowed to imbue the Internet with their libertarian values. These two groups disagree about what constitutes good cyberspace behaviour and good faith and about when it is in one's interests to trust (O'Hara 2004; and see Ch. 14).

*2.4.4.3 Trust and rationality*

There is also a spread of views about trust and rationality. The reciprocity required by trust is part of the uncertainty that trust tries to dispel. Under what conditions is it rational to assume that reciprocity will be respected? The narrower the conception of when it is rational to trust, the lower the level of trust in a society, and also the lower the level of betrayal. The various views are defined in terms of how egotistical the actors are assumed to be and how their identities influence their motives. Some views are more forward-thinking and less egotistical than others (Hollis 1998; and see Table 14.1, Ch. 14). There are numerous problems with the different positions and many are sceptical that they could sustain or nurture trust. Where identity is highly fluid, as in cyberspace, and subject to different conceptions, there is scope for very different views on cyberspace and its governing values.

*2.4.4.4 Liberalism and liberty*

Another ethical issue concerns the question of how much western bias informs debate on and policies for crime prevention and the security of networks. The idea that environments are definable in terms of local features (all of which may be virtual) stems from the philosophy of Descartes. The idea of people as individuals – and therefore of identity as something that can be fluid and self-defined – is notably western. Many argue that such positions cannot be sustained without threat of severe social breakdown and that the social context of interactions must be taken into account (Gray 1995; Mahbubani 2002). The positions – both historically and more recently – that are most commonly discussed in connection with cyberspace are all characteristically western liberal positions. Those that argue against western liberal hegemony assert that treating people as egotistical or of equal value is unrealistic. There must be some intermediate position.

One line of argument is a principled one, which states that the essential aim of authorities should be to allow any actor to pursue his or her own conception of the good (if this does not interfere with others) (Ackerman 1980; Rawls 1972). For cyberspace this means architectures allowing maximum freedom, including the freedom to be illiberal (Manasian 2003). This position takes liberalism as a universal ideology although it is a western-centric idea. The second line of argument is pragmatic and conservative; liberal culture dominates the Internet and departing from liberal western principles would be a nod too far towards a multicultural agenda. Hence, western concerns about organized crime, cyber-terrorism or the growth of electronic commerce, should come first, even if other users are to be respected. The third response is a compromise. Liberalism's conception of the 'good' is rooted in rights, but all parties around the world may not agree these. Retreating from the rights-based discourse, the issue becomes what privileges people should have in cyberspace. This, in turn, becomes a political problem in response to which a compromise may be reached.

It is essential to allow access for non-western representatives to such negotiations on how to promote cyber trust and enable crime prevention. Positions on this ethical issue are closely linked to the role of the media and strategies for building awareness of the risks in cyberspace and about trust in cyberspace. If there is a need for an informed and reasoned debate in society, citizens need to be better informed about crime associated with cyberspace and about the way the Internet is permeating our lives. But there is a risk that concerns about cyberspace will become amplified. Thus, two uncertainties lie at the heart of the ethical dilemma – how will the general population engage in such a debate and how will the media report the issues?

### 2.4.5 Implications for Cyberspace Trustworthiness and Trusting Behaviour

Models for understanding trust between individuals or human agents of individuals operate within well-established social and ethical contexts. In the preceding sections we have seen that different assumptions underpin models developed within different disciplines. The advent of cyberspace raises the question of whether any distinction should be made between *online* and *offline* trust. Human societies support numerous contexts for trustworthiness and trusting behaviour and cyberspace adds new dimensions in that it may involve varying combinations of agents (two cases where this applies are discussed in Chs 5 and 6 in this volume).

- Two human agents
- A human and an artificial agent
- Two artificial agents
- One or more artificial proxies for human agents.

The metaphor of trust in cyberspace could become over-extended, but without such a metaphor linkages with social and economic behaviour would be difficult. Cross-disciplinary research between the software engineering disciplines and the social sciences is needed to understand these linkages (see Ch. 5).

As indicated in our earlier discussion about ethics and cyberspace it is uncertain whether a utilitarian or a moral notion of cyberspace trust is appropriate and whether either is mutually exclusive within the context of using cyberspace environments. We may take a utilitarian view when carrying out financial transactions, but a moral one when considering sharing open source software. This issue may affect approaches to DRM software. One view would be to treat it purely in utilitarian transactional terms, whereas the other would be make the content available for the common good, but to monitor and punish any abuse of agreed ethical principles.

The nature of trustworthy knowledge acquisition in cyberspace is poorly understood. A number of approaches exist in the offline world, but it is not readily obvious that they translate to the cyberspace environment. The scale and volume of information to be acquired in the future are such that within the technologies being developed some understanding of the trustworthiness of the acquisition processes needs to be developed to contribute to trusting behaviour (see Ch. 5).

In summary, the discussion in this section emphasizes that perceptions about the dangers of cyberspace are influenced by the media and that people's social networks may amplify or attenuate such perceptions. Trust in cyberspace depends on many factors that need to be understood by technology developers and other stakeholders. Economic models of trust provide insights into the behaviour of human and non-human agents in cyberspace and it may be that aligning the rules of networks with the distribution of trust could improve the efficiency of cyberspace interactions. In addition, the development of social capital is an important consideration in fostering trusting behaviour and there is a wide range of views about whether actors in cyberspace will follow their self-interests or other motivations.

## 2.5 APPLYING TRUST MODELS IN CYBERSPACE

Two technology developments that are likely to be critical for the development of cyberspace are the deployment of software agent-based computing and the development of the semantic web. Each of these is examined here to assess how concepts of trust and risk are being modelled and whether there is reason to be concerned about knowledge management and the information aspects of cyberspace.

It is clear that if future ICT systems are to become more dependable and secure there will need to be changes in the design and implementation of ICT components, hardware and software (see Ch. 3). They will need themselves to become more reliable and trustworthy. Many modern computer applications are open distributed systems in which the (very many) constituent components are spread throughout a network in a decentralized control regime that is subject to constant change throughout the system's lifetime. Examples include peer-to-peer computing, the semantic web, the grid, web services, e-business, m-commerce, autonomic computing, and pervasive computing environments. In all of these cases there is a need to have autonomous components that act and interact in flexible ways in order to achieve their design objectives in uncertain and dynamic environments. Given this, agent-based computing has been advocated as the natural computation model for such systems (see Ch. 6).

Knowledge technologies and the semantic web are enabled by recent technological developments that allow much more intelligent machine engagement with the documents, services and other objects on the World Wide Web. They manipulate and create knowledge, that is, usable information in a context, and we take developments in this area as a further case study to illustrate how concepts of trust are being applied that influence the future of cyberspace (see Ch. 5).

### 2.5.1 Agent-based Systems and Trust

The application of autonomous software agents, sometimes representing their human owners, in large-scale open distributed systems presents a number of new challenges. We focus specifically on the challenges that relate to the interactions in such systems. How do agent-based system designers decide *how* to engineer protocols (or mechanisms) for multi-agent encounters? How do agents decide *with whom* to interact? How do agents decide *when* to interact?

As our discussion about trust in preceding sections has shown, it is impossible to reach a state of perfect information about the environment and the interaction partners' properties, possible strategies and interests. Agents are faced with significant degrees of uncertainty in making decisions. Agents have to trust each other in order to minimize the uncertainty associated with their interactions, for example, a buyer has to trust that a seller will deliver goods in time, or a seller will have to trust an auction house to sell its goods at the highest possible price) (see Ch. 6). Trust can be defined in this context as: “A belief an agent has that the other party will do what it says it will (being honest and reliable) or reciprocate (being reciprocal for the common good), given an opportunity to defect to get higher payoffs” (see Ch. 6, p. x).

In designing agent and open multi-agent systems, it is important to distinguish between *individual-level trust* (an agent believes its interaction partners are honest or willing to be reciprocal) and *system-level trust* (actors in the system are forced to be trustworthy by the rules of encounter, that is, protocols and mechanisms, that regulate the system).

Individual-level trust between agents means endowing them with the ability to reason about the likely reciprocal nature, reliability or honesty of their counterparts. Trust models aim to enable agents to calculate the amount of trust they can place in their interaction partners. To calculate the degree of trust, agents need to gather some knowledge about their counterparts' characteristics in many different ways, for example, through inferences drawn from the history of outcomes of multiple direct interactions with these partners or through indirect information provided by other agents.[18]

System-level trust concerns the design of protocols and mechanisms of interactions, that is, the rules of encounter, including security. These interaction mechanisms need to be devised to ensure that those involved can be sure they will gain some utility if they rightly deserve it, that is, a malicious agent cannot tamper with the correct payoff allocation of the mechanism. We expect agents to interact using a particular mechanism only if it can be trusted. This highlights the need for protocols that ensure that the participants will find no better option than telling the truth and interacting honestly with each other (see Ch. 6). The state-of-the-art in this area with respect to multi-agent software systems is shown in Box 2.17.

With the advent of open distributed systems, agents representing different countries, institutions or societies, will be interacting. This could give rise to a clash of norms and cultures that will result in software agents making the wrong assumptions about their counterparts, leading to distrust. Future agent-based trust models will need to have a means of effectively modelling differences in expectations arising from differences in norms and cultures. One aspect of this challenge concerns the relationship between the data that agents encounter or collect and their meaning.

*Box 2.17 Trust in multi-agent software systems*

Trust models based on sociology, machine-learning techniques and game theoretic approaches have been shown to be useful in helping software agents to interact better. As indicated in Section 2.4, these models each look at different facets of the trust problem without relating to each other. A very small number of interaction protocols have been shown to be trustworthy because the computational complexity of interaction protocols can be a barrier to designing trustworthy interaction mechanisms.

Security mechanisms provide a number of techniques to make interactions secure. However, they do not control the semantics of interactions beyond the line of defence provided by security policies and encryption techniques. Most trust models and interaction protocols do not cope effectively against strategic lying by agents. Most trust models and interaction protocols are not collusion-proof and agents can collude in order to exploit other agents or the system itself.

Game theoretic approaches to studying interactions, require protocol designers to make many unrealistic assumptions about the environment and the social network. A more precise modelling of the context of interactions is needed and trust models and interaction protocols should be adapted to the dynamic context in which they are used (see Ch. 6).

We examine developments in knowledge technologies next.

### 2.5.2 Knowledge Technologies and the Semantic Web

The major concerns for trust in cyberspace environments resulting from developments in this area are: (i) making sure that the input to knowledge and information manipulation processes is trustworthy and (ii) ensuring that the processes themselves are trustworthy, and their limits and margins for error are known and predictable (see Ch. 6).

Operationalizing the concept of trust can be accomplished in many ways in the context of knowledge technology development. The goal is to create or maintain trust in the cyberspace domain and some of the approaches can be characterized as ‘tactics for trust’ (see Table 5.1, Ch. 5).

There are costs and benefits associated with each of the tactics for establishing or maintaining trust. For instance, using knowledge technologies to manage knowledge more effectively implies the need for improved knowledge technologies. This, in turn, requires a better understanding of the knowledge technologies that will be implemented in the future and, in part, focusing research on this area of application. At present the technologies are immature so the cost of ownership is high. As they become better automated and ‘trustworthy’, it is expected that this cost will decline and their use will expand.

The tactics for trust need to be combined in active trust management strategies (see Ch. 5). As a counterpart to the human behavioural approaches to risk and trust management (see Chs 10 and 11), there is a need to maintain flexible policies for managing trust where software is concerned. These include the collection of rich sets of metadata about knowledge sources and agents, and ontologies for expressing trust requirements. A physical analogy might be a library of books, catalogued by subject, authors and CVs, reviews of the books with reviewers' credentials, cross references to other books not in the library, with similar metadata for them, all linked and available at any time from any place. Such information needs to be dynamically and automatically updated as new sources are 'published'.

Maintaining the distinction between trust and trustworthiness, so that signalling trustworthiness does not become detached from trustworthiness itself is crucial. Corritore et al. (2003) argue that trust is an act by the principal and trustworthiness a property of the agent. Where the principal and agent are 'software agents', such strategies are complex and demanding to maintain. We are already using primitive forms of such constructs in spam filters and privacy engines within browsers. It is also important to ensure that functionality is not sacrificed to trustworthiness. The scale of the information resource that will be available online for social, economic and academic purposes is growing exponentially. Any strategy for trustworthiness has to take into account such growth. Ensuring that privacy is sufficiently protected so as not to undermine trust is clearly important too (see Ch. 9).

In the offline world branding and promoting a reputation are very effective. It appears that they transfer well as contributors to trustworthiness in cyberspace. What is less clear is how fragile they might be and open to different forms of criminal attack that are not available in the offline world, for example, mass attack, denial of service or masquerade. Effective procedures for the maintenance of knowledge bases will need to be developed to ensure that as sharing of knowledge in a controlled way becomes a major influence on commercial and social behaviour, the sources that are used are maintained and exploited in ways that ensure they can be trusted. At present there is very little understanding of the end-user's perspective on these issues. We examine the results of the first large scale survey in the UK that examined how the experience of users with cyberspace tools and applications may be influencing their ideas about trust and the trustworthiness of cyberspace.

### 2.5.3 Evidence of Trust in Cyberspace

A problem confronted by research aimed at examining end-user perceptions of trust and the trustworthiness of cyberspace is that, as in the case of operationalizing trust for the development of software-agent based systems and knowledge management, it is difficult to define trust in a way that is meaningful for lay respondents to a survey.

Definitions based on rational expectations and game theoretic models are difficult to apply in social surveys. However, a conventional definition of trust can be applied. Trust can be defined as: "a firm belief in the reliability or truth or strength etc. of a person or thing. ... *a confident expectation*. … reliance on the truth of a statement etc., without examination" (Oxford English Dictionary, see Ch. 7).

This conventional definition of trust allows for the possibility that the use of cyberspace technologies might undermine trust and prevent people from obtaining electronic services (Guerra et al. 2003). One possibility is that the use of the Internet will undermine trust because it eliminates face-to-face interaction. Empirical evidence on this possibility is sparse and contradictory. Some researchers argue that trust may be undermined in electronic interactions because the reduced communication channel makes it harder to observe non-verbal physical cues (Wallace 2001).

There is no definitive research on the impact of different media on trust.[19] Trust might, in fact, be enhanced by making effective use of the vast amount of information and new forms of online social networks that are available through cyberspace interactions (Ben-Ner and Putterman 2002). Generally, personalized interactions are perceived as being more trustworthy in the offline world than in cyberspace. Technology to support such interactions in a geographically independent way will become available in the near future. Understanding how this might affect trusting behaviour is likely to influence how these technologies are developed and operated (see Ch. 5).

The relationship between information, uncertainty and trust is likely to vary along many dimensions including the extent of experience in using online forms of communication (MacKenzie 1999; and see Ch. 7). If trust as conventionally defined is closely related to a greater level of certainty or confidence in the reliability and security of the Internet, it is likely that trust will be enhanced as a person learns more about the technology. However, it is also the case that information can create, rather than reduce, uncertainty.

Proximity or 'experience' with the Internet is one of many factors that could play an important role in perceptions of appropriate levels of trust in cyberspace. How much (dis)trust does the public place in cyberspace? How does cyber trust shape use of the Internet? In the US an empirical basis for examining the use and implications of the Internet for trust is being developed (Lohse et al. 2000; Lunn and Suman 2002).

The Oxford Internet Institute at the University of Oxford conducted the first large-scale survey of Internet use in the UK in 2003, focusing on many issues including trust in cyberspace.[20] The results of the survey with respect to issues of cyber trust are summarized in Box 2.18.

*Box 2.18 Results of first Oxford Internet Survey*

Results based on a survey of 2,030 respondents participating in a multi-stage random sample of the population, aged 14 and upwards, in England, Wales and Scotland shed initial light on public perceptions of the trustworthiness of the Internet and how levels of trust are related to an individual's patterns of (non)use of the Internet over time.

Using the conventional view of trust as a 'confident expectation', the survey examined expectations about the reliability and value of the Internet and related ICTs. The survey revealed wide variations in cyber trust between individuals. Few exhibit a blind faith in the Internet, but most people are reasonably confident – if guarded – in the information and people they are able to access over the Internet.

Well over half – 59 per cent - of the respondents were using the Internet. This suggests that there is sufficient trust to support the continued diffusion of this technology, despite a general awareness of the potential risks entailed in exposure to unwanted mail, viruses and other potential risks.

The Internet does appear to be an 'experience' technology. Experience on the Internet tends to engender a higher level of cyber trust. Users of the Internet have more certainty and more confidence in the information and people they can access than do non-users, and many non-users have no opinion about the Internet's trustworthiness. Greater proximity to the Internet tends to instil more trust, to some extent, where 'proximity' is indicated by the use of the Internet over more years, in more ways and with greater expertise.

Those who are most proximate often become more sceptical and aware of potential risks, conforming to the 'certainty trough' model. The presence of cyber trust is positively associated with the use of the web for electronic commerce. However, those who use the Internet more, for example, for shopping online, are somewhat more likely to expose themselves to spam, email and other bad experiences. This tends to undermine trust in the Internet and raise concerns about risks.

Individuals with more formal education tend to be somewhat more sceptical of the information and people accessible on the Internet, but also somewhat less concerned about the risks of Internet use (see Ch. 7).

This research highlights issues concerning cyber trust for which more evidence and analysis is needed to gain a better understanding of the underlying social dynamics and learning processes. A surprisingly small percentage of users reported bad experiences on the Internet. This suggests that it is the right time, before problems with Internet use such as spam become more widespread, to take initiatives to reduce the likelihood of more users experiencing greater difficulties. Research on the co-evolutionary nature of human, organizational and technological systems is needed to underpin effective policies towards cyber trust and crime prevention.

All technologies are social in the sense that they are designed, produced, used and governed by people (Dutton 1999; Dutton et al. 2003). Understanding relevant social and institutional dimensions should be a key priority in addressing the way these technologies affect trust, crime and related issues (see Ch. 7).

This is especially important because trust in the Internet among certain categories of users, such as the less affluent who have less access to the Internet, is lower. For these groups, experience in using the Internet has a particularly disproportionate positive impact, increasing their trust in the Internet and lessening their preconceived concerns about risks. Education and exposure to the Internet may offer a general strategy for coping with the risks and threats to the perceived trustworthiness of this technology. However, as education and exposure to ICTs are skewed towards higher socio-economic groups this could reinforce the 'digital divide' in access to the Internet. Advances such as broadband Internet may exacerbate this divide. Initiatives to enhance the perceived trustworthiness of the Internet may be warranted, but such efforts will create a tension, competing against other values, such as privacy, which could be threatened by some trust-enhancing services (see Chs 9 and 14).

Other empirical evidence suggests that in many advanced industrial countries and in international organizations trust is a crucial factor that influences the future development of electronic transactions in cyberspace (Raab 1998; PIU 2002), and that more needs to be known about the public's concern about how their personal information is used and protected (6 1998). Most survey research into attitudes towards privacy and the processing of personal data is of variable quality (Bennett and Raab 2003). A MORI (2003) survey in the UK revealed considerable ignorance on the part of citizens about what happens to their personal data when it is used by public agencies. These studies need to be complemented by more comparable and systematic evidence about why people trust organizations, what specifically they trust organizations to do or not to do, how privacy attitudes relate to risk perception and how people evaluate the trustworthiness of cyberspace and public and private organizations.

In summary, software designers need to consider individual and system-level trust when they design multi-agent computer systems. The existing models of trust are inadequate and there is a need for further work in this area. However, no single tactic with respect to knowledge technologies is sufficient for ensuring appropriate levels of trust in the knowledge management process. In addition, the way that users experience cyberspace is only beginning to be studied empirically in the UK and there is a need for comparative and systematic research to strengthen the evidence base in this area.

## 2.6 CYBERSPACE MARKETS AND POLICY CONTEXTS

Incentives for investing in the deployment of more trustworthy networks and applications depend substantially on the dynamics of the market and how markets interact with legislation (and its enforcement) and policy intervention. We examine the economic drivers of cyberspace technology and service markets and the European legislative context in this section, focusing particularly on privacy protection.

In order to understand the evolutionary dynamics that will influence how the technical components of cyberspace develop in the market, we need to consider the special characteristics of these markets. Economic theory does this by focusing on expectations about the reputations and actions of firms in the market that supply the technologies (see Ch. 12).

The future of cyber trust and crime prevention in the UK also has to be seen in a global context and, particularly, in terms of the impact of the existing legislative environment and crime prevention strategies. The need for additional measures, for new policy deliberation fora and for investment in research must be addressed with full awareness of the current constraints on and opportunities for crime. Deliberations about how to build trust in cyberspace, to alleviate perceptions of risk and to mitigate opportunities for crime invoke considerations of the need for, and feasibility of, both individual privacy protection and collective security. Therefore, we also focus specifically on privacy protection and the issue of social equity (see Ch. 9).

### 2.6.1 The Economics of Emerging Cyberspace Markets

An industrial structure, conduct and performance (SCP) analysis is helpful in understanding how markets for ICT systems and services are likely to evolve and the implications for cyber trust and crime prevention. The SCP framework is helpful in considering how reputation and the expectations that it engenders relate to market competition. To maintain their reputation and belief in this reputation, that is, trust, firms have incentives to use trust to create or consolidate their market power. From an economic viewpoint, reputation is constructed from prior experience and the possibility always exists of exploiting reputation by engaging in opportunistic behaviour (see Ch. 12).

The asymmetry of information between firms and their customers can lead to customer ‘lock-in’ which reinforces the emergence of dominant firms. Opportunities exist for influencing competition through the use or misuse of trust in horizontal, vertical and networked market relationships involving: (i) the construction or opportunistic use of trust; (ii) the use of strategies to influence trust by attempting to ‘signal’ quality or risk; and (iii) by changes to liability rules that assign risk and thus can either reinforce or obviate the need for trust (Ch. 12).

In horizontal relations, cyberspace changes the scope for collusive behaviour. Firms competing in electronic marketplaces have expanded opportunities for using anonymity to cloak their actions if they depart from collusive agreements and, in some cases, a global platform for their activities. This could increase the likelihood of defection – and thus the need to rely on trust (Belleflamme and Bloch 2001). A second cyberspace influence is the scope for rapid and effective detection and response to defection due to improved information.

Trust may also be critical to vertical relationships, those involving input markets, access provision and retail sales to consumers, which involve search, payment, fulfilment and follow-up stages. New technologies have the potential to increase market competition by augmenting consumer search either directly, by empowering users, or, indirectly, through strengthening the capacities of intermediaries. It is not obvious, however, that intermediaries will act solely in consumer's interests – they may seek to exploit consumers or collude with their suppliers. The way that the various components of market exchanges in cyberspace may favour concentration is suggested in Box 2.19.

*Box 2.19 Forces for cyberspace market concentration*

Achieving trust in cyberspace payments favours the prominence of financial intermediaries. This may become a force for increasing market concentration. A firm's prominence also increases risk by making a larger target for fraudulent activities, that is, 'phishing' attacks on online banking sites and transactions service providers (The Independent 2003). Market prominence may reinforce concentration in the fulfilment phase where the selling party may be located in another (even an unknown) jurisdiction in which pursuing consumers' rights may be difficult or expensive. The follow-up stage of relations with consumers also highlights the importance of signalling. Verified information (for example, quality certification by independent third parties) or assurance may advantage players with greater capacities to invest in these signals. This may favour increased market concentration (see Ch. 12).

In oligopolistically competitive environments where the market is dominated by a small number of suppliers that are able to exert control over supply and price, such as those characterizing many cyberspace markets, firms may attempt to signal their *relative* trustworthiness by calling attention to problems encountered in doing business with their competitors. They may do so even though this may reduce trust in the market as a whole. Certification is an attractive alternative, but depends on the reliability of the certifying authority. Much recent literature on trusted third parties, cyber-notaries and Internet governance concerns the relative merits of competitive and coordinated certification.[21] While such third parties are regarded as essential to effective competition in electronic markets (Williamson 2000), at present the effectiveness of a market in certification services is uncertain.

The increasingly heavy information content of goods and services delivered over the Internet is an important consideration for the evolution of cyberspace markets. They have the classic problem of incomplete information.[22] A relatively high level of trust is required – perhaps on both sides – to fit such transactions into the relatively anonymous framework of retail commerce and this raises many issues for the technical means of securing identity and authenticity. In addition, cyberspace consists of many tiered networks and relationships and these have a major impact on the strength of demand for security precautions in the market. Demand for particular security solutions will be strongly influenced by the costs involved in switching between products on the market (see Box 2.20).

*Box 2.20 Networking and switching costs*

A major source of network relations involves economic entities that produce complements rather than substitutes (Katz and Shapiro 1994). In a variety of cyberspace markets including software and telecommunication services, incumbents have an incentive to maximize, and potential entrants to minimize, the costs of switching between networks. 'Churn' can undermine trust in the stability of the market and reduce suppliers' incentives to invest in durability, dependability and continuity. Proprietary standards may serve to stabilize these markets at the cost of reduced market competition. The first-mover advantage of leading firms and the need to capture suppliers of complementary technologies or services may lead firms to reduce security barriers to developers, share information with them, and shift the cost, complexity and liability burdens of security to customers. Inferior security precautions may drive out good ones (Anderson 2003; and see Ch. 12).

It is mainly market-led developments that will enable the spread and wider use of cyberspace technologies and influence their dependability. The rate at which technical developments leave the laboratory will be strongly influenced by the strategies of firms and the variety of products on the market. In turn, the legislative and policy frameworks that we examine next will influence the supply of and demand for more secure technologies.

Economic analysis tends to endogenize trust – to treat it as an aspect of the functioning of economic systems where the calculations are far removed from the intuitive notion of trusting behaviour. For individuals, the decision to trust another or to behave in a trustworthy way is analyzed in terms of expected costs and benefits. The economic view of trust includes a rational commitment to limited rationality and to considerations of monitoring and enforcement. From this perspective, goods and services that enhance trust are valuable products and this extends to the provision of trust and identity services. These are information goods and the economics of incomplete information is relevant to analysis of the problems of hidden information and hidden action. Institutions that permit credible or verifiable signals (assurance) and informal institutions (reputations) can improve efficiency, and specific contractual forms can align incentives. Trust is also a public good. A person cannot fully ‘own’ trust or exact payment for it and it is possible to ‘free-ride’ on the trust or trustworthiness of others. To the extent that trust is costly, it will thus be underprovided (see Ch. 12).

Because trust is bound up with expectations, the incompleteness of information, of markets and of contracts, is critical. This suggests a role for self-regulatory mechanisms (for example, open standards, reputations) and for appropriate allocation or low-cost trading of liabilities. Other aspects of trust enhancement may be provided by public or open, self-regulatory bodies. The sustainability of trust relationships in cyberspace markets may depend on asymmetry among the participants – in such cases, ‘improvements’ that reduce this asymmetry (such as the provision of identical information to both sides) may actually undermine trust.

If people choose trust in the face of ‘exogenous’ risks, for example, of loss due to accident or mistake, they can get locked in to high or low trust behaviour independently of whether such behaviour is collectively efficient. If crime is added to the model, the rule of law may break down and criminal behaviour may become the prevailing practice. This depends on how people are connected: in fully-connected or symmetric situations, behaviour is likely to be homogeneous. Where networks are very asymmetric, a form of stable diversity is possible, with ‘small worlds’ or semi-private groups enjoying very different levels of trust (see Ch. 12).

Trust may be viewed as a societal norm or convention. The stability of high trust behaviour does not depend on whether it is efficient, but rather on the balance between temptation and exposure. It may be less costly to help a population to evolve from low trust lock-in than to force them into high trust equilibrium. The results are significantly different when crime is added to the picture – the policy interventions required to ‘escape’ the low trust outcome may need to be both more extensive and more precise, and there is a danger of undermining the rule of law and getting locked in to ‘criminal equilibrium’ (see Ch. 12).

### 2.6.2 The Legislative and Policy Context – Privacy Protection

The evolution of the UK’s crime prevention strategies will in part result from international cooperation. Some observers are concerned that the spread of global networks is outstripping the pace of law makers (Goodman et al. 2002). Although considerable international work is underway in this area, there are few signs that there will be efforts to adopt a formal treaty (Bryen 2002). This means that there is unlikely to be a clear international framework within which to consider the implications of crime prevention strategies for privacy as cyberspace develops.

In the European Union a very high priority is being given to ensuring that Europe achieves competitiveness in the global knowledge-based economy. The Union's Lisbon strategy outlined policies, measures and actions that are expected to strengthen Europe's performance by accelerating the transition to the knowledge-based economy, "while preserving – and modernizing – Europe's unique social welfare model and decoupling economic growth from environmental damage" (European Commission 2003, p. 31). This intention to stimulate economic growth depends partly on leadership in the development and use of ICTs in ways that are both efficient and socially valued.

In some areas, such as technical standards and organizational practices to achieve improved risk management and crime reduction, the UK is well-placed to take the lead. It is argued by some that any measures (formal legislative or self-regulatory) that might discourage the early commercial introduction of advanced applications that have not been fully certified for dependability, could slow the pace of ICT innovation and reduce the competitiveness of the European economy. Others argue that it is essential to create economic incentives for cyber-technology suppliers and end-users to invest in greater levels of dependability and security even if this may slow the rate of diffusion of the most advanced technologies.

The parameters of the European Union's existing legislative framework, which affects decisions about cyber trust and crime prevention, are complex and involve numerous interdependencies. At the European Union level relevant legislation comes from directives on privacy and electronic communications, electronic commerce, telecommunication data protection and consumer policy. As European legislation is transposed into the UK's legislation its combination with specific laws where the UK retains full national jurisdiction, is creating a veritable jungle of law making.[23] These combinations can produce contradictory outcomes: in some cases they foster greater privacy protection, while in others they sanction measures that, for crime prevention purposes, alter the extent to which information about individuals is revealed.

In the area of privacy protection, which has a major impact on the future deployment of cyberspace technologies, the opportunities for crime and the feasibility of certain crime prevent strategies, there are four main classes of information privacy instruments: international instruments, national legislation, self-regulation and Privacy-Enhancing Technologies (PETs), but also pressure-group activity, citizen and consumer education, market-based practices and contracts (Bennett and Raab 2003; and see Ch. 9).

The interdependence and interaction between the various instruments is not very well understood. In the UK, for example, the Information Commissioner has powers regarding the promotion and promulgation of codes of practice, and also contributes to policy-making and statute-formation within government. The Information Commissioner's responsibilities bring this office into relationships with the media, pressure groups, technology designers and others whose activities affect privacy outcomes in a variety of ways. There is a growing need for a more holistic approach to regulatory policy and practice in the light of complex relationships and outcomes for privacy protection and crime prevention (Bennett and Raab 2003). We examine the case of privacy protection and cyber trust to illustrate important ways in which policy developments in this area are likely to influence crime prevention strategies in the future.

#### *2.6.2.1 Cyber trust, crime prevention and privacy protection*

The development of cyberspace, including software agent-based computing and many knowledge management applications for cyberspace, has drawn considerable attention to the need for protection against the privacy-invading processing of personal information – "For the general public as well as large swathes of the policy classes, … what baffles us often frightens us. What frightens us often stimulates, as well as feeds on, lack of trust in whatever it is that causes us to worry about our privacy" (Ch. 9, p. x). This observation is confirmed by studies on the public perception of risk (see Ch. 8).

The underpinning of the conventional privacy paradigm rests on assumptions derived from liberal political philosophy and epistemology. Civil society is assumed to comprise relatively autonomous individuals who need a modicum of privacy in order to be able to fulfil the various roles of the citizen in a liberal democratic state (Westin 1967). Individuals are assumed to know their interests in privacy. Toward the end of the 19$^{th}$ century in the US, Warren and Brandeis (1890, pp. 219-20) defined privacy as "the right to be let alone" and argued that "the protection of society must come mainly through a recognition of the rights of the individual. Each man is responsible for his own acts and omissions only".

Surveys on privacy in many western countries suggest that people generally have high, and increasing, levels of concern about privacy (Bennett 1992; Bennett and Raab 2003). Privacy is taken to be something that 'we' once had, but that is now being denied to us by public and private organizations employing the latest tools of cyberspace. Popular culture and the mass media often amplify the public's concern (see Ch. 8). This conventional paradigm has encouraged the policy goal of giving individuals greater control over the information about them that is collected, stored, processed and disseminated by public, and in some cases, private organizations. The paradigm and its assumptions underpin the doctrine of ‘fair information principles’ (FIPs), which has been codified in national data protection or information privacy laws, including the UK’s Data Protection Act 1998, voluntary codes, and standards and guidelines. The notion of *balance* is a key feature of policy responses in this area because privacy must be balanced against other rights and obligations (Raab 1999; see Ch. 9). Critiques of this paradigm come from a number of perspectives as suggested in Box 2.21.

*Box 2.21 Critiques of the privacy paradigm*

Critiques come from those who argue that the possessive-individualist implications of privacy should be rejected because this approach gives too little weight to community interests. Some argue that this serves to legitimize personalized information systems and to extend social control in ‘surveillance societies’. The importance of privacy as a value for democratic society beyond the single individual or aggregate needs to be considered (see Ch. 9).

Because of its emphasis on procedural due process and on an individualistic construct of the value of privacy, it is difficult to raise distributional issues and equity concerns within the conventional privacy paradigm. It is important to ascertain who enjoys what privacy, and why; and who does not, and whether an uneven distribution of data protection is justifiable on social and political grounds. The privacy paradigm does not address the distribution of privacy protection in terms of gender, ethnicity, social class, age, income or other typical socio-economic and demographic categories (see Ch. 9).

A better understanding of the distributional characteristics of privacy protection would provide an evidence base for consideration of whether inequalities can be justified and whether public policy and its implementation can alter them. Privacy protection could be treated as an element of social policy and debated in terms of alternatives such as public or private provision, costs and benefits, responsibilities and entitlements, and the best way to ‘deliver’ privacy (Bennett and Raab 2003; Regan 1995, 2002; Schoeman 1992; and see Ch. 9). This issue is particularly important when we consider the way crime prevention is used to protect citizens from infringements of privacy and threats to their identities.

Existing data and privacy protection legislation aims to ensure consent for data storage, assurance that the data collected are necessary and that matching up of personal records, such as health and insurance records, with police data does not occur. However, the matching of information from different sources can be the basis for judgements about criminality. Despite assurances against the secondary use or linking of personal data, some people have little trust in those that currently and in the future will manage their data.

*Box 2.22 Identity and identity cards*

Supporters of compulsory identity cards in the UK maintain that around 90 per cent of the population already carry identifying information on plastic cards, and an ID card would be more convenient resulting in the necessity for fewer cards to be carried. Card holders exercise 'informed consent' regarding their cards. However, combining information on one card would potentially facilitate the linking together of different pieces of information about an individual's identity. The implications of this need to be considered in the light of the fact that consent to reveal a 'piece of ourselves' in one context does not necessarily imply consent in another context (Rogerson and Pease 2003).

In addition, few of the most frequently used websites meet basic privacy standards (Electronic Privacy Information Centre 1997). Although cookies can be disabled, most people do not have the technical expertise to do this and know little about firewalls and other protection mechanisms (Rogerson and Pease 2003). Many of the tools being developed for use in cyberspace such as encryption, digital signatures, digital pseudonyms and anonymous re-mailers are also available to criminals and terrorists. It may also be the case that too great a focus on limiting encryption may be at the expense of more effective, yet less intrusive, crime prevention interventions. This may also apply to the excessive use of Closed Circuit Television (CCTV) surveillance as discussed in Box 2.23.

*Box 2.23 CCTV surveillance and crime prevention*

Unimaginative implementation of CCTV may be contributing to concerns associated with the extension of its use. von Hirsch (2000) recommends that CCTV should be limited to the tracking of activity within a specific location over time, providing a record of activity for inspection when, and only when, an offence is known to have taken place. Constant surveillance involves growing intrusion of privacy and the crime prevention benefits need to be sufficiently high to justify this and also should directly benefit those being monitored. The effectiveness of CCTV as a crime prevention mechanism has not been empirically demonstrated (Welsh and Farrington 2002). The use of CCTV may lead to more self-policing as people aim to avoid being wrongly identified as criminals (Palmer 2000). CCTV can be used to track individuals using human or software agents to identify faces, suspicious behaviour or a potentially criminal 'gait'. This raises issues of the ethics of crime prevention and whether class or other interests shape efforts designed to prevent crimes (Rogerson and Pease 2003). .

Ekblom (1996) argues that the goal should be to reduce crime to 'tolerable' levels, while Kleinig (2000) suggests that a level of crime must be tolerated if it cannot be diminished without incurring unacceptable privacy intrusions. Establishing what is 'unacceptable' is partly a matter for empirical research on citizen's beliefs and preferences, but it is also a matter for ethical debate. There are different interests and vantage points as to what constitutes ‘acceptable’ and ‘unacceptable’ levels of protection, as suggested by the following:

> there is evidence that citizens are reacting to new anti-terrorism surveillance measures by calling for more checks and balances within their own democratic state structures. However, market agents are utilizing new technologies to collect personal data, mostly in the absence of effective enforcement of privacy protection legislation, in order to financially benefit from their further processing and use (IPTS 2003, p. 19).

Crime prevention measures to tackle crime linked to global networks in the future will rely on models that yield predictions and crime scenarios (Levi 2001). The perception of risk in cyberspace and of the acceptability of using intrusive technologies to monitor potentially criminal behaviour may become amplified or may be attenuated depending on a wide variety of factors, many of which have come to light as a result of the review of existing scientific evidence. It seems clear, however, that much more will need to be done to ensure that cyberspace developments do not lead to the exacerbation of existing criminal opportunities or to new ones.

The evidence reviewed in this section indicates that the economic dynamics of cyberspace markets tend towards horizontal and vertical integration. There are numerous opportunities for lock-in to less than optimal systems, and the costs of networking and switching affect technology supplier and user incentives to invest in secure technologies. The legislative and policy contexts for cyberspace development are complicated by the need for cooperation at global, regional and national levels and by interdependency between the policy instruments available. This is particularly apparent in the area of privacy protection, which should be considered in the light of social policy concerns about equity and the varying types of protection available to different categories of cyberspace users. Informed consent and anonymity are involved in the use of identity cards and surveillance as means of crime prevention and, there is not sufficient empirical evidence available to back up claims about the effectiveness of these approaches.

## 2.7 CYBER TRUST AND CRIME PREVENTION – KEY ISSUES AND LESSONS

In this section, we highlight the key issues and lessons from the scientific evidence reviewed in the preceding sections of this chapter and in the chapters that follow. We recapitulate the earlier sections without the detail in order to emphasize those areas where there is a need for measures to encourage more trustworthy cyberspace systems and improved strategies for crime prevention. In most cases, such measures will need to be underpinned by a stronger cross-disciplinary research effort.

The sections in this chapter offer many insights into the interrelationships between the human and technical components of cyberspace. These need to be distilled to highlight where there are gaps in understanding and where there are areas of consensus or controversy over future developments. We have stressed that cyberspace is a complex human and technical system. This observation is being accepted increasingly by experts and non-experts alike. What is much less well understood by stakeholders, including cyberspace system developers and users, is that the whole of this system is subject to unpredictable emergent behaviour, which may yield unintended results. This means that the balance between the anticipation of, and scanning for, new problems leading to reactions is likely to favour the latter. More will need to be invested in scanning for new forms of criminal activity, enabling versatile responses and ensuring that, in cases where remedies fail, there is sufficient redundancy in the system.

This means that at any given time, parts of the system will be relatively stable while other parts are not.[24] It also means that there will always be ambiguity about the interpretation of the results of research. This is because the co-evolution of all the components of cyberspace is subject to a large number of possible emergent outcomes. This observation has particular consequences for interventions aimed at improved crime prevention because interventions for other purposes may confound crime prevention. Nevertheless, there is sufficient evidence from existing studies of cyberspace developments and, more generally, from research in related areas of science and technology, to draw inferences about the outcomes associated with the most likely future developments. In the face of uncertainty and the need to strengthen the evidence base in key areas, decisions about the most effective crime prevention strategies must be considered in the light of ethical considerations and principles that are derived from plausible theories.

The existing scientific evidence can be applied to clarify some of the interdependencies between the human and technical components of cyberspace, especially in areas that have achieved a degree of stability. This suggests how interventions in cyberspace are likely to reverberate throughout the whole social and technical system, locally and globally. Our review of developments in cyberspace technologies and components of the social system demonstrates that – in nearly every area – there are new opportunities for criminal activity. Strategies to mitigate these involve numerous trade-offs and choices, some of which we consider in this section.

As the dynamics of the cyberspace system unfold, much will need to be done to build confidence both in people and in the 'mechanics' of cyberspace. As electronic services of all kinds continue to evolve, people will appraise cyberspace threats in different ways and ascribe to them quite different meanings. The variety of responses will depend on the way various people value the consequences of perceived threats. Therefore, a better understanding of the relationships between human factors, risk and trust is essential for the future security of cyberspace.

So far, relatively little attention has been given to the analysis of public perceptions of cyberspace risk. This is a major gap in the evidence base.[25] We can infer, however, from studies of the public perception of risk in other fields of science and technology that there is a complex set of risk factors. This research indicates that future problems and perceived dangers in cyberspace could be interpreted by the public as a failure of the technical system, as a failure on the part of system designers and users or as a failure in the governance model. It is also essential to bear in mind that reported perceptions of risk may not be aligned with the trust that people actually place in cyberspace technologies or in the individuals (and software agents) and institutions that govern cyberspace.

It is clear from research undertaken by organizations across Europe that the solutions to cyber trust and crime prevention in a pervasive computing environment will be quite different from those in use today. There will be a need for a new *paradigm for cyberspace security*, even in the face of the current situation in which the majority of potential users of cyberspace services and products have a poor understanding of security.

In Chapter 1 of this volume we posed several questions:

- What sorts of cyber trust issues will be of dominant concern – what will be the new kinds of vulnerability and how will the risks of cyberspace be perceived?
- How will the overall structure of the emerging system drive the uptake of cyber trust technologies?
- What kinds of interventions might be made to influence the system's dynamics for the purpose of improving cyber trust and crime prevention?

Some answers are provided in the discussion that follows, but it is important to remember that addressing these questions within existing paradigms of trust, security and technology is unlikely to be enough to alleviate concerns about potential threats in this environment. A strengthened cross-disciplinary research effort is needed to create a better foundation for understanding key facets of the technical and human dimensions of cyberspace.

### 2.7.1 Dependable Software Systems and Commercial Issues

Part 2 of this volume includes reviews about the dependability of pervasive and complex computing systems and the development of various means of identity verification and authentication of users of these systems. A deployment gap is associated with software development methods and procedures. These are currently insufficiently robust to produce a more trustworthy network infrastructure and service applications. The dependability or 'trustworthiness' of a computer system refers to the ability to avoid computer system failures beyond an 'acceptable' level.

One key issue then is the level of failure that in the eyes of users would be regarded as being unacceptable. Another is the management of the software engineering process in which there are numerous dependencies and constraints. In response to the first issue, there is a need to develop fault prevention and fault removal techniques that maintain satisfactory service in the face of attacks on networks. In relation to management, there must be good project leadership and close involvement of the customer to ensure that the system meets required levels of dependability, and standards must be established against which system dependability performance can be measured.

In large-scale software engineering projects there must be flexibility in the development process to allow responses to specific customer requirements and changes in the external environment. This means that it is essential that appropriately educated and very experienced people work on the design and implementation of large software projects in order to avoid low levels of system dependability. If future networked computer systems are to attain higher levels of dependability or trustworthiness, considerably greater attention will need to be given both to commercial issues, which influence customer willingness to invest in such systems, and risk management. Improved ways of managing the components of large-scale software projects will be needed. Whether these components are developed using proprietary or open source software code, and whether they rely on re-usable code, the problems of managing their aggregation/disaggregation processes will remain.

It may become technically feasible to develop warrantable software and systems. This would require a software system development approach that: (i) enables the likely impact on system dependability of all design and deployment decisions and activities to be assessed throughout the system life cycle; and (ii) caters for system adaptation and the realities of huge, rapidly evolving, pervasive systems (see Ch. 3).

In this context, the commercial relationship between those that commission a project and its developers and deliverers involves financial, functional and time risks, all of which need to be managed in an equitable manner. Contracting regimes may be based on fixed price or cost plus arrangements, but because of the difficulties of estimation and resource allocation and unexpected component integration problems, adherence to a rigid structure of contracting regimes often contributes to the failure of such projects. ‘Best practice’ codes can play a role, but adjustments and flexibility are needed in conjunction with a change manager with a very high level of expertise, experience and education.

Incentives for all parties involved in complex software projects to adopt ‘best practice’ are essential, as is the maintenance of an intimate collaborative relationship on all aspects of a software project (Collins 2004). In addition to the methods for managing technical, financial and timescale risks, software development involves two additional risks. The first involves estimation. The lack of any physical legal constraints introduces considerable uncertainty as to how long a piece of software will take to develop.

To address this risk there is a need to achieve a balance between delivering functionality within the expected time and cost while not bounding the creativity of the software developer to deliver functional code. At present software development is seen as a mix of art and science. The challenge for software engineers in attempting to provide solutions to large complex problems is that the solution will also inevitably be very complex. In addition, the processes by which such complex artefacts are created are complicated and ill-defined. Concentration on the modularity of functionality is leading to a neglect of the connectivity between the software modules (see Box 2.24).

> *Box 2.2.4 A holistic view of modularity*
>
> A holistic view of modularity and the links between modules is essential if the implicit decomposition that modularity implies is to be successful. Several engineering disciplines adopt holistic approaches to the design of large complex structures, including software engineering. While there are no physical laws, and the constraints are less rigorous and well-shared within the project, it might benefit software engineering methods if the holistic approaches of other disciplines are evaluated for their applicability in the software engineering process (Collins 2004).

The second specific risk in large-scale software lies in the difficulty of describing accurately the relationship between critical elements of the requirements. The use of prototyping, rapid application development approaches or other approaches to risk reduction in areas of critical uncertainty within a project is essential. It is people in the main that write software. There is research ongoing looking at how software could be used to generate software, but up to now automatic software generation tools have not met with widespread success. For the foreseeable future, people will continue to play a critical role in the generation of software. Greater efforts are needed to encourage a holistic view of software engineering in order to reduce the risks of software unreliability. Alongside this, there are divergent views about whether open source software developments will produce software that has greater reliability and dependability when employed on a large scale and as a component of hybrid proprietary/open source applications.

Achieving greater dependability of complex ICT systems in the future will require greater investment in training and education. On a global scale software engineering and computer science training is increasing, but in the UK it is on the wane. Efforts to improve this situation are being made by a number of bodies, but the skills and expertise available to British industry in this field are declining. The key issue is appropriate education to produce graduates that are capable of participating effectively in the development of large complex software projects (Collins 2004). The skills base necessary to develop trustworthy software requires a body of experienced professionals that are appropriately certified or chartered. It also requires that employers need to recogize that it is imperative that they recruit experienced people to work on projects to develop software. To ensure that such people are available the overall qualifications of the labour pool must be continuously upgraded. Also there must be greater awareness of vulnerabilities among those who invest in the components of cyberspace systems. This would create stronger incentives to introduce measures aimed at reducing cyberspace system vulnerabilities.

Future research on the dependability of software systems must be cross-disciplinary. It will need to bring together those who undertake research within technical and procedural disciplines that presently concentrate on particular types of systems, dependability attributes, types of faults and means for achieving dependability, with those researchers that tackle socio-technical issues including design, usability, functionality specification, acceptable levels of failure, recovery modes and incident management, as well as 'best practice' and innovative approaches to project management and software engineering throughout the whole of the life cycle. If the practice of software engineering is strengthened by measures that enhance the dependability or trustworthiness of software systems the opportunities for criminal attack or accidental failures could be minimized.

The UK could gain a competitive advantage if it provides leadership in standards setting with respect to the testing and certification of all aspects of dependable systems, including autonomous software agents (see Ch. 6). If processes and systems created in the UK are accredited, and this accreditation is seen elsewhere as having value, practices, procedures and technical designs, especially with respect to networks and software, could spread rapidly producing externalities and a strong potential for global impact. However, for this to happen cyberspace systems developers and users would need to see a reasonable financial return, given the additional costs of more dependable systems. This suggests the need for cross-disciplinary research on the economic incentives that will arise in future markets and the links between these incentives, people's perceptions of risk and their willingness to trust networks despite their relatively low levels of dependability (economic incentives and markets are considered below).

### 2.7.2 Managing Identity(ies) in Cyberspace

One of the most significant issues for crime prevention is the fact that in cyberspace users may choose to maintain their anonymity. In addition, new issues will be raised in areas where identification of users is essential for commercial services, or for access, for instance, to health records and income tax returns or for crime prevention, for example, the appropriate means of authentication of identity. In Parts 2 and 3 of this volume we have included reviews of the many instances in which people, devices or digital data need to be identified and authenticated (see Chs 4 and 10). Users (including computers, software agents and people) can be authenticated using something they own, something they know or something they are. All these techniques, whether used alone or in combination, assume that there has been an initial, accurate identification and then rely on that assumption. If the original identification is not conducted properly then there is a risk of error in later identification.

Passwords, encryption and biometrics can be used as means of identification. The last offers a direct means of authentication but, even in this case, there is a risk of error insofar as no two biometric templates match perfectly. In using this type of authentication a Type 1 error may occur such that the system fails to recognize a valid user or a Type 2 error may occur where the system accepts an impostor. The likelihood of such errors has implications for the usability of cyberspace systems and for the extent of actual and perceived risk. Decisions in this area will influence the perceived trustworthiness of the service applications that are supported by the cyberspace infrastructure and raise questions about people's attitudes to intrusions into their bodies.[26] One means of addressing this area will be to examine empirically how people respond to specific measures and how they perceive the trade-offs between intrusion and protection, and their respective benefits and costs. Use of biometrics will mean that it will not be possible to maintain multiple core identities for a given purpose without introducing considerable system and process complexity.

### 2.7.3 Cyberspace Usability, Risk Management and Security

Changes in the design of secure technologies and in social practices and cultural norms of information assurance influence the effectiveness of strategies to reduce crime and the threats arising from changes in information handling procedures. Empirical research demonstrates that, despite the availability of mechanisms that can be used to authenticate the identity of cyberspace users, many of these are hard to use or are rendered ineffective because of the demands they make on users. Unless users are given training in the use of those mechanisms that are available, human error will make them of little benefit (see Chs. 10, and 11).

The usability of such mechanisms as passwords, tokens and encryption, depends on the organizational processes and the workflows that are involved as well as on the extent to which users believe themselves to be at risk. Studies of organizational and behavioural change demonstrate that effective risk management requires the development of a 'culture of security' where end-users, rather than their physically present or distant managers, take responsibility for monitoring risks and acting appropriately. Although information security management codes have been developed, the complexity of cyberspace systems and the dangers of unwanted intrusion or attack mean that there will be an increasing need for the interoperation of management policies and new frameworks to ensure that security measures become more closely integrated into business processes. In parallel with the need for new approaches to software engineering and the design of large complex software systems, there is a need to foster 'persuasive design' techniques that reward cyberspace users for good security practices (see Ch. 10).

A key lesson from empirical research on security mechanisms and behaviours is that appropriate and effective security must be an integral part of the socio-technical system. Security needs to be integrated into all cyberspace development approaches. A central focus for crime prevention strategies may be the point at which human beings directly interface with the digital world. Research on cyberspace market evolution also suggests that as the cyberspace system evolves, a major area of development concerns the technical interfaces and standards that are used. These interfaces and standards are the vulnerable points in cyberspace in terms of security and the risks associated with them will either be amplified or attenuated in the future.

The vast scale and scope of cyberspace also highlights the need to achieve greater reliability in the authentication of information and digital documentation, which may be accompanied by metadata describing the document's use and functionality. This raises issues of digital rights management, data and information ownership, identity and privacy. As agent software is used in an increasingly large number of cyberspace applications, the necessity for identification and authentication of software and data objects, as well as of people, will grow in importance.

There will continue to be a need for research into the security of technology and on the effectiveness of identification processes used for important everyday processes. The questions that must be addressed on an ongoing basis are: (i) How much 'security' or 'strength' is appropriate? (ii) What is the appropriate balance between procedural approaches and architectural solutions to reduce the risk of vulnerabilities arising as a result of human behaviour? (iii) What kinds of education programmes could be used to highlight the need for compliance with local security policies?[27]

### 2.7.4 Cyberspace and Crime Prevention Strategies

Crime occurs in many forms and one way of depicting generic crime problems and solutions as a guide for future crime prevention strategies in cyberspace is within the Misdeeds and Security framework (see Table 2.3) This could be modified as further consideration is given to the risks encountered in cyberspace.

Cyberspace developments of this kind could be addressed in the context of crime prevention strategies through the further elaboration of 'criminal opportunity' models. Felson's routine activity theory has been used to encourage those responsible for crime prevention to consider the physical and virtual locations and times in everyday life when potential offenders are likely to become motivated by contact with vulnerable crime targets, especially in the absence of 'capable guardians' (Felson 1987). In an extension of this model, efforts are being made to develop crime prevention activities to reduce the likelihood of the 'conjunction of criminal opportunity' (Ekblom 2003; Rogerson and Pease 2003).

The 'conjunction of criminal opportunity' model provides a means of systematically considering the conditions necessary for a crime to occur and the possibilities for prevention. It focuses both on the predispositions of potential offenders and on the immediate characteristics of the crime situation – in this case the online and offline situation of cyberspace users and the systems within which they operate (Ekblom 2002, 2003). With respect to the situation, the model signposts many factors that encourage crime. Crime prevention can be defined as an intervention that tackles the causes of criminal events to reduce the risk of their occurrence and/or the potential seriousness of their consequences. The causes of crime can be complex, but also remote and fairly weak. However, immediate causes are reducible to 11 generic precursors which act through common aspects of crime situations and of criminals – whether in the physical world or in cyberspace.

*Table 2.3 Cyberspace developments and risk and security measures*

| Misdeeds (Ms) | Actions Supporting Security (Ss) |
|---|---|
| Misappropriated (theft) | Secured against theft |
| Mistreated (damaged or injured) | Safeguarded against damage |
| Misused (for crime, including counter measures against prevention or enforcement) | Shielded against misuse |
| Mishandled (fraud, counterfeiting, smuggling, illegal divulgence) | Supporting – justice, crime reduction, community safety (facilitating arrest, forensics, identification, punishment, reassurance) |
| Misbehaved (disorder and antisocial behaviour) | Scam-proofed |
| Mistaken (false alarms, wrongful accusation, leading to miscarriage) | 'Sivilized' –conducive to good behaviour |
| Mistrusted (non-reporting of crime to authorities) | Straightening adverse side-effects |

*Source: Adapted from Ekblom (2004a).*

The conjunction of criminal opportunity occurs when a predisposed, motivated and equipped offender encounters, seeks or engineers a crime situation involving human, material or informational targets, enclosures (such as a building or a firewall), a wider environment (such as a shopping centre or a financial system) and people (or intelligent software agents), which are acting in diverse ways as crime preventers or promoters (see Table 2.4).

Preventive interventions can act by interrupting, diverting or weakening any of these causes. Understanding these resources for offending is important because they influence the situation that crime preventers confront and the strength of the offender's predisposition and motivation to commit a crime (Ekblom and Tilley 2000).

*Table 2.4 Generic precursors of crime*

| Potential Offender | Crime Situation |
|---|---|
| Presence (incl. virtual) in crime situation without leaving traces | Target of crime (person, company, govt.; material goods, systems, information) that is vulnerable, attractive or provocative |
| Perception of risk, effort, reward and conscience and consequent decisions | Enclosure (safe, building, firewall) that is vulnerable, contains targets |
| Resources for crime (skills, weapons, knowledge, equipment, access to supporting network; *modus operandi* to maximize reward and minimize risk and effort, creating a crime opportunity. | Wider environment (town centre, airport, computerized financial system) that contains targets, generates conflict; favours concealment, ambush and escape over surveillance and pursuit |
| Readiness to offend (motivation, emotion, influenced by current life circumstances) | Absence of preventers (people or intelligent software) that make crimes less likely to happen |
| Lack of skills to avoid committing crime (literacy, social skills) | Presence of promoters (people or intelligent software) that make crime more likely to happen, including careless individuals, reckless designers/manufacturers, deliberate fences and criminal service providers |
| Predisposition to criminality (personality, ideology) | |

*Source: Ekblom (2004b).*

Trust fits into this framework in several ways. An Internet shopper who is too trusting may act as a careless or negligent crime promoter, as may a system designer. Conversely, being an effective crime preventer means being equipped with appropriate applications and systems. Offenders exploit misplaced trust, sometimes to an expert degree and are aided by software and hardware based resources, for example, 'skimming' devices fitted into cash machines to clone cards.

Efforts to improve the security of complex information systems often rely on the use of risk analysis to justify the cost of designing and implementing security features (Courtney 1977; Fitzgerald 1978). The concept of a criminal opportunity can be used to understand the means of reducing crime opportunities in organizational contexts where threats to security are posed by dishonest staff (see Ch. 11). Clarke's (1997) 'Crime Specific Opportunity Structure' model focuses, for example, on the opportunities available to potential inside perpetrators of network related crimes (see Ch. 11).

These approaches could be extended to examine the organizational contexts and behavioural characteristics that are most likely to give rise to criminal opportunities. Notwithstanding the development of these approaches, answers to questions about acceptable levels of dependability and trade-offs require an understanding of the nature of trusting behaviour among human and software agents and of the actual and perceived risk associated with cyberspace.

A key area is this context is ICT Forensics. Data held on hard disks can be put to criminal use. If they can be identified and authenticated, these data can provide evidence of malfeasance. The problem of identifying 'the original' is difficult and frequently overlooked. In the future, as the scale of cyberspace systems increases, the sheer volume of distributed stored data may overwhelm the capacity of the law enforcement agencies. As data management tools are developed, they are not likely to have the processes of auditability and traceability incorporated in them required for evidence gathering. It will be necessary, therefore, to document these requirements, which, in turn, will require stakeholder collaboration to reach agreement on the principles and standards to be met.

As data are increasingly likely to be stored in jurisdictions beyond the reach of national law enforcement agencies some form of international code of practice will be needed to enable access to data by the agencies involved in crime detection and criminal prosecutions. If the match between these data and a suspect with seemingly appropriate spatial and temporal proof is insufficiently strong, the data will not stand up in court as evidence. One objective in using forensic data could be to establish sufficient strength of 'binding' or linkage to allow other physical investigations to be instigated that would add to this evidence. This would require collaboration between system designers and legal and law enforcement specialists.

The availability of mobile and transportable miniature mass storage devices that use strong encryption will expand enormously over the next decade. Reliance on the analysis of log files to identify when and where specific devices have accessed or are accessing systems and networks and being able to very rapidly and accurately trace subsequent use seems the only means at present for tracing illegal activities. As the volume of encrypted material within which the criminal can conceal his or her activities increases, it is possible that, where data are shown to be encrypted and not legitimate, they could be used to justify further investigations. The question of whether the public or private sector would be willing to bear the costs of very expensive tracking or endure rapidly spreading unprosecutable crime is an urgent subject for debate.

Forensic tools are being developed by a very small number of academic groups and companies to meet specific needs. Without some collaboration with their developers, the ability of investigators and computer forensic experts to maintain parity with the environment within which the data under investigation are used and stored, will be limited. The ability to carry out forensic investigations will need to be seen as a legitimate requirement placed on a system or application design if this situation is not to become worse. All of these issues need discussion, but it is unclear who should initiate it. There is some indication that cyberspace users do not ‘want to know’ in advance of any potential weaknesses. Nevertheless, there is a need to consider what balance between evidential – investigative – preventative computer forensics could be struck and the risks and benefits of the various options.

At present there has been little fundamental research into the issues of the scale of cyberspace and the criminal use of data, especially that stored outside the jurisdictions of law enforcement agencies, and the ethical, social, economic and legal strategies that might be adopted. There is a need for cross-disciplinary research in the area of ICT forensics and cyber-evidence management. Enhancement of trustworthiness itself will reduce the likelihood of malfeasance by temptation, but without strong cyber-policing, the determined criminal will find in the use of ICTs and the applications that will be running on the Internet, a ‘honey pot’ of opportunity and illegal gain.

### 2.7.5 Trust and Risk in Cyberspace

We have included reviews of research on risk perception and on trust from the perspectives of the social sciences in Part 3 of this volume. There is a growing body of literature that provides insight into whether the technical possibility of risk in cyberspace is the same as the perception and actual experience of risk. We can gain insight into perceptions of risk in cyberspace by drawing upon research into the way members of the public have been found to appraise uncertainty and the risks associated with scientific and technological innovations (see Chs 7 and 8). It seems clear that the social meaning of a risk will influence its salience and the way uncertainty is judged. People’s perceptions of risk are related to their cultural and social values, their attitudes to blame, their morality and how they view an event such as an intrusion that reveals their identity in cyberspace. In addition, the attitude of the public towards experts and regulators can be expected to influence the way cyberspace risks are interpreted. Risk perception is also intimately linked to levels of trust.

These observations rely on theories and empirical research in the fields of cognitive psychology, psychometric analysis and studies of risk and emotion. There is also evidence from studies in the field of media and communications that people’s perceptions of risk are strongly influenced by the symbols within their social networks and in the media’s reporting of events. There is empirical evidence based on people’s stories about their perceptions of risk that suggests that whereas experts see risks as chains of cause and event, lay people tend to see them in a social context of relationships. Research is needed to assess the importance of these observations for cyberspace and crime prevention. This body of research helps to explain why probabilistic analyses of actual risk may vary considerably from analyses that take the context of cyberspace experience into account in a qualitative way.

It is also important to distinguish between reported perceptions of trust and the way in which people actually conduct their lives. We have little evidence of the extent of inconsistency between reports of mistrust in individuals or institutions and the capacity to place trust in various parts of the socio-technical system (O'Neill 2002).

The literature on risk perception suggests that perceived risk may be amplified or attenuated depending on a large number of socio-technical factors. The Social Amplification of Risk Framework (SARF) has been developed as a means of integrating disparate approaches to risk (Kasperson et al. 2003; and see Ch. 8). The SARF:

> … aims to examine broadly, and in social and historical context, how risk and risk events interact with psychology, social, institutional, and cultural processes in ways that amplify and attenuate risk perceptions and concerns, and thereby shape risk behavior, influence institutional processes, and affect risk consequences (Pidgeon et al. 2003, p. 2).

Debate among adherents to different positions with regard to the risk people will encounter or perceive in cyberspace are informed by very different knowledge claims (Callon 2003; Rosa 2003). The SARF could be further developed to understand why some risks associated with cyberspace attract particular social and political attention (risk amplification), even when experts judge them to be relatively unimportant. Application of the SARF could produce a new frame in which to evaluate the likely effectiveness of crime prevention strategies.

We know that trust is a means for alleviating risks, but there is little empirical research on the conditions under which people are prepared to trust others in cyberspace or to trust in the trustworthiness of cyberspace systems. Yet, with the spread of access to global networks, it is clear that in many circumstances people are willing to trust in each other in cyberspace and in the notion that system-to-system interdependencies and relationships are trustworthy. Empirical research in the fields of human-computer interaction and computer-mediated communication is beginning to provide insight into person-to-person and person-to-system trust in cyberspace. Key variables influencing trust include: the number of actors involved, the types of actors, whether relationships are conducted synchronously or asynchronously, the availability of trust-warranting properties and signals to convey those properties, prior experience and the propensity to trust, and the perceived benefits and risks of trusting behaviour.

It seems that as more information exchanges are mediated by technology, the responsibility for supporting trust will increasingly fall on cyberspace system designers and operators. Studies of trusting behaviour in these areas also provide suggestions for the types of factors that are likely to influence agent-based behaviour in contexts where system-to-system trust must be established. However, most of the research in this area is conducted using stylized game-theoretic models, which limit the number of variables that can be examined in a given 'game', as discussed below, and are difficult to populate with data reflecting the experiences of cyberspace users.

Empirical evidence suggests that the propensity to trust another person or software agent is partly informed by expectations (see Chs 12 and 13). Agents' expectations also can be modelled probabilistically to provide insight into the likelihood that choices about whether or not to trust will yield various outcomes. Such game-theoretic approaches assume that an agent's decision to play in a game involves trust that actor(s) will behave as expected. The outcomes of the games are influenced by the completeness of the institutional framework (laws, rules and standards), by the completeness of the information available to the agents in the game and the network structure of the game that is established at the outset.

One application of this approach is a coordination game in which it is feasible to establish whether high or low trust equilibria will emerge if all the agents interact in a fully connected network according to a pre-specified set of rules, and definitions of trustworthiness. One of the assumptions in this approach is that the players engaged in a game will act rationally and this allows their behaviour to be predicted. This approach facilitates understanding of the consequences of precautions that may be taken to avoid crime in the face of externalities. Research in this area helps to demonstrate when such measures are likely to affect the risk to others and when it is appropriate to transfer the cost of protection to others, that is, from the cyberspace system developer to the end-user firm or the consumer. This work suggests that it is the distribution rather than the level of trust that supports the setting of priorities for establishing trust relationships and establishes a structure for negotiating the distribution of liabilities arising from cyberspace interactions.

In recent years there has been a revival of the concept of social capital in which trust is a major component. This concept can be applied to examine the positive effects expected from networks of trusted agents. Drawn from studies in sociology, human geography and economics, it has been suggested that societies with a more complex and dense pattern of networked social relations may benefit from lower transaction costs and stronger assumptions about whether agents will act opportunistically. This approach could be extended in the future to examinations of the way webs or networks of trust emerge in virtual communities of various kinds. There is a need to better understand how social capital can be fostered in cyberspace (see Ch. 13).

Just as there is uncertainty about how best to design and operate trustworthy or dependable cyberspace systems, the trusting behaviour and trustworthiness of human and software agents is not clearly understood. In the light of this uncertainty, it is important to consider cyber trust and crime prevention issues in terms of the ethical issues, especially with respect to identity, anonymity and privacy. In cases where the evidence-base is weak, we also need to rely on principles derived from plausible theories. We have seen that cyberspace security systems often require identity authentication, but the Internet is currently designed to facilitate the way people can 'play' with their identity. This will remain the case, as long as the design and architecture of the Internet provides for anonymous communications.[28]

Views are divided about the ethical justification for interventions in cyberspace that seek to limit this potential. From an ethical standpoint, this suggests the need for a forum in which those who remain sceptical of the need for security interventions to prevent crime indicate their requirement for justification of changes that might limit the scope for anonymity (see Ch. 14). However, the reviews in Chapters 8 and 14 demonstrate why it is so difficult to discuss these key issues in generic open forums. The principal difficulties are the extent to which different meanings become attached to the perceptions of risk and danger, uncertainty about how the media are likely to influence opinion in this area, and the strongly polarized views about the origins and appropriate future of the Internet.

With respect to the polarized views about the Internet, while some seek to place the burden of proof on those that wish to alter the libertarian and open principles that underpin the Internet as we know it today, others argue that, although recognizing that certain privileged activities such as science or commerce must be able to continue in a secure way, liberty and openness are important values. The judgements, however, might be made by those with political power, in which case the trade-offs between individual privacy and the benefits of greater collective security would need to be taken account of in such a way that specific issues would be considered and assessed as transparently as possible.

From a moral standpoint, some regard trust as the effect of good behaviour while others regard it as being the cause of good behaviour. Some argue that liberty and openness are essential and non-negotiable in cyberspace; others want to alter the design of cyberspace to make inappropriate behaviour more difficult. Different views about the moral arguments supporting different approaches to crime prevention strategies for cyberspace hinge on the extent to which actors are presumed to be rational and are likely to act to maximize their own self-interest. In an environment where there are multiple complete or partial identities, standard assumptions about what motivates actors need, at the very least, to be carefully scrutinized.

Having originated in the west, the Internet has a western bias, which tends to inform debate and policies for crime prevention. On the one hand, it can be argued that actors should be allowed to pursue their conception of what is ‘good’ (if this does not interfere with others). On the other hand, it can be argued that there should be no departure from western principles and their implications for crime or cyber-terrorism. It is also possible, however, to argue that the key issue is the privileges that people should have in cyberspace, thus enabling debate about this to become a political problem that may be addressed through compromise and various social policy measures.

Positions on this issue are closely linked to the role of the media and strategies for building awareness of the risks in cyberspace, and about trust and the trustworthiness of cyberspace. As with other issues where there is uncertainty and a possibility of the amplification of risk, if there is to be informed and reasoned debate about these issues, citizens must be well informed about cyber trust and crime prevention issues.

The government, the private sector, citizens and civil society groups – as well as the traditional and alternative media outlets – will continue to draw attention to many of the problems and issues in this area.[29] The debates that ensue will not all be based on reasoned argument and the provenance of some of the information upon which these debates rely may be difficult or impossible to trace. However, as awareness of cyberspace risk and vulnerability continues to spread, there are growing numbers of forums (national and international) that are seeking to foster critical and reasoned debate and to adopt measures to tackle specific issues. This highlights the importance of ongoing monitoring by governments and other actors of opportunities to facilitate such debates such that consideration is given to the feasibility and appropriateness of actions proposed to limit crime.

Existing theory and empirical evidence do not support unambiguous conclusions in this area. This is to be expected given the emergent properties of a complex system. Similarly, there are a substantial number of models and perspectives on trust and trustworthiness in cyberspace, but these enable relatively few inferences to be drawn about trust and trustworthiness. One of the difficulties of translating the results of existing research into practical solutions for crime prevention is that many conceptual frameworks and models are based on strict parameters and assumptions and some approaches do not lend themselves to empirical verification.

Those that can be analyzed empirically often yield results that are open to different interpretations depending on views about how opinions are influenced by the media and other psychological and sociological factors. In addition, even though the use of computers and the Internet has reached a reasonably high level in the UK, the more advanced components of cyberspace systems have yet to diffuse widely. Globally, too, usage is very uneven and interactions are globally dispersed in many cases adding to the difficulties involved in understanding trust and risk perception. This too is an area that represents a major gap in the evidence base necessary to support more effective crime prevention strategies.

### 2.7.6 New Cyberspace Technologies and Trust

We have examined how various models of trust are being applied in two important areas of technical development – knowledge technologies and the semantic web and software agent-based systems (see Chs 5 and 6).

If cyberspace systems are to become more dependable and secure there will need to be changes in the design and implementation of the ICT components. Agent-based computing is regarded as a means of achieving this. Software agents have to trust each other in order to minimize the uncertainty associated with their interactions and take account of individual and system-level trust. In both cases, there is a need for protocols that ensure that the software and human agents will find no better option than telling the truth and interacting honestly with each other. This is a major challenge for the future.

In addition, work on knowledge technologies and on the semantic web requires a certain degree of trust in the means of ensuring that the input to knowledge and information manipulation processes are trustworthy. The available tactics for imbuing trust include transparency, ownership rules, the means to extend trust between sub-networks, certification, restriction of entry, formal methods, calculations, interrogation and knowledge management. Research in this area shows that each of these tactics has costs and benefits and that they must be combined with effective trust management strategies for the software systems – including the use of metadata and ontologies for trust requirements. Use of all of these tactics raises questions with respect to identity, anonymity and privacy.

Effective procedures for the maintenance of knowledge bases will need to be developed to ensure that, as sharing of knowledge in a controlled way becomes a major influence on commercial and social behaviour, the sources used are maintained and exploited in ways that ensure they can be trusted. At present there is very little understanding of the end-user's perspective on these issues.

A problem related to research aimed at examining end-user perceptions of trust and the trustworthiness of cyberspace is that it is difficult to define trust in a way that is meaningful for survey respondents. When trust is defined as a 'confident expectation', survey results for the UK suggest that the relationship between information about the Internet, uncertainty and trust varies along many dimensions, including the extent of experience in using online forms of communication (see Ch. 7). Trust appears to be enhanced as a person learns more about the technology, but that experience over time may also create new uncertainties and perceptions of risk. Individuals with more formal education tend to be somewhat more sceptical of the information and people accessible via the Internet, but also somewhat less concerned about the risks of Internet use. Evidence and analysis are needed to gain a better understanding of the underlying social dynamics and learning processes that are involved.

The problems associated with the ‘digital divide’ are likely to persist even when people have obtained access to cyberspace. Evidence from the Oxford Internet Survey in 2003 suggests that there is lower trust of the Internet among categories of users such as the less affluent or the disabled (see Ch. 7). For these groups, experience in using the Internet has a particularly disproportionate positive impact, increasing their trust in the Internet and lessening their preconceived concerns about risks. Education and exposure to the Internet may offer a general strategy for coping with the risks and threats to the perceived trustworthiness of this technology. However, education and exposure to the Internet are skewed towards higher socio-economic groups. As a result, these strategies could actually reinforce the ‘digital divide’ in access to the Internet. Other survey data (MORI 2003) suggest that there is considerable public ignorance about what happens to personal data when it is used by public agencies. Overall, there is a gap in the evidence base in this area partly because of the lack of comparable and systematic data.

### 2.7.7 Cyberspace Market Evolution, the Policy Context, and Privacy

We have included reviews of research on the economic dynamics of the evolution of cyberspace technology and service markets (see Ch. 12) and the interaction of these features with policy measures and the legislative environment (see Ch. 9). A key observation about market dynamics and the changing legislative policy context is that the development of cyberspace is a global phenomenon. In the future, monitoring global developments will continue to be very important. Effective monitoring across a wide range of issues is essential for effective national crime prevention strategies.

The special characteristics of these markets are an important consideration in understanding how cyberspace technologies will evolve and whether there will be incentives to invest in more dependable and secure systems. Industrial SCP analysis has been used to address this issue. The analysis in Chapter 12 shows how asymmetrical information between firms and their customers can produce customer lock-in, often leading to the emergence of dominant firms. Firms will use trust in a variety of ways, sometimes to achieve a form of lock-in to the market, which is in a ‘low trust equilibrium’ in which there are few incentives to invest in more dependable systems.

In cases where there are few suppliers competing in the market, a small number of supplier firms can influence the rate of investment in new technologies through their influence over supply and price. In addition, analysis suggests that when firms compete in electronic marketplaces they encounter new opportunities for using anonymity in ways that make their participation in potentially collusive agreements difficult to detect. At the same time, new technologies can be used by firms to monitor customer behaviour and allegiance to firms because of the customer-related information that is available as a result of new information management systems.

From the customer's perspective, the analysis of cyberspace markets highlights the way new technologies may increase competition by augmenting consumer search capabilities through the use of search engines as intermediaries. However, intermediaries may not act solely in the consumer's interest, given the economic incentives that drive their operations. In addition, in areas such as financial intermediation and electronic payment systems, greater trust may enable such intermediaries to encourage increasing market concentration. Cyber trust agents are essential if effective competition in electronic markets is to be fostered, but it remains uncertain whether the market for certification services will grow rapidly in the future.

The demand for security solutions will be influenced strongly by the costs involved in switching between cyberspace security products on the market. Economic analysis suggests that the sustainability of trust relationships in cyberspace markets may actually depend on *asymmetry* among the participants. 'Improvements' or measures designed to enhance the security of cyberspace products leading to greater symmetry in the marketplace, may actually undermine trust. This indicates again that it is the distribution of trust rather than its level that is central to future economic outcomes and whether they foster technologies that reduce or exacerbate cyberspace vulnerabilities.

The parameters of the European Union's existing legislative framework, which affects decisions about cyber trust and crime prevention, are complex and involve numerous interdependencies (RAND Europe 2003a,b). This issue is considered in Chapter 9. Given that perceptions about privacy are closely related to the acceptance of measures to enhance the security of cyberspace, we examined whether the prevailing 'privacy paradigm' is consistent with the need to assess the requirements for improved crime prevention strategies.

Privacy protection, in particular, relies on many international instruments, national legislation, self-regulatory or voluntary tools, and privacy enhancing technologies or PETs. Research in this area suggests that PETs cannot provide a 'magic bullet' to solve privacy problems or address issues of identity authentication. It is much more likely that a mix of instruments will have to be applied to protect privacy alongside instruments and technologies that are consistent with equity considerations and the collective interests of society.

Given the complexity of cyberspace and varying levels of dependability or trustworthiness, future developments will create new possibilities for opportunistic crime and for privacy intrusions. Although technical solutions to provide for communications and transactions with rigorous authentication may eventually provide a foundation for a higher level of trust in cyberspace, they will also create new threats to privacy. One possibility is to encourage the development of relatively fine grained 'digital principles' to complement the security and privacy guidelines developed by organizations such as the OECD (2002; and see Ch. 15). Such self-regulatory arrangements might build on developments in autonomous software agent computing, but will raise issues of privacy protection and surveillance.

Surveys in many western countries suggest that people generally have high and increasing levels of concern about privacy (Bennett 1992; Bennett and Raab 2003; and see Ch. 9). While this could be attributed to reports from various pressure groups or to press coverage of data protection issues, the important point in the context of cyber trust and crime prevention is that discussions about privacy generally presume that balance is the main feature of policy responses aimed at protecting individual interests in privacy and other rights and responsibilities.

This view has been criticized by those who believe that insufficient weight is given to collective or community interests. In the future it will be necessary to examine distributional issues and equity concerns within the conventional privacy paradigm. This will mean examining who enjoys what privacy and why. This view is another feature of the 'digital divide', suggesting that insofar as there are inequalities in the distribution of privacy protection, the issues need to be treated as a social policy concern.

Very little is known about the distribution of privacy protection in terms of typical socio-economic and demographic categories. Empirical research is needed on this issue. The results would enable privacy protection to be treated as an element of social policy. It could then be debated, together with collective security, in terms of alternatives, such as public or private provision, the costs and benefits, rights and entitlements, and the best way to secure privacy. This is important given that crime prevention will be used to protect citizens from infringements to their privacy, for example, as a result of the theft of their identities. Better understanding of the distributional characteristics of privacy protection would provide an evidence base for considering whether inequalities can be justified and whether public policy and its implementation can alter them.

This raises the issue of how much information about our identities is required for crime prevention purposes and what should constitute informed consent. Research indicates that some people have low levels of trust in those who currently and in the future will manage their personal data in both the public and private sectors. Few web sites today meet even existing privacy protection standards and it is unclear whether a focus on limiting encryption will be at the expense of more effective, yet less intrusive, crime prevention interventions. Similar arguments may apply to the use of surveillance, the effectiveness of which has not been empirically demonstrated. The overriding goal should be to reduce crime to 'tolerable' levels without incurring unacceptable privacy intrusions, and to consider the potential benefits of more equitable means of delivering privacy whatever the level of privacy protection that is accepted.

It has been suggested that the development of a Privacy Impact Assessment (PIA) methodology would provide a basis for assessing the actual or potential effects that an activity or policy may have for individual privacy (Raab 1995; Stewart 1996; and see Ch. 9). Further development could help to answer questions such as whether we should see cyberspace and various practices as being safe until proven dangerous, or dangerous until proven safe. A system where the role of the 'precautionary principle' in privacy protection is more explicit could become increasingly important (European Commission 2000; European Union Council 1999; and see Ch. 9), especially if consideration is given to how and when (and when not) to apply it. Measures will be needed to resolve tensions between individual privacy and collective security and to assess the adequacy and enforceability of data protection and freedom of information legislation. Resolution of ethical issues in the contexts where privacy issues come to the fore will play a key role in determining the acceptability of crime prevention measures.

### 2.7.8 Lessons for the Future

The scientific evidence yields insights into the way technical innovation is intersecting with human capacities for learning about cyberspace developments. In each of the areas we address in this book there are uncertainties about the trade-offs that will accompany future human and technical measures to develop more dependable and secure cyberspace systems to minimize the risk of new 'conjunctions of criminal opportunity'. Some of these trade-offs are summarized in Table 2.5.

The literature on risk and trust formation and their relationships to the design and implementation of cyberspace systems emphasizes the importance of values, reciprocity, information management and human and technical capabilities.

*Table 2.5 Cyberspace and the potential tradeoff*

| Software dependability | User requirements, cost and complexity |
|---|---|
| Identification | Anonymity |
| Authentication of software, data objects and people | Privacy protection |
| Type 1 false rejection errors | Type 2 false acceptance errors |
| Cyberspace security | Cyberspace usability |
| Risk | Trust and trustworthiness |
| Libertarian, open networks | Network Control, Surveillance |
| Informed debate | Risk amplification |
| Individual privacy | Collective interest |
| Liability | Risk and cost |
| Security | Economic growth and innovation |

Available research is inconclusive with respect to the implications of interventions in cyberspace by those that seek to minimize crime. Given the relatively weak scientific evidence in key areas, there is a need to consider the ethical positions associated with crime prevention measures and to draw inferences about their impact. In some of the areas addressed in this book, the lack of systematic and comparable quantitative evidence means the foundation for evidence-based decision-making will be weak. In these areas, it will be important to consider the ethical positions and to reach judgements. Critical reasoning can be applied to reach such assessments – subject to review as new evidence accumulates – about 'acceptable' and 'unacceptable' levels of trustworthiness in relation to the cyberspace system. This is essential for evaluations of the distributional issues associated with intrusive privacy protection measures and of the benefits of crime protection.

It is clear that:

- improved crime prevention in cyberspace depends upon a better understanding of human motivations and practices and the way these are embedded within complex cyberspace systems;
- problems facing crime preventers will not be solved by better technology alone; enforcement of behavioural change consistent with ‘good’ behaviour in cyberspace will mean enabling people to do the ‘right’ thing easily with substantial implications for the usability and cost of cyberspace technologies;
- trust in cyberspace can be fostered in both technical and non-technical ways; the options need to be considered in the light of studies of risk perception and the actual risk encountered in cyberspace and in the wider situation;
- crime prevention measures for cyberspace will need to receive widespread consent nationally and internationally if they are to be effective; and
- the dependability of future cyberspace systems and the extent to which they ensure human safety and well-being are matters of human choice; understanding the human and non-human relationships often requires an assumption that it is feasible to believe that agents, both human and technological, will act or, in the case of the latter, will have been designed and implemented to act, in rational or at last quasi-rational ways.

The scale of the challenge facing government policy makers is vast. The speed at which the machinery of government operates can be slow relative to the potential rate of technological change, and further slowing of the decision making process due to the need to adopt international solutions may become a larger problem. There are also concerns about introducing legislative and governance solutions, which may manage risks more effectively, but stifle innovation and competitiveness. When new measures are introduced, they interact with other measures often giving rise to unexpected outcomes that may be inconsistent with policy – or indeed, with changing social mores.

No ‘future-proof’ set of measures can be put in place through unilateral action because the positions of stakeholders are changing and insufficiently clear. Partnerships will be needed between the public and private sectors, working with civil society representatives, to create an accepted framework for cyber trust and crime prevention. Lessons must be learned from policy and regulatory initiatives and the corresponding failures and successes of these initiatives. There are several research frameworks (new frameworks for dependable software engineering, the criminal opportunity models, the social amplification of risk framework and the privacy impact assessment framework) that could be further developed and interconnected to increase understanding of security measures and crime prevention strategies. Crime prevention, especially in cyberspace, occurs in a rapidly changing technical, economic and social context where unforeseeable properties emerge. The key knowledge about what works as a crime prevention strategy is a wasting asset that must be constantly replenished if crime preventers are to innovate faster than criminals.

This review and synthesis of the existing scientific evidence in a number of key areas has identified some gaps in research that is underway in the UK (see Appendix 2A for a summary of these areas). All of these would benefit from cross-disciplinary investigation. This work will need to include research on the dependability and trustworthiness of all aspects of the cyberspace system. There is, in particular, a need to promote cyberspace system design: that enables users to manage their privacy and their security and for crimes to be prevented or detected; and that encourages greater system reliability and robustness, while maintaining a degree of transparency for users. This must include ensuring appropriate levels of investment in research and development in cyberspace systems, advanced knowledge services, management and engineering and in information assurance initiatives. There is also a need for a collaborative approach across the research community that will harness the considerable breadth of expertise that is available and help to overcome existing fragmentation.

Research needs to be complemented by investment in adequate levels of education to build awareness of cyberspace developments and crime prevention measures. Many ethical and moral issues are raised by innovations in ICTs, which must be debated in the future. Cyberspace must not become exclusive to only the 'experts', thereby exacerbating 'digital divides'. Building confidence in the information provided by government about the risks to those who encounter cyberspace and about the trustworthiness of cyberspace systems is essential. The social and economic threats from the social fragmentation and exclusion that will arise if some groups take up the new technologies and benefit from them, but others do not, must also be examined.

The complexity of cyberspace and its emergent properties means that it will be essential to develop methodologies for testing when changes in the human and technical system are likely to create new vulnerabilities. Only in this way will it be feasible to encourage alternative action. The greatest challenge in the future will be managing emergent properties and vulnerabilities in ways that respect changing individual and collective values.

## APPENDIX 2.1 POTENTIAL FOR CROSS-DISCIPLINARY RESEARCH

*Dependable Pervasive Systems*

- Achieving adequate operational dependability from large complex software systems when they are deployed is a critical research programme and will remain so for some time – adequate resources are needed to support this work.
- Socio-technical and technical dependability expertise will be required.
- A key question is at what level does system failure become unacceptable and how does the perception of this level differ across user groups?
- Research is needed on the four basic dependability technologies – fault prevention, fault removal, fault tolerance and fault forecasting.
- Research is also needed on the feasibility of developing warrantable software and systems that is sufficiently valued by industry to justify the cost of deployment.
- There is a continuing need for a fundamental review of the problems in software engineering including formal methods and the creative art of software development.
- Research on software project organization, involvement of end-users/customers in design and implementation and with a concern for the usability of security mechanisms is needed.
- Research is needed on the appropriate balance between evidential – investigative – preventative computer forensics that could be struck and on the risks and benefits of options.

*Risk Perception and the Experience of Cyberspace*

- In cognitive psychology, for example, Prospect Theory should be applied to investigate the heuristics that influence how people experience cyberspace and the likelihood that stereotyping perpetrators (especially in the media), contexts and places influences risk perceptions and whether such stereotyping has a greater impact than expert reassurance.
- Psychometric research should be applied to determine whether intensive users of ICTs have a sense of familiarity and control that inoculates them against feeling risk while also leading to a sense of complacency about criminal activity – how attentive are people to threat-related stimuli in cyberspace?
- Research is needed on security and risk to develop the ‘criminal opportunity model’.

- The SARF approach should be applied to cyberspace and crime prevention to provide a means of understanding the communication of risk and how it shapes public perceptions.
- Studies should be made of how learning and risk perception are related to ICT system design and implementation.
- The complexity of individual beliefs, motivations and actions in cyberspace requires longitudinal surveys; international comparative studies such as the World Internet Project in which the Oxford Internet Institute is participating, are needed.

*Security, Trust and Trustworthiness*

- Research is needed on whether trust in cyberspace follows the trustworthiness of systems – how do people place trust and refuse to trust?
- Research is needed on modelling that has a greater capacity to take the contexts of agent interactions into account.
- Research is required on the trustworthiness of the information acquisition processes in knowledge acquisition and the consequences for trusting behaviour.
- Research is needed on effective procedures for the maintenance of knowledge bases.
- Continuing research is needed on the viability of various biometric techniques from market and usability standpoints.
- Research is needed on the means to establish primary secondary verification of 'the original' identity and the development of products that secure the transmission between the biometric sensor and the matching module.
- Research is needed on perceptions of intrusive measures, such as the use of DNA samples and chip insertions in the body, and on the physical consequences of implanting chips for life.
- Analysis of how security, trust and trustworthiness are signalled in open global network environments, drawing in part on signalling theory from economics as well as on cultural theory, is required.
- Studies of the impact of ICT legacy applications and system features and the potential for lock-in in emerging markets and the mechanisms giving rise to market failures in these markets, especially with regard to trust services, are needed.
- Empirical research is needed on the formation of trust via technical channels and on how best to encourage usable ICT designs.
- Research is needed on the semantics of security to develop a better understanding of the security discourse is needed to facilitate communication and policy development.

- Research methodologies should be developed for investigating organizational risk management using new combinations of problem structuring methods and ethnographic methods to provide and evaluate risk management decision support in a variety of organizational settings.
- Research is needed to encourage social values and behavioural changes to inculcate the valuing by society of the use of shared cyberspace, with a focus on attitudes towards rights and responsibilities, and to establish the factors that favour acceptance of these spaces as safe, secure and reliable.
- Research is needed on PETs and the appropriate allocation of control over cyberspace as between users and system designers and operators.
- Research is needed on the notion of balancing cost and risk with reward by developing a methodology for investigating the effects of different (portfolio) management strategies.

*Risk, Precautionary Measures and Innovation*

- Research is needed to establish whether precautionary measures are likely to lead to a failure to take advantage of the benefits of new technologies. In particular, there is a need to develop the PIA methodology.
- Research is required on the distribution of capabilities for privacy protection among different groups within the population.
- Research is needed on the potential trade-offs between productivity gains and levels of 'acceptable' risk.
- Evaluations are needed of whether crime that is linked to cyberspace developments is being kept within tolerable limits and whether the perceived riskiness of cyberspace is diminishing over time.

*Policies, Principles and Legislation*

- Qualitative and experimental research is needed to examine the relevance to cyber trust and crime prevention of past research and the effectiveness of actual policies and techniques that are being applied.
- Research is needed on international developments and distinctive approaches to legislation, policy and regulation.
- Research is required on the epidemiology of cyberspace attacks to identify 'treatment' or policy intervention points adopting the analogy HIV/AIDS insofar as the scale of the problem and development of possible strategies for treating individuals and slowing the spread of infection were only possible after a thorough understanding of the epidemiology of the disease was achieved.

- Research is needed on the implications of software liability approaches including the development of new fine grained principles and practices.

*Futures Research*

- Future work is needed to consider the potential future impacts of today’s applications, together with those of potential future applications deriving from today’s science base.

## NOTES

1 This chapter draws in substantial part on the state-of-the-art science reviews that follow. Text from these chapters, in some instances, is incorporated directly within this chapter. We are grateful to the authors of subsequent chapters for allowing us to draw upon their work in this way. The views incorporated in this synthesis chapter are not necessarily those of any institution. We accept full responsibility for the views expressed in this chapter and for any errors or omissions.

2 This synthesis chapter and the science reviews, i.e. Chapters 3 to 12 of this book, were peer-reviewed by a minimum of two anonymous referees who were acknowledged experts in their respective fields. The authors of this chapter thank all those who participated in the review process and acknowledge the comments that were received and fed back to the contributors to this volume.

3 Chapters 13 to 15 were commissioned to address key areas that came to light as a result of discussion among participants in the Foresight project and are not intended to provide comprehensive reviews in the style of the preceding chapters.

4 And see Castells (2001); Gibson (1984); and Mitchell (1996).

5 Social technology is terminology often used in the social sciences, including the social studies of technology and sociological literatures. For instance, Foucault (1970) uses the term ‘technology’ to refer to technologies of the self and governance structures and processes, see also Rose (1999). Others use this terminology to refer to aspects of the social system that either become embedded in a technical system by virtue of design choices that reflect alternative values or, alternatively, represent the discourses, processes and procedures that are used to develop and implement the components of a technical system (see Pinch 1992).

6 Throughout, we use the term cross-disciplinary to encompass those who favour multi-disciplinary or inter-disciplinary research; what we intend is stronger cooperation based upon excellence in research located in many different disciplines.

7 RSA (Rivest, Shamir, and Adleman public key encryption technology).

8 See also Frith and Blakemore (2003); McClue (2003); Morris et al. (2003); Thiel, 2001; and O’Hara et al. (2003) for Foresight research on memory and cognition.

9 For empirical data on high-tech crime in the UK see National Hi-Tech Crime Unit (2004), which indicates that from a sample of 105 business employees the following computer-related crimes were identified as serious – sabotage of data or networks 91%; virus attacks 90%; financial fraud 88%; theft of proprietary information 86%; attacks, e.g. Denial of Service 79%; theft of laptops 76%; unauthorized website access/misuse 75%; spoofing attacks 74%; theft of other hardware 71%; telecommunications fraud 55%; telecoms eavesdropping 48%; and active wiretapping 43%.

10 Current advice on the management of computer crime-related evidence is contained in the ACPO (Association of Chief Police Officers) guidelines which can be found at http://www.nhtcu.org/ACPO%20Guide%20v3.0.pdf accessed 17 Apr. 04.

11 The ‘grid’ refers to efforts to build the next generation computing infrastructure

providing intensive computation and analysis of shared large-scale databases, from hundreds of TeraBytes to PetaBytes, across widely distributed scientific communities, see http://eu-datagrid.web.cern.Ch/eu-datagrid/ for an example of one project accessed 17 Apr. 04.

12 http://www.pwc.com/Extweb/service.nsf/docid/B2ECC9B0E9EFA3D785256C330052 47D3 accessed 6 May 04.

13 See, e.g., Douglas and Wildavsky (1982) and Poortinga and Pidgeon (2003).

14 Summary of Key Themes and Issues, Foresight Expert Workshops, London, November 2003.

15 See, for example, Corritore et al. (2003); Egger (2001); McKnight and Chervany (2000); Riegelsberger and Sasse (2001); and Ch. 10).

16 See also Hawkins et al. (1999); Silverstone (2003).

17 See, for example, Himanen (2001); Lessig (1999); Miller (2003); and Naughton (1999).

18 See Figure 2.1 on game-theoretic approaches to trust and von Neuman and Morgenstern (1944).

19 Some earlier research was conducted by Johansen (1988); Rice (1984) and Short et al. (1976).

20 See http://www.oii.ox.ac.uk/research/?rq=oxis accessed 17 Apr. 04, for the full survey results.

21 See, for example, Froomkin (1996); Gotoh (2003); Moreh (1997); OECD (2000) and Smith and Keehan (1997).

22 Incomplete information with respect to bargaining and contracts as compared to the assumption of perfect information and market equilibrium, see d'Aspremont and Gerard-Varet (1979); Gibbons (1992) and Ch. 12.

23 See European Commission (1999, 2000, 2002a,b); European Union Council (1999) and United Kingdom Government (1988, 1990, 1998, 2000a,b,c, 2003).

24 The OST Foresight programme examined complex systems within the framework of the Foresight Cognitive Systems Project, see Austin et al. (2003) for a review.

25 OST Foresight was commissioning research reviews in this area in the Spring of 2004. There is some research on perceptions of risk with respect to the Y2K issue (Pidgeon et al. 2003) and on risk management, particularly in the financial services sector (Backhouse et al. 2003; and Ch. 11).

26 Biometric solutions using iris recognition that do not rely upon the use of a data template are being developed. If the method is scalable, and the signs are encouraging, this has potential. However, usability studies show that there will be a small percentage of the population for whom this will not be feasible (see Ch. 10).

27 The European Commission has launched a 'preparatory action', 'Towards a programme to advance European security through Research and Technology', IP/04/145, Brussels, 5 Feb. 04. The programme covers: improving situation awareness; optimising security and protection of networked systems; protecting against terrorism; enhancing crisis management; and achieving interoperability and integrated systems for information and communication.

28 Since the Internet and its platforms are subject to continuous evolution, it is important to distinguish analytically here between the public and private spaces that can be created, the changes in the Internet Protocol with respect to quality of service and other features, and the differences in the requirements for security of various industry sectors, government services, and public spaces frequented by citizens and civil society groups.

29 There are growing numbers of articles in the press focusing, for instance, on the impact of anti-spam laws in the US, use of software for anti-terrorism surveillance and the privacy and freedom of speech issues that are raised. The subjects for future research suggested raised by this volume indicate that information control and assurance, together with the overall stability of the cyberspace system will continue to provide a focus for, and give rise to, debate.

## REFERENCES


Ackerman, B. (1980), *Social Justice in the Liberal State*, New Haven CT: Yale University Press.

Adams, A. and Sasse M.A. (2001), 'Privacy in Multimedia Communications: Protecting Users, Not Just Data', in A. Blandford, J. Vanderdonkt and P. Gray (eds) *People and Computers XV - Interaction without Frontiers, Joint Proceedings of HCI2001 and ICM2001*, Lille, September, Dordrecht: Springer, pp. 49-64.

Anderson, R. (2003), 'Cryptography and Competition Policy: Issues with "Trusted Computing"', Cambridge University working paper, http://www.ftp.cl.cam.ac.uk/ftp/users/rja14/tcpa.pdf accessed 17 Apr. 04.

Austin, J., Cliff, D., Ghanea-Hercock, R. and Wright, A. (2003), 'Large-Scale, Small-Scale Systems', *Foresight Cognitive Systems Research Review*, http://www.foresight.gov.uk/cognitive.html accessed 17 Apr. 04.

Axelrod, R. (1984), *The Evolution of Cooperation*, New York: Basic Books.

Bacharach, M. and Gambetta, D. (2001) 'Trust in Signs', in K. Cook (ed) *Trust in Society*, New York: Russell Sage Foundation, pp. 148-184.

Bacharach, M., Guerra, G. and Zizzo, D. (2001), 'Is Trust Self-fulfilling: An Experimental Study', Oxford University Department of Economics Working Paper 76, http://users.ox.ac.uk/~kebl1218/istrussf.pdf accessed 17 Apr. 04.

Backhouse, J., Hsu, W.Y., and McDonnell, A. (2003), 'Toward Public Key Infrastructure Interoperability', *Communications of the ACM* 46(6): 98-100.

Barber, B. (1983), *The Logic and Limits of Trust*, New Brunswick NJ: Rutgers University Press.

Beck, U. (1992), *Risk Society: Towards a New Modernity*, London: Sage.

Belleflamme, P. and Bloch, F. (2001), 'Market Sharing Agreements and Collusive Networks', University of London Queen Mary College Working Paper 443, http://www.econ.qmul.ac.uk/papers/docs/wp443.pdf accessed 17 Apr. 04.

Bener, A. (2000), 'Risk Perception, Trust and Credibility: A Case in Internet Banking', Department of Information Systems, London School of Economics and Political Science.

Ben-Ner, A. and Putterman, L. (2002), 'Trust in the New Economy', HRRI Working Paper 11-02, University of Minnesota, Industrial Relations Center, abstract, http://netec.mcc.ac.uk/WoPEc/data/Papers/hrrpapers1102.html accessed 17 Apr. 04.

Bennett, C.J. (1992), *Regulating Privacy: Data Protection and Public Policy in Europe and the United States*, Ithaca NY: Cornell University Press.

Bennett, C.J. and Raab, C.D. (2003), *The Governance of Privacy: Policy Instruments in Global Perspective*, Aldershot: Ashgate.

Bourdieu, P. and Passeron, J.-C. (1977), *Reproduction in Education, Society and Culture*, translated by R. Nice, London: Sage.

Bowles, S. and Gintis, H. (2000), 'Optimal Parochialism: The Dynamics of Trust and Exclusion in Networks', Santa Fe Institute Working Paper, 16 February, http://www.santafe.edu/sfi/publications/Working-Papers/00-03-017.pdf accessed 17 Apr. 04.

Brooks, F.P. (1995), *The Mythical Man-Month: Essays in Software Engineering*, Anniversary Edition, 2nd Edition, New York: Addison-Wesley Publishing Co.

Bryen, S. (2002), 'A Collective Security Approach to Protecting the Global Critical Infrastructure', ITU Workshop on Creating Trust in Critical Network Infrastructures', Seoul, 20-22 May, http://www.itu.int/osg/spu/ni/security/docs/cni.09.doc accessed 17 Apr. 04.

Callon, M. (2003), 'The Increasing Involvement of Concerned Groups in R&D Policies: What Lessons for Public Powers?' in A. Geuna, A.J. Salter, and W.E. Steinmueller (eds) *Science and Innovation: Rethinking the Rationales for Funding and Governance*, Cheltenham: Edward Elgar, pp. 30-68.

Castells, M. (2001), *The Internet Galaxy: Reflections on the Internet*, Business, and Society, Oxford: Oxford University Press.

Chauvidul, N. (2003), 'Formality and Informality in Internal Control Systems: A Comparative Study of Control in Different Social and Cultural Environments in a Global Bank', Department of Information Systems, London School of Economics and Political Science.

Checkland, P. (1999), *Soft Systems Methodology. A 30-year Retrospective*, Chichester: John Wiley & Sons.

Clarke, R. (1997), *Situational Crime Prevention: Successful Case Studies*, Albany, NY: Harrow and Heston.

Collins, B.S. (2004), 'Submission to the Royal Academy of Engineering on Complex Software Projects', London, January.

Corritore, C.L., Kracher, B. and Wiedenbeck, S. (2003), 'On-line Trust: Concepts, Evolving Themes, A Model', *International Journal of Human Computer Studies* 58(6): 737-758.

Courtney, R. (1977) 'Security Risk Analysis in Electronic Data Processing', *AFIPS Conference Proceedings*, New York: AFIPS Press.

Cremonini, L., Rathmell, A., and Wagner, C. (2003), 'Cyber Trust & Crime Prevention – Foresight Overview', Annotated Briefing prepared for Office of Science & Technology, UK, by RAND Europe, July.

d'Aspremont, C. and Gerard-Varet, L. (1979), 'Incentives and Incomplete

Information', *Journal of Public Economics*, 11: 25-45.
Douglas, M. (1966), *Purity and Danger: An Analysis of Concepts of Pollution and Taboo*, London: Routledge and Kegan Paul.
Douglas, M. (1992), *Risk and Blame: Essays in Cultural Theory*, London: Routledge.
Douglas, M., and Wildavsky, A. (1982), *Risk and Culture: An Essay on the Selection of Technical and Environmental Dangers*, Berkeley CA: University of California Press.
Durkheim, E. (1893/1984), *The Division of Labour in Society*, London: Palgrave Macmillan.
Dutton, W.H. (1999), *Society on the Line: Information Politics in the Digital Age*, Oxford/New York: Oxford University Press.
Dutton, W.H., Gillett, S.E., McKnight, L.W., and Peltu, M. (2003), 'Broadband Internet: The Power to Reconfigure Access'. OII Forum Discussion Paper No. 1, Oxford: Oxford Internet Institute, University of Oxford.
Earle, T., and Cvetkovich, G. (1995), *Social Trust: Toward a Cosmopolitan Society*, Westport CT: Praeger.
Egger, F.N. (2001), 'Affective Design of E-Commerce User Interfaces: How to Maximise Perceived Trustworthiness', in M. Helander, H.M. Khalid, and Tham, (eds) *Proceedings of CAHD: Conference on Affective Human Factors Design,* Singapore, June, pp. 317-324.
Eisenstadt, S. and Roniger, L. (1984), *Patrons, Clients and Friends*, Cambridge: Cambridge University Press.
Ekblom, P. (2004a in press), 'How to Police the Future: Scanning for Scientific and Technological Innovations which Generate Potential Threats and Opportunities in Crime, Policing and Crime Reduction', in M. Smith and N. Tiley (eds) *Crime Science: Prevention and Detection*, Cullompton, Devon: Willan.
Ekblom, P. (2004b) 'The Conjunction of Criminal Opportunity', developed between 2001 and 2004, http://www.crimereduction.gov.uk/learningzone/cco.htm accessed 17 Apr. 04.
Ekblom, P. (2003), 'The Conjunction of Criminal Opportunity: A Framework for Crime Reduction', Home Office Crime and Policing Group, Research Development and Statistics Directorate, London, 3 March, http://www.crimereduction.gov.uk/learningzone/cco.htm#1 accessed 17 Apr. 04.
Ekblom, P. (2002), 'Future Imperfect: Preparing for the Crimes to Come', *Criminal Justice Matters* 46(Winter): 38-40.
Ekblom, P. (1999), 'Can We Make Crime Prevention Adaptive by Learning from Other Evolutionary Struggles?' *Studies on Crime Prevention* 8(1):

27-51.
Ekblom, P. (1997), 'Gearing Up Against Crime: A Dynamic Framework to Help Designers Keep Up with the Adaptive Criminal in a Changing World, *International Journal of Risk, Security and Crime Prevention* 2(4): 249-65.
Ekblom, P. (1996), 'Towards a Discipline of Crime Prevention: A Systematic Approach to its Nature, Range and Concepts', in T. Bennett (ed.) *Preventing Crime and Disorder: Targeting Strategies and Responsibilities*, Cambridge: Institute of Criminology, pp. 47-9.
Ekblom, P. and Tilley, N. (2000), 'Going Equipped: Criminology, Situational Crime Prevention and the Resourceful Offender', *British Journal of Criminology* 40(3): 376-98.
Electronic Privacy Information Centre (1997), 'Surfer Beware: Personal Privacy and the Internet', June, http://www.epic.org/reports/surfer-beware.html accessed 17 Apr. 04.
European Commission (1999), *The Telecoms Data Protection Directive (97/66/EC) and the Telecommunications (Data Protection and Privacy) Regulations 1999 (SI 1999 No. 2093)*, http://www.dti.gov.uk/industries/ecommunications/directive_on_privacy_electronic_communications_200258ec.html#overview accessed 17 Apr. 04.
European Commission (2000), 'EU's Communication on Precautionary Principle', Brussels, 2 February, http://www.gdrc.org/u-gov/precaution-4.html accessed 17 Apr. 04.
European Commission (2002a), *The Directive on Privacy and Electronic Communications (2002/58/EC)*, http://www.dti.gov.uk/industries/ecommunications/directive_on_privacy_electronic_communications_200258ec.html accessed 17 Apr. 04.
European Commission (2002b), *The Electronic Commerce Directive (00/31/EC) & the Electronic Commerce (EC Directive) Regulations 2002 (SI 2002 No. 2013 UK)*, http://www.dti.gov.uk/industries/ecommunications/electronic_commerce_directive_0031ec.html accessed 17 Apr. 04.
European Commission (2003), *Third European Report on Science & Technology Indicators 2003 – Towards a Knowledge-based Economy*, Brussels, EC, http://www.cordis.lu/indicators/third_report.htm accessed 17 Apr. 04.
European Commission, IST Advisory Group (2002), 'IST Advisory Group – Trust, Dependability, Security and Privacy for IST in FP6', June, http://www.mcst.org.mt/public/01_Sixth%20Framework%20Programme/02_Information%20Society%20Technologies/Reports%20and%20Publications/istag_kk4402464encfull.pdf accessed 17 Apr. 04.

European Union Council (1999), ‘Council Resolution of 28 June 1999 on Community Consumer Policy 1999 to 2001’ (1999/C 206/01), *Official Journal of the European Communities* 21 July.

Felson, M. (1987), *Crime and Everyday Life*, Thousand Oaks CA: Pine Forge Press.

Fitzgerald, J. (1978), ‘EDP Risk Analysis for Contingency Planning’, *EDP Audit Control and Security Newsletter* 6(Aug.): 1-8.

Fogg, B.J. (2003), *Persuasive Technology. Using Computers to Change What We Think and Do*, San Francisco CA: Morgan Kaufmann.

Freudenberg, W.R. (1993), ‘Risk and Recreancy: Weber, the Division of Labor, and the Rationality of Risk Perceptions’, *Social Forces* 71(4): 909-932.

Frith, U. and Blakemore, S.-J. (2003), ‘Social Cognition’, *Foresight Cognitive Systems Project, Research Review*, http://www.foresight.gov.uk/ accessed 17 Apr. 04.

Froomkin, A.M. (1996), ‘The Essential Role of Trusted Third Parties in Electronic Commerce’, *Oregon Law Review* 75(Spring): 49.

Fukuyama, F. (1995), *Trust: The Social Virtues and the Creation of Prosperity*, New York: Free Press.

Gibbons, R. (1992), *Game Theory for Applied Economics*, Princeton NJ: Princeton University Press.

Gibson, W. (1984), *Neuromancer*, New York: Ace Books.

Giddens, A. (1991), *Modernity and Self-identity: Self and Society in the Late Modern Age*, Stanford CA: Stanford University Press.

Glaeser, E., Laibson, D. Scheinkman, J. and Soutter, C.L. (2000), ‘Measuring Trust’, *Quarterly Journal of Economics* 115(3): 811-846.

Goodman, S.E., Hassebroek, P.B., King, D. and Ozment, A. (2002) ‘International Coordination to Increase the Security of Critical Network Infrastructures’, ITU Workshop on Creating Trust in Critical Network Infrastructures’, Seoul, 20-22 May, CNI/04, http://www.itu.int/osg/spu/ni/security/docs/cni.04.doc accessed 17 Apr. 04.

Foucault, M. (1970), *The Order of Things: An Archaeology of the Human Science*, translation of *Les Mots et les Choses* (1966), New York: Pantheon Books.

Freeman, C. and Louça, F. (2001), *As Time Goes By: From the Industrial Revolutions to the Information Revolution*, Oxford: Oxford University Press.

Gotoh, R. (2003), ‘For Building e-Confidence: A Proposal for the Trusted Third Party Model’, *National Institute of Informatics (NII) Journal*, 6, http://www.nii.ac.jp/hrd/HTML/Journal/pdf/06/06-06.pdf accessed 17 Apr. 04.

Gray, J. (1995), *Enlightenment's Wake: Politics and Culture at the Close of the Modern Age*, London: Routledge.

Guerra, G., Zizzo, D., Dutton, W. and Peltu, M. (2003), 'Economics of Trust in the Information Economy: Issues of Identity, Privacy and Security', Oxford Internet Institute, University of Oxford Working Paper, April, http://www.oii.ox.ac.uk/resources/publications/OIIRR_ElectronicTrust_0403.pdf accessed 17 Apr. 04.

Guerra, G. and D. Zizzo (2002), 'Trust Responsiveness and Beliefs', Oxford University Department of Economics Working Paper 99, http://www.econ.ox.ac.uk/Research/WP/PaperDetails.asp?PaperID=131 accessed 17 Apr. 04.

Hardin, R. (1991), 'Trusting Persons, Trusting Institutions', in R. Zeckhauser (ed.) *Strategy and Choice*, Cambridge MA: MIT Press, pp. 185-209.

Hawkins, R.W., Mansell, R. and Steinmueller, W.E. (1999), 'Toward Digital Intermediation in the Information Society', *Journal of Economic Issues* XXXIII(2): 383-391.

Himanen, P. (2001), *The Hacker Ethic*, New York: Random House.

Hofstede, G. (1991), *Cultures and Organisation – Software of the Mind – Intercultural Cooperation and Its Importance for Survival*, New York: McGraw-Hill.

Hollis, M. (1998), *Trust Within Reason*, Cambridge: Cambridge University Press.

Horlick-Jones, T., Sime, J. and Pidgeon, N. (2003), 'The Social Dynamics of Environmental Risk Perception: Implications for Risk Communication Research and Practice', in N. Pidgeon, R.E. Kasperson and P. Slovic (eds) *The Social Amplification of Risk*, Cambridge: Cambridge University Press, pp. 262-85.

The Independent (2003), 'Gone Phishing', *The Independent*, 17 December.

Institute for Prospective Technological Studies (2003), 'Security and Privacy for the Citizen in the Post-September 11 Digital Age: A Prospective Overview', Technical Report Series, IPTS, Seville, July.

Johansen, R. (1988), *Groupware: Computer Support for Business Teams*, New York: Free Press.

Kasperson, J.X., Kasperson, R.E., Pidgeon, N. and Slovic, P. (2003), 'The Social Amplification of Risk: Assessing Fifteen Years of Research and Theory', in N. Pidgeon, R. E. Kasperson and P. Slovic (eds) *The Social Amplification of Risk*, Cambridge: Cambridge University Press, pp. 13-46.

Katz, M. and Shapiro, C. (1994), 'Systems Competition and Networks Effects', *Journal of Economic Perspectives* 8(Spring): 93–115.

Kleinig, J. (2000), 'The Burdens of Situational Crime Prevention', in A. von Hirsh, D. Garland and A. Wakefield (eds) *Ethical and Social Perspectives on Situational Crime Prevention*, London: Hart, 37-58.

Knack, S. and Keefer, P. (1997), ‘Does Social Capital have an Economic Payoff?’, *Quarterly Journal of Economics* 112(4): 1251-1288.
Latham, R. (ed) (2003) *From Bombs and Bandwidth: The Emerging Relationship Between Information Technology and Society*, New York: New Press.
Lessig, L. (1999), *Code and Other Laws of Cyberspace*, New York: Basic Books.
Levi, M. (2001), “‘Between the Risk and the Reality Falls the Shadow”: Evidence and Urban Legends in Computer Fraud’, in D. S. Wall (ed.) *Crime and the Internet*, London: Routledge, pp. 44-58.
Liberatore, A. (2000), ‘From Science/Policy Interface to Science/Policy/Society Dialogue’, paper for the conference ‘The Contribution of Social Sciences to Knowledge and Decision Making’, Bruges, 26-28 June.
Lohse, G.L., Bellman, S., and Johnston, E.J. (2000), ‘Consumer Buying Behavior on the Internet: Findings from Panel Data’, *Journal of Interactive Marketing* 14(1): 15- 29.
Luhmann, N. (1979), *Trust and Power*, Chichester: John Wiley & Sons.
Lunn, R. J., and Suman, M. W. (2002), ‘Experience and Trust in Online Shopping’, in B. Wellman and C. Haythornthwaite (eds) *The Internet in Everyday Life*, Oxford: Blackwell, pp. 549-77.
MacKenzie, D. (1999), ‘The Certainty Trough’, in W. H. Dutton (ed.) *Society on the Line*, Oxford: Oxford University Press, pp. 43-6.
Mahbubani, K. (2002), *Can Asians Think? Understanding the Divide Between East and West*, South Royalton VT: Steerforth Press.
Manasian, D. (2003), ‘Caught in the Net’, *The Economist*, 23 January.
Mansell, R., Schenk. I. and Steinmueller, W.E. (2000), ‘Net Compatible: The Economic and Social Dynamics of E-commerce’, *Communications & Strategies* 38(2): 241-276.
Mansell, R. and Steinmueller, W.E. (2000), *Mobilizing the Information Society: Strategies for Growth and Opportunity*, Oxford, Oxford University Press.
Matsumoto, T. (2002), ‘Importance of Open Discussion on Adversarial Analyses for Mobile Security Technologies – A Case Study for User Identification’, Yokohama National University, presentation to ITU-T Workshop on Security, Seoul, 14 May, slides, http://www.itu.int/itudoc/itu-t/workshop/security/present/s5p4.html accessed 17 Apr. 04.
McClue, A. (2003), ‘Nationwide Ditches Iris and Fingerprint Biometrics’, 23 September, http://www.silicon.com/software/security/0,39024655,10006129,00.htm accessed 17 Apr. 04.

McKnight, D.H. and Chervany, N.L. (2000), 'What is Trust? A Conceptual Analysis and an Interdisciplinary Model', in *Proceedings of the American Conference on Information Systems 2000*, pp. 827-833.

Mill, J.S. (1869), *On Liberty*, London: Longman, Roberts and Green (republished New York: Bartleby.com, http://www.bartleby.com/130/ accessed 17 Apr. 04.

Miller, P. (2003), 'The See-through Society: Openness and the Future of the Internet', DEMOS, London, Note prepared for the Foresight Cyber Trust and Crime Prevention Project, London.

Mitchell, W.J. (1996), *City of Bits: Space, Place and the Infobahn*, Cambridge MA: MIT Press.

Moreh, J. (1997), 'Digital Certificates and Certificate Authorities', Database Web Advisor, September.

MORI (2003), Privacy and Data-Sharing: Survey of Public Awareness and Perceptions, Research Study Conducted for Department for Constitutional Affairs, Market and Opinion Research International, London.

Morris, R., Hitch, G., Graham, K., and Bussey, T. (2003), 'Learning and Memory', Foresight Cognitive Systems Project, Research Review, http://www.foresight.gov.uk/ accessed 17 Apr. 04.

Murdock, G., Petts, J. and Horlick-Jones, T. (2003), 'After Amplification: Rethinking the Role of the Media in Risk Communication', in N. Pidgeon, R.E. Kasperson and P. Slovic (eds) *The Social Amplification of Risk*, Cambridge: Cambridge University Press, pp. 156-78.

National Hi-Tech Crime Unit (2004) 'Hi-Tech Crime: The Impact on UK Business, Report by the National Hi-Tech Crime Unit', London, http://www.nhtcu.org/ accessed 17 Apr. 04.

Naughton, J. (1999), *A Brief History of the Future*, London: Phoenix.

OECD (2000), 'Building Trust in the Online Environment: Business to Consumer Dispute Resolution', Orientation Documents at the Joint Conference of the OECD, HCOPIL, ICC, Hague, The Netherlands, December 11-12, p.5.

OECD (2002), 'Guidelines for the Security of Information Systems and Networks: Towards a Culture of Security', OECD, Paris.

O'Hara, K. (2004), *Trust: From Socrates to Spin*, Cambridge: Icon Books.

O'Hara, K., Hall, W., van Rijsbergen, K. and Shadbolt, N. (2003), 'Memory, Reasoning and Learning', Foresight Cognitive Systems Project, Research Review, http://www.foresight.gov.uk/ accessed 17 Apr. 04.

O'Neill, O. (2000), *Bounds of Justice*, Cambridge: Cambridge University Press.

O'Neill, O. (2002), *Autonomy and Trust in Bioethics*, Cambridge: Cambridge University Press.

Osborne, K. (1998), 'Auditing the IT Security Function', *Computers &*

*Security*, 17(1): 34-41
O'Siochru, S. and Constanza-Chock, S. (2003), 'Global Governance of Information and Communication Technologies: Implications for Transnational Civil Society Networking', prepared for the Social Science Research Council, New York, http://www.ssrc.org/programs/itic/governance_report/index.page accessed 17 Apr. 04.
Palmer, G. (2000), 'The New Spectacle of Crime', in D. Thomas and B.D. Loader (eds) *Cybercrime Law Enforcement, Security And Surveillance In The Information Age*, London: Routledge, pp. 85-102.
Parker, D. (1997), 'The Strategic Values of Information Security in Business', *Computers & Security* 16(7): 572-582.
Perez, C. (2002), *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages*, Cheltenham: Edward Elgar.
Petts, J. Horlick-Jones, T. and Murdock, G. (2001), 'Social Amplification of Risk: The Media and the Public, Health and Safety Executive Contract Research Report 329/2001. Sudbury: HSE Books.
Pidgeon, N., Kasperson, R.E. and Slovic, P. (eds) (2003), *The Social Amplification of Risk*, Cambridge: Cambridge University Press.
Pinch, T.J. (1992), 'Opening Black Boxes: Science, Technology and Society', *Social Studies of Science* 22(3): 487-510.
PIU (Performance and Innovation Unit) (2002), 'Privacy and Data Sharing', Performance and Innovation Unit, Cabinet Office, London.
Pollitt, M. (2001), 'The Economics of Trust, Norms and Networks', Judge Institute of Management Working Paper, Cambridge University, http://www.econ.cam.ac.uk/electricity/people/pollitt/economicstrust.pdf accessed 17 Apr. 04.
Poortinga, W. and Pidgeon, N. (2003), 'Public Perceptions of Risk, Science and Governance: Main Findings of a British Survey of Five Risk Cases', Norwich: Centre for Environmental Risk, University of East Anglia.
Putnam, R.D. (2000), *Bowling Alone: The Collapse and Revival of American Community*, New York: Simon & Schuster.
Putnam, R.D. (1993), *Making Democracy Work: Civic Traditions in Modern Italy*, Princeton NJ: Princeton University Press.
Raab, C.D. (1995), 'Connecting Orwell to Athens? Information Superhighways and the Privacy Debate', in W. van de Donk, I. Snellen and P. Tops (eds) *Orwell in Athens: A Perspective on Informatization and Democracy*, Amsterdam: IOS Press, pp. 195-211.
Raab, C.D. (1998), 'Electronic Confidence: Trust, Information and Public Administration' in I. Snellen and W. van de Donk (eds) *Public Administration in an Information Age: A Handbook*, Amsterdam: IOS Press, pp. 113-33.

Raab, C.D. (1999), 'From Balancing to Steering: New Directions for Data Protection', In C. Bennett and R. Grant (eds) *Visions of Privacy: Policy Choices for the Digital Age*, Toronto: University of Toronto Press, pp. 68-93.

RAND Europe (2003a), 'Handbook of Legislative Procedures of Computer and Network Misuse in EU Countries for Assisting Computer Security Incident Response Teams (CSIRTs)', http://www.iaac.org.uk/csirt/csirtWS-flyer.pdf accessed 17 Apr. 04.

RAND Europe (2003b), 'Benchmarking Security and Trust in Europe and the US', Statistical Indicators Benchmarking the Information Society (SIBIS), Report by L. Cremonini and L. Valeri, IST-2000-26276, EC IST Programme, Santa Monica CA, http://www.rand.org/publications/MR/MR1736/MR1736.pdf accessed 17 Apr. 04.

Ravetz, J.R. (1987), 'Usable Knowledge, Usable Ignorance', *Knowledge: Creation, Diffusion, Utilization* 9(1): 87-116.

Rawls, J. (1972), *A Theory of Justice*, Oxford: Oxford University Press.

Rayner, S. (1992), 'Cultural Theory and Risk Analysis', in S. Krimsky and D. Golding (eds) *Social Theories of Risk*, Westport CT: Praeger, pp. 83-114.

Regan, P.M. (1995), *Legislating Privacy: Technology, Social Values and Public Policy*, Chapel Hill NC: University of North Carolina Press.

Regan, P.M. (2002), 'Privacy as a Common Good in the Digital World', *Information, Communication & Society* 5(3): 382-405.

Rice, R. (1984), 'Mediated Group Communication', in R. Rice and Associates (eds) *The New Media: Communication, Research, and Technology*, Beverly Hills, CA: Sage Publications, pp. 129-54.

Riegelsberger, J., Sasse, M.A. and McCarthy, J. (2003), 'The Researcher's Dilemma: Evaluating Trust in Computer-Mediated Communication', *International Journal of Human Computer Studies* 58(6): 759-781.

Riegelsperger, J. and Sasse, M.A. (2001), 'Trustbuilders and Trustbusters: The Role of Trust Cues in Interfaces to E-commerce Applications', in B. Schmid, K. Stanoevska-Slabeva, and V. Tschammer (eds) *Towards the E-Society. Proceedings of I3E 2001, Zurich, Switzerland, October*, Amsterdam: Kluwer, Norwell, pp. 17-30.

Rogerson, M. and Pease, K. (2003), 'Privacy, Identity and Crime Prevention', Note prepared for the Foresight Cyber Trust and Crime Prevention Project, University of Huddersfield.

Rosa, E. (2003), 'The Logical Structure of the Social Amplification of Risk Framework (SARF): Metatheoretical Foundations and Policy Implications', in N. Pidgeon, R.E. Kasperson and P. Slovic (eds) *The Social Amplification of Risk*, Cambridge: Cambridge University Press, pp. 47-79.

Rose, N. (1999), *Governing the Soul*, London: Free Association Books.

Royal Academy of Engineering and British Computer Society (2004), 'The Challenges of Complex IT Projects', Report of a Working Group from The Royal Academy of Engineering and The British Computer Society, London.

Royal Society for the Prevention of Accidents (1992), *Risk: Analysis, Perception and Management*, London: ROSPA.

Sasse, M.A., Brostoff, S. and Weirich, D. (2001), 'Transforming the "Weakest Link": A Human-computer Interaction Approach to Usable and Effective Security', *BT Technology Journal* 19(3): 122-131.

Sharpe, B. (2003), 'Foresight Cognitive Systems Project – Applications and Impact', DTI Foresight Report for the Cognitive Systems Project, The Appliance Studio Ltd, September, http://www.foresight.gov.uk/cognitive.html accessed 17 Apr. 04.

Sharpe, B. and Zaba, S. (2004), 'CTCP Technology: Forward Look', The Appliance Studio Ltd, report prepared for the Foresight Cyber Trust and Crime Prevention Project, London.

Schneier, B. (2003), *Beyond Fear: Thinking Sensibly about Security in an Uncertain World*, New York: Copernicus Books.

Schneier, B. (2000), *Secrets and Lies: Digital Security in a Networked World*, Chichester: John Wiley & Sons.

Schoeman, F. (1992), *Privacy and Social Freedom*, Cambridge: Cambridge University Press.

Shavell, S. (1987), *Economic Analysis of Accident Law*, Cambridge MA: Harvard University Press.

Short, J., Williams, E., and Christie, B. (1976), *The Social Psychology of Telecommunications*, London: John Wiley & Sons.

Siegrist, M., Cvetkovich, G., and Roth, C. (2000), 'Salient Value Similarity, Social Trust, and Risk/Benefit Perception', *Risk Analysis* 20(3): 353-362.

Silverstone, R. (2003), 'Media and Technology in the Everyday Life of European Societies', Final Deliverable, The European Media and Technology in Everyday Life Network, 2000-2003, http://www.lse.ac.uk/collections/EMTEL/main1.html accessed 17 Apr. 04.

Skibell, R. (2002), 'The Myth of the Computer Hacker', *Information, Communication & Society* 5(3): 336-356.

Slovic, P. (1993), 'Perceived Risk, Trust, and Democracy', *Risk Analysis* 13(6): 675-682.

Smith, B. and T. Keehan (1997), 'Digital Signatures: The State of the Art and the Law', *Banking Law Journal* 114: 506.

Sobel, J. (2002), 'Can We Trust Social Capital?', *Journal of Economic Literature* 40(2): 139-54.

Stewart, B. (1996), ‘Privacy Impact Assessments’, *Privacy Law & Policy Reporter*, *Vol. 3-4*, http://www.austlii.edu.au/journals/PLPR/1996/39.html accessed 17 Apr. 04

Surman, M. and Reilly, K. (2003), ‘Appropriating the Internet for Social Change: Towards the Strategic Use of Networked Technologies by Transnational Civil Society Organizations’, prepared for the Social Science Research Council, New York, http://www.ssrc.org/programs/itic/civ_soc_report/index.page accessed 17 Apr. 04.

Theil, C. (2001), ‘Voraussetzungen für den Ersatz der PIN bei Geldausgabeautomaten: Bankfachliche Anforderungen, Presentation at BIOTRUST Workshop, 5 June, University of Giessen-Friedberg. Slides, http://biotrust.de/ws050601/SIZ.pdf accessed 17 Apr. 04.

Thomas, D. and Loader, B.D. (eds) (2000), *Cybercrime: Law Enforcement, Security and Surveillance in the Information Age*, London: Routledge.

Tyrrell, P. (2004), ‘Realities of a Virtual Economy’ *FT.com*, 1 January.

United Kingdom Government (1988), ‘Data Protection Act 1988’, http://www.hmso.gov.uk/acts/acts1998/19980029.htm accessed 17 Apr. 04.

United Kingdom Government (1990), ‘Computer Misuse Act 1990’, http://www.hmso.gov.uk/acts/acts1990/Ukpga_19900018_en_1.htm accessed 17 Apr 04.

United Kingdom Government (1998), ‘The Human Rights Act 1998’, http://www.hmso.gov.uk/acts/acts1998/19980042.htm accessed 17 Apr. 04.

United Kingdom Government (2000a), ‘The Telecommunications (Lawful Business Practice) (Interception of Communications) Regulations 2000’, http://www.hmso.gov.uk/si/si2000/20002699.htm accessed 17 Apr. 04.

United Kingdom Government (2000b), ‘Electronic Communications Act 2000’, Chapter c.7, http://www.uk-legislation.hmso.gov.uk/acts/acts2000/20000007.htm accessed 17 Apr 04.

United Kingdom Government (2000c), ‘Regulation of Investigatory Powers Act 2000’, http://www.hmso.gov.uk/acts/acts2000/20000023.htm accessed 17 Apr 04.

United Kingdom Government (2003), ‘Statutory Instrument 2003 No. 2426, The Privacy and Electronic Communications (EC Directive) Regulations 2003’, http://www.hmso.gov.uk/si/si2003/20032426.htm accessed 17 Apr. 04.

Uslaner, E.M. (2002), *The Moral Foundations of Trust*, Cambridge:

Cambridge University Press.
Varian, H. (2002), ‘System Reliability and Free Riding’, Economics and Information Security Workshop, Berkeley, CA, http://www.sims.berkeley.edu/resources/affiliates/workshops/econsecurity/econws/49.pdf accessed 17 Apr 04.
von Hirsch (2000), ‘The Ethics of Public Television Surveillance,’ in A. von Hirsch, D. Garland and A. Wakefield (eds) *Ethical and Social Perspectives on Situational Crime Prevention*, London: Hart, pp. 59-76.
von Neuman, J. and Morgenstern, O. (1944), *Theory of Games and Economic Behavior*, Princeton NJ: Princeton University Press.
von Solms, B. (2001), ‘Corporate Governance and Information Security’, *Computers & Security*, 20(3): 215-218.
Wall, D.S. (ed) (2001), *Crime and the Internet*, London: Routledge.
Wallace, P. (2001), *The Psychology of the Internet*, Cambridge: Cambridge University Press.
Wamala, F. (2002), ‘Comparing Public Key Infrastructure Institutionalisation in Two Global Organisations’, The Fuducia Project, Department of Information Systems, London School of Economics and Political Science.
Warren, S. and Brandeis, L. (1890), ‘The Right to Privacy’, *Harvard Law Review* 4(5): 193-220.
Welsh, B.C. and Farrington, D.P. (2002), ‘Crime Prevention Effects of Closed Circuit Television: A Systematic Review’, Home Office Research Study 252, London.
Westin, A. (1967), *Privacy and Freedom*, New York: Athenaeum.
Wiedemann, P.M., Clauberg, M. and Schutz, H. (2003), ‘Understanding Amplification of Complex Risk Issues: The Risk Story Model Applied to the EMF Case’, in N. Pidgeon, R.E. Kasperson and P. Slovic (eds) *The Social Amplification of Risk*, Cambridge: Cambridge University Press, pp. 286-301.
Williamson, O.E. (2000), ‘The New Institutional Economics: Taking Stock, Looking Ahead’, *Journal of Economic Literature* 38(3): 595-613.
Williamson, O.E. (1975), Markets and Hierarchies: Analysis and Antitrust Implications, New York, Free Press.
Wood, C. (1995), ‘Writing InfoSec Policies’, *Computers & Security* 14(8): 667-674.
Woodward Jr., J. D., Orians, N. M. and Higgins, P. T. (2002), *Biometrics*, New York: McGraw-Hill Osborne Media.
Zurko, M.E. and Simon, D. (1996), ‘User-Centered Security’, *Proceedings of the New Security Paradigms Workshop*, New York: ACM Press, 1997.
6, Perri (1998), *The Future of Privacy, Volume 1: Private Life and Public Policy*, London: DEMOS.