

1 Introduction

1.1 Scope of the problem

In today's information society, the commercialisation of creative works and the industries associated with this field have assumed a significant role with regard to the economy and employment [Wirt01,14-17]. It is estimated that currently 5% to 7% of the Gross Domestic Product is generated in branches of the economy concerned with the creation or commercialisation of copyrighted products [Krög02,14]. Such industries are currently threatened by extensive product piracy. Representative bodies of the entertainment industry claim that the negative impacts on these industries are significant. For example, the International Federation of the Phonographic Industry (IFPI) estimates in their *Commercial Piracy Report 2004* that commercial piracy of physical formats accounted for an estimated US\$4.5 billion in 2003 in terms of illegal sales worldwide [IFPI04]. The Motion Picture Association of America (MPAA) estimates that the US motion picture industry alone loses \$3 billion in revenues yearly [MPAA04]. Neither of these statistics includes losses due to Internet piracy, which are assumed to be substantial.

However, the scope of losses claimed by the media industries should be accepted with caution. A careful study of the assumptions upon which the calculations of losses are based suggests that the figures have been obtained simply by multiplying the estimated number of pirated media products by the retail price. Thus, these theoretical calculations are based on the assumption that in a world without piracy, the present consumers of pirated products would instead purchase legitimate content. However, without price reductions, it is unlikely that all illegal users would purchase the legitimate products, in the event that piracy was prevented by whatever means. It can therefore be seen that the methodology employed in some studies of illegal commercial copying leads to exaggerated estimates of losses in revenue [CSTB00,188-190].

Furthermore, the point should be made that not all media segments are equally affected by piracy. This is because not all media segments are dependent on the generation of direct revenues. Media companies can also derive indirect revenue from advertising, which is based on the generation of attention [Sche02,38-45]. As Figure 1.1/1 illustrates, the ratio between direct and indirect revenues differs according to the media segment. Whereas a book publishing company generates almost its entire turnover by means

of direct revenues, a free TV broadcaster usually derives most of its revenue from advertisements and related sources [Wirt01,19].

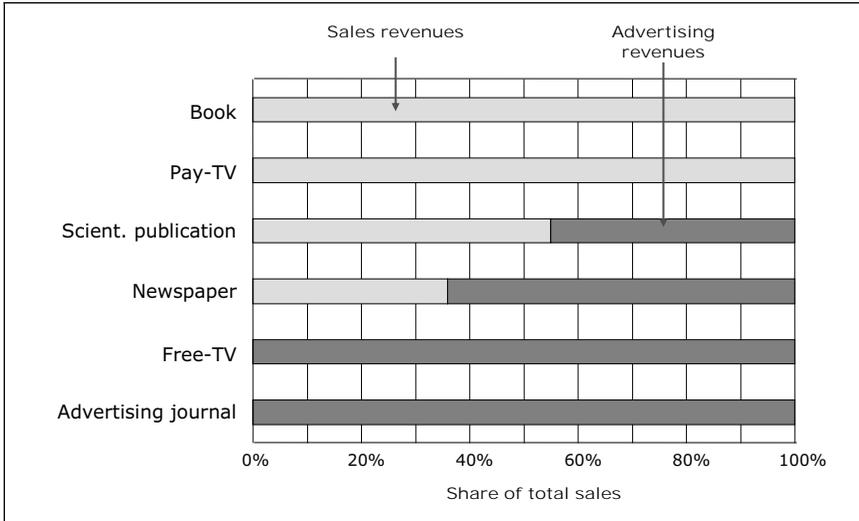


Figure 1.1/1: Proportion of direct revenue in various media segments [Sch02,23]

Despite the above-mentioned methodological shortcomings of some of the reported studies, and the fact that some media segments are protected from piracy through advertising-based revenue models, it can still be seen that the overall scope of content piracy is substantial. This is especially true in the case of the music segment, where worldwide turnover declined by about 10.9% in the first half of 2003 [IFPI03]. This significant decrease in revenue cannot be explained in terms of ageing demographics, the excess revenues generated during the vinyl-to-CD conversion cycle and greater competition for the disposable income of young consumers, but rather is to a significant extent attributable to copyright infringements.

As the downward trend continues, extensive segments of the cultural industries are threatened - as a logical consequence - with a loss of their means of existence. This tendency also has negative implications for society as a whole, since the provision of information, the motor of societal development, is endangered. The relevance from a micro- and macroeconomic point of view is obvious, and the immense short- and long-term implications for media companies and legislators warrant investigation of this problem. The aim of this dissertation is therefore to analyse how the

media industry and public policy should address the proliferation of content piracy.

The problems and objectives have been broadly outlined in this introductory section. They will be refined in the following sections, which will look beyond the symptoms to analyse the structural change factors that have led to the current situation, so as to suggest economically sound techno-legal remedies to help media companies resolve these issues.

1.2 Refinement of problem structures and objectives

In a situation with extensive Intellectual Property (IP) piracy, where current legislation fails to provide the necessary security, media companies need to develop self-help mechanisms, so as to ensure their means of existence [Dam99]. The content industry is determined to address this critical situation by seeking various means of preventing the uncontrolled redistribution of content, in order to safeguard sustained sources of direct revenue. Three major strategies for protection against the present piracy challenge can be identified: technical, legal and structural strategies [CSTB00,184]. These are illustrated in Figure 1.2/1 in conjunction with concrete actions.

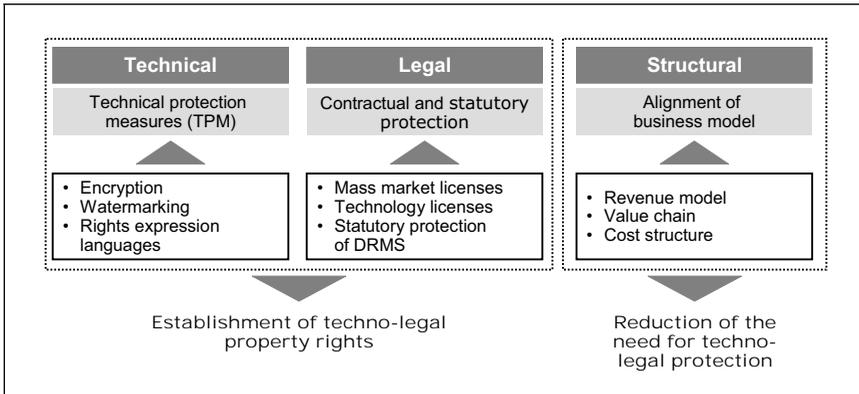


Figure 1.2/1: Copyright protection strategies in the digital context

Technical strategies aim to protect the economic interests of media companies through the deployment of *Technical Protection Measures (TPMs)* based on key technologies such as encryption, watermarking and rights expression languages. In this context, Charles Clark has stated that "The answer to the machine is in the machine" [Clar96]; in other words, the survival of the media industries presupposes the development of suitable technical

infrastructure. Technical strategies are effective only when accompanied by contract-based legal strategies (e.g. mass market licenses or technology licenses) and by an appropriate legal framework that supports the use of DRMS solutions by ensuring the protection of technical measures [Comm02,8]. In fact, the technological and legal approaches provide mutual support for one another, thereby constituting a protective unity. Technology prevents infringements, while legal measures provide deterrents regarding circumvention of the technology. Finally, structural strategies may be used to align the business model with respect to a revenue model, value chain positioning and cost structures [Wirt01,49-56]. The selection of an appropriate business model may significantly reduce the need for techno-legal protection [CSTB00,15]. For example, the move from the direct sale of content to advertising-based models could entirely solve the problem of piracy [Boyl00,2016].

Technical, legal and structural protection strategies must be used in combination to be effective. Each strategy is associated with a different level of costs, risks and potential rewards. They therefore have significant economic implications, which will be analysed in this work. Rump uses the metaphor of a three-legged stool, and points out that the stool can only stand upright when all three legs are the same length, i.e. the three strategies must be in harmony with one another [Rump03,5].

It is certainly true that all of these dimensions must be optimised. The principal task of realising content protection can be achieved only by means of techno-legal strategies, since these can effectively monitor and enforce usage at the end-user level. However, despite these benefits, media companies are hesitant to implement such measures. For instance, as early as 2001, a study on technical protection installations by Seybold identified an aversion toward implementing such techniques. Only seven percent of the publishing professionals polled were currently using technical protection measures, and only 18 percent stated that they intended to implement such forms of protection in the near future [Seyb01]. As a result, the market for technical solutions has been facing stagnation and even a downturn since 2001 [Rous02;GiLu02]. Even today, the content industry continues to be reluctant to embrace technical protection strategies, in spite of a wide range of existing solutions that are available on the market.

How can this apathy toward investing in promising technical tools be explained in the light of existing threats? Of course it is obvious that preliminary experience with this new class of technical system must

be gained within the context of pilot projects [ÜRHF04a]. However, in addition to understandable initial reservations, it can be discerned that decision-makers in media companies have the following three fundamental concerns.

First, it can be argued that the cost-benefit profile of Digital Rights Management System (DRMS) investments is as yet unclear. This is confirmed by the Seybold report, which indicates that almost 75 percent of the media professionals surveyed felt that these systems would not provide economic value to their companies [Seyb01]. Although they have the potential to protect the product and the revenue base, technical implementations also imply substantial costs. Depending on the desired level of security, media companies have to invest not only in the technical systems themselves, but also in the integration of these systems with the existing system environment, the training of staff and the alignment of business processes. Decision-makers are thus confronted with a trade-off between costs and benefits for varying degrees of content protection, resulting in a need to identify an appropriate level of technology-based protection.

Secondly, media managers may be alienated by the technical and legal complexity of the protection mechanisms. Technical protection measures, which are based on various integrated core technologies, are still in an embryonic phase and are not robust against attacks. Furthermore, media managers may prefer to wait until the initial competition among competing standards has led to the establishment of de facto technical standards. In addition, the legality of both technical protection measures and contract-based measures (e.g. mass market and technology licenses) is unclear in terms of existing codified law.

Thirdly, media companies are concerned about potential adverse reaction of the legislator toward the new technological options. In effect, TPMs give content providers the ability to enforce property rights beyond the limits of copyright law. This might enable media managers to exclude some usage forms which are legally protected (e.g. fair use), which could undermine the delicate balance between individual and collective rights that intellectual copyright law seeks to achieve. Moreover, TPMs give rise to consumer privacy concerns, since customer profiles can be used to record individual media consumption patterns [PiFi03,294-295]. These conflicts could result in the prohibition of certain protective features, which might make existing installations obsolete or necessitate additional investment in order to lower the technological protection level. Such legislative requirements could prove to be expensive, technologically difficult or

even impossible to meet [Bech02,375].

Based on these considerations, the problem structure can be refined, and the pending research issues can be made more concrete, as shown in Table 1.2/1.

Research #1	Issue	What is the architectural design of a DRMS? What core functions and underlying techniques are necessary in order to ensure content protection?
Research #2	Issue	What statutory framework and legal protection measures are necessary for the effective enforcement of technological property rights?
Research #3	Issue	What is the optimal level of content protection?
Research #4	Issue	Is the determination of the ideal protection level affected by public policy reaction?
Research #5	Issue	How can media companies design a DRMS with a specific level of content protection?

Table 1.2/1: Thesis research issues

These five research issues can be condensed into two core research objectives (see Figure 1.2/2). The first objective is to assist media managers in determining an optimal level of protection, taking into account the cost-benefit trade-offs of various protection strategies and the probable reaction of the legislator. The second objective is to provide pointers for the subsequent techno-legal implementation of the optimal level of protection. The economic statements made in both parts of the research are primarily *normative*; in other words, they are prescriptive and/or policy-oriented, incorporating value judgements concerning preferred actions (e.g. the choice of protection level) and concerning particular policy actions recommended in order to achieve a desirable goal. Research regarding the second objective will also be combined with a positive analysis (e.g. of the anatomy of technical protection systems), in order to determine a way of attaining the normative goals.

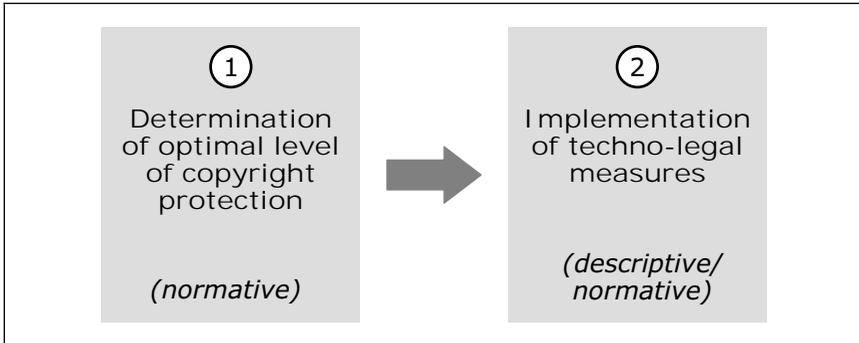


Figure 1.2/2: Thesis objectives

In light of the complexity of the subject and the ambitious targets that have been set, it can be seen that it is necessary to analyse the problems of content in the digital era, and to evaluate the most appropriate solutions from four principal perspectives: technology, economics, law and public policy. Each perspective implies a different concept of the problems and a different approach to analysing them. Additional complexity results from the fact that these perspectives are strongly interrelated. The relationship of the research issues to these perspectives will now be examined.

Research issues #1 and #5 are concerned with the technical perspective, which defines instrumental actions in order to reduce uncertainty in the cause-and-effect relationship involved in achieving a desired outcome [Roge83,12]. Technology includes both a hardware aspect (based on physical objects) and a software aspect (consisting of the information base used with the hardware). This analysis would focus on stipulating a threat model, setting security objectives, define core functions, specifying the architectural set-up and examining how various protection levels can be realised.

Analogously, research issues #2 and #5 have to be investigated using legal methods. For instance, an analysis is required as to whether the content protection measures conform to currently existing legislation. To this end, legal scholars examine and interpret codified law and recent case history. In general terms, an analysis of the existing legislative framework is highly relevant with regard to immaterial goods such as information products at all parts of the value chain, for all stakeholders.

Research issue #3 is of primary concern to the economist. Here the aim is to determine the optimal use of valuable resources (e.g. protection installations), using classical concepts as costs, benefits and economic efficiency, and methods such as decision analysis. An

economist would recommend protection measures only to the extent that they contribute to the economic goals of an organisation. Thus, in simple terms, the total net benefits of protection should exceed the cost of protection. In a more sophisticated approach, an investment in protection techniques should have a positive Net Present Value, so as to contribute to the creation of equity value.

Finally, research issue #4 takes into account the public policy perspective, which is concerned with the formulation of laws with respect to overall societal goals (e.g. promoting innovation or economic competitiveness). The focus here is not on currently existing law, but rather on what the law might or ought to say [Posn98,26-29]. The policy analyst employs multidisciplinary analyses, using methods from the fields of law, economics and other social sciences [Hadf99,54]. This approach evaluates various policy options, based upon predetermined efficiency criteria. As a result of such an analysis, a policy maker could decide to prohibit certain protective features, which would in turn influence the decisions of individual media companies.

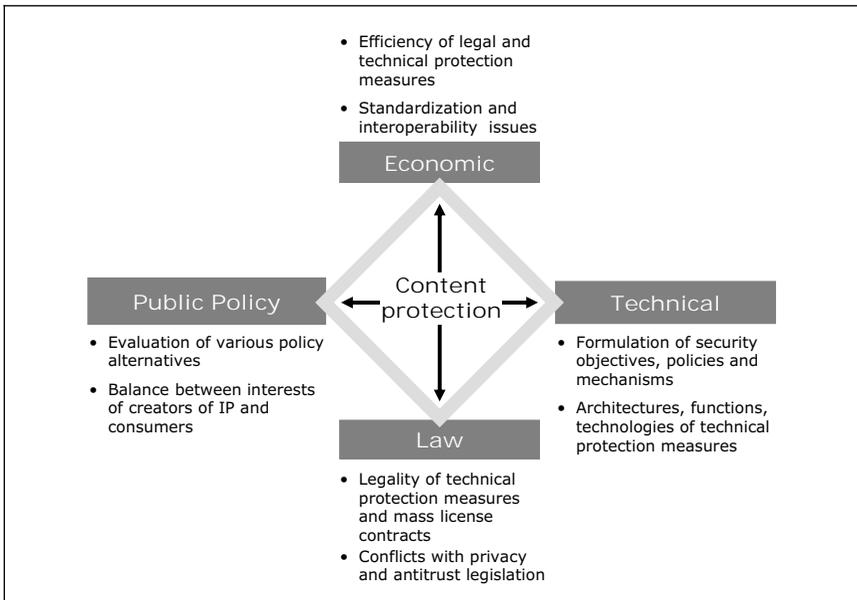


Figure 1.2/3: Multidisciplinary analysis of content protection

Solutions to these complex problems must incorporate concepts from the fields of economics, law, and technology [Laid01b,57], in order to meet the research objectives which have been set. Sample

questions from these four perspectives are illustrated in Figure 1.2/3. Thus, content protection mechanisms should be technologically feasible, should conform to the currently existing legal framework, should anticipate future legislative changes, and most importantly should be economically efficient. For example, a strong technical mechanism might seem promising in terms of ambitious security objectives, but could be prohibitively expensive, and might turn out to be illegal in terms of current or future legislation. Thus, this subject needs to be addressed using an interdisciplinary research approach [CSTB00,53]. Although analysing the research issues from a multiplicity of perspectives adds richness and potential to the thesis, it must be kept in mind that these various fields are associated with different mind-sets, vocabulary and methodologies, which can result in conflicting results and recommendations. However, given the complexity of the interrelated problems and the proposed remedies, considering a breadth of perspectives at the expense of depth can be expected to be more fruitful than an investigation confined solely to one dimension.

The preceding paragraphs have presented an attempt to refine the research objectives. In order to clarify the objectives further, it is also useful to indicate which objectives are not included in this dissertation.

First, it should be noted that the thesis focuses on techno-legal means of protection and touches only briefly on structural forms of protection such as business model alignment. Radical advocates of structural protection measures argue that media companies must eventually abandon revenue models based on the end user, or else specialise in the sale of non-copiable products and services or concentrate on other products and services for which the digital content is complementary [Buhs04,213]. Other alternative views advocate a transition to more progressive forms of digital business models [CSTB00,181-183]. Of the three protection strategies, structural protection approaches are perhaps the least well understood. Yet this factor may be critical, since it affects the need to enforce protection at all. Little is known about how digital business models could function and how they could be combined with technical and legal measures. In addition, customer acceptance of these new models is little understood. In the light of these uncertainties and the lack of scientific research, the thesis does not focus on this aspect.

Secondly, only the four perspectives mentioned above are considered, ignoring two other relevant dimensions that are of potential interest: psychology and sociology. Psychological and

sociological analyses contribute to an understanding of individual consumer behaviour, which is rooted in perceptions of equity and responsibility, pragmatism and other feelings toward transactions involving Intellectual Property (IP) [CSTB00,54]. This dimension could help to determine whether certain protection mechanisms would be perceived to be fair, in order to assess customer acceptance involving the majority of end users.

Thirdly, the thesis analyses public policy primarily from the point of view of IP legislation. In particular, copyright law is examined as the main body of law relevant to a DRMS. Although other legal aspects are also relevant, including those addressed by antitrust and privacy laws, they are not the main focus of attention.

Finally, it should be pointed out that the principal perspective considered is that of decision-makers in media companies who are involved in selecting and implementing economically sound protection measures. Thus, the focus is solely on providing support to media company decision-makers in the area of solution selection and implementation. The viewpoints of other institutional stakeholders are considered only in order to assess the normative implications for individual media companies. For example, the utility function of consumers, the production function of pirates and the probable reactions of legislators are considered as ancillary conditions and constraints in the overall perspective of the media industry.

1.3 Methodology

1.3.1 Normative model-based approach

In this dissertation, the refined problem structure is analysed with the aid of a normative model-based approach that encompasses the entire problem solution cycle from the identification, formulation and solution of the problem to the implementation of the solution in a concrete, real-world situation.

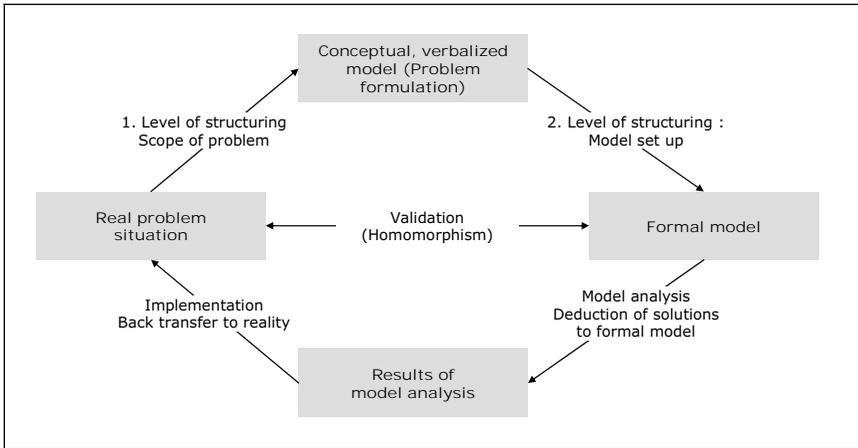


Figure 1.3/1: Overview of model-based approach [Pfoh77,27]

In general terms, a model can be understood as a representation of a fragment of reality [RoEi02,10], where the fragment of reality is the target system of the model. In the German management literature there is no generally accepted definition of the term "model" [Herr91,19]. According to the *representation-oriented definition*, the purpose of modelling is to create a representation of reality. Thus the role of the modeller is basically to describe the real system "objectively", by means of exact observation and measurement, before a formal system is developed. The modelling process in the representation-oriented paradigm is depicted in Figure 1.3/1. Here it can be seen that in the first step of structuralisation, the empirical original is transferred through gradual abstraction into a verbal model in which all the elements and structures of the problem are revealed and the target system is described. The most important step in the modelling processes is the transformation of the verbal model into a formal model. Ultimately, the problem represented by the model is solved through mathematical techniques, and the result is transferred directly back to reality. The quality of the model is measured in terms of the structural resemblance of the model to the original. A model which is structurally identical to reality is referred to as an "isomorphic" representation, i.e. there is an unequivocal transfer from reality to a formal system. If only some, but not all, structures of the original are represented, the model is referred to as a "homomorphic" (i.e. similar structure) representation. Models can be thus be regarded as portraits of reality. Whether the model is empirically "true" or "realistic", depends upon how homomorphic the representation is.

This *representation-oriented* notion of a model presupposes that reality is already pre-structured, and that the essential elements and relations of the empirical original can be perceived passively and can be extracted by the modeller simply by using trained perception skills. However, this approach is rejected by *constructivists* [Glas97,32]. According to constructivist epistemology, human knowledge of reality is not regarded as a representation of it, but rather as an act of active construction of reality. Thus the perception of a problem is already assumed to be an interpretation of it. This means that the act of construction cannot be reduced to the passive perception and representation of a problem [Watz97,94]. Modelling is assumed to be a creative act, which draws upon the experience and competence of the modeller. Without these characteristics, a useful model cannot be developed [Schm90,18].

A variety of normative models will be used for the three domains depicted in Figure 1.3/2. The economic problem will be scrutinised by means of a media asset value model, while a game-theoretical industrial organisation model will constitute the main focus of attention. In addition, a law and economics model will be used to assess the impact of various policy alternatives on overall social welfare. Finally, the technical objectives will be pursued by the construction of a normative reference model which will form the basis of the DRMS design model that reconciles the results of all the domains.

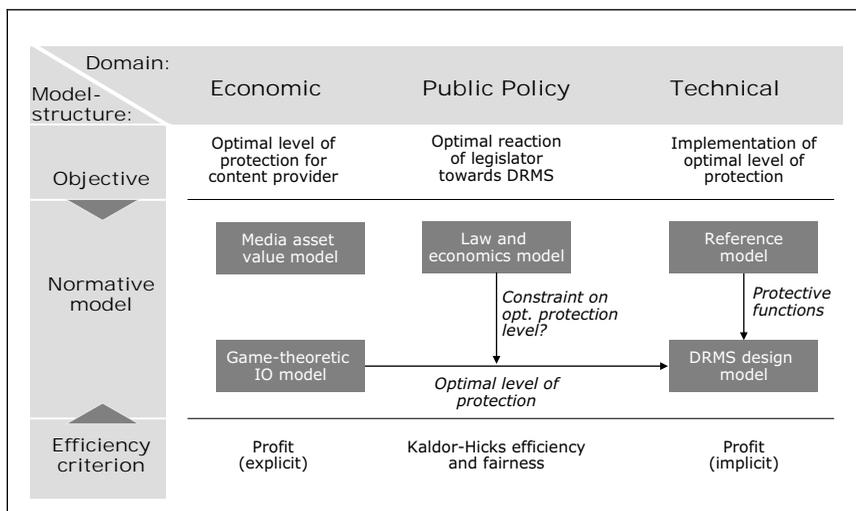


Figure 1.3/2: Overview of model-structure and domain

These models exhibit varying degrees of formalisation. Whereas the game-theoretical industrial organisation model uses a highly formalised mathematical approach, the law and economics model is based more on qualitative, verbal reasoning. The reference model has an intermediate level of formalisation, since it uses standardised modelling language to represent an idealised information model. All three models have a low level of structural resemblance (homomorphism) to the segment of reality being portrayed. This is due to the more abstract level of reasoning required by the research questions.

The models also differ with regard to their aims. The game-theoretical industrial organisation model and the law and economics model are optimisation models, where the criterion of efficiency is either profit or social welfare. In contrast, the reference model is a structural model representing the idealised scope of protection measures.

The media asset value model and the DRMS design model are based on the simple, well-known portfolio approach. Underlying the portfolio methodology is the notion that positioning an object within a portfolio matrix permits normative statements to be made concerning the object. For example, the media asset value model presented in section 4.1 stipulates that the characteristics of a given media product, from an internal company point of view and an external market point of view, can be unequivocally mapped on a matrix, and that the relative position of a media good within the consolidated portfolio indicates the optimal level of protection.

The following sections will focus on the principal methods underlying each domain: the game-theoretic industrial organisation model, law and economics methodology, and reference modelling.

1.3.2 Economic perspective – Game-theoretic industrial organisation model

Model formulation can involve varying levels of formalisation, ranging from qualitative-verbal to more mathematical. Based on the refined problem structure presented in Section 1.2, a game-theoretic Industrial Organisation (IO) approach [Shep97,19-23] will be employed. This approach studies how firms and markets are organised and how they interact [CaPe90,2]. The following discussion explains what IO is and shows why it is the most appropriate methodology for analysing the economic implications of protection measures.

Industrial organisation is often mistakenly assumed to be exclusively a research area in the field of microeconomics. However, it must be

clearly distinguished from analytical microeconomic theory, which is primarily concerned with strictly defined theoretical issues that are analysed by means of abstract mathematics [Reid89,1-2]. Microeconomists do not make reference to empirically plausible assumptions, and the implications of the theory have no required link to practical managerial and public policy decision-making. The following comments by Machlup reflect the abstract nature of microeconomics:

"The model of the firm is not ... designed to serve to explain and predict the behaviour of real firms: instead, it is designed to explain and predict changes in observed prices ... as effects of particular changes on conditions ... In this causal connection the firm is only a theoretical link, a mental construct helping to explain how one gets from the cause to the effect." [Mach67]

In contrast, the work of the IO researcher must be grounded in the reality of the business environment in which firms operate. An understanding of empirical reality is essential. The industrial economist is concerned with a normative framework in order to be able to appraise the functioning of the industry. Thus, IO models are intrinsically more concrete than microeconomic models. However, due to the subject area, IO models are often too abstract to be applied to a concrete business decision problem. This is the classical domain of Operations Research (OR), the study of mathematical methods that can be used to solve managerial decision problems, especially in functional areas such as production, finance and marketing [EIBL03,1-3].

This discussion shows that economic models can be designed with different levels of abstraction, to illuminate different perspectives of economic phenomena. Industrial organisation models have an intermediate level of abstraction and in this sense fall between Operations Research and classical analytical microeconomic models.

Industrial organisation research is undertaken using diverse theories including, for example, transaction-cost theory, the theory of contestable markets and information theory. A game-theoretic approach will be used here, since this provides valuable tools for analysing an imperfect market characterised by strategic interaction [FoTh92,13-14]. Game theory, sometimes referred to as "Interactive Decision Theory", is the study of mathematical models of conflict and co-operation between rational decision-makers (players). Von Neumann is regarded as the modern founder of game theory. In 1944, von Neumann and Morgenstern [vNMo44] presented the notion of a co-operative game with transferable

utility, discussing its coalitional form and von Neumann-Morgenstern stable sets. Following this seminal work, the most important ideas in the field of game theory were those expounded by Nash [Nash50] regarding non-co-operative, multi-person games. Selten [Selt65] later refined the Nash equilibrium with the concept of subgame perfect equilibria. Osborne and Rubinstein [OsRu94] provide a good introduction to game theory.

Stated so broadly, it would seem that most situations of interest to economists can be studied using game-theoretic tools. However, the applications are not restricted to economics, but also extend to other fields such as political science, sociology and military studies. In fact, game theory is much more than a component of economic theory, and can be regarded as part of applied mathematics.

The field of IO is primarily concerned with the analysis of oligopolies, i.e., markets in which firms are neither monopolists nor perfect competitors, but something in between [Mart94,1]. Oligopolistic market structures predominate in the real world. This is applicable to game theory, which is especially useful when the number of interactive agents is small [Shy95,11-12]. In this case, the action of each agent may have a significant effect on the payoff for the other players. The goal of a game-theoretic model is to predict the outcomes (a list of the actions adopted by each participant), given the assumed incentives of the participating agents. Thus, game theory is extremely helpful in analysing industries containing a small number of competing firms, since the actions of each firm have a significant effect on the profit levels of the competing firms. Influential articles by Fisher [Fish89] and Shapiro [Shap89] discuss the usefulness of game theory in understanding industrial structure.

Nevertheless, game theory is not exclusively the domain of IO research. In general terms, the mathematical language of games permits economists to ask questions about the dynamics of competitive interactions. The key contributions involve providing a common language for economic contexts and formalising the nature of competition between economic agents (whether co-operative or non-co-operative) [Krep92,87-89;CaPe90,299-300].

The following quotation from Fuldenberg and Tirole, two of the most distinguished researchers in the field of IO, confirms this point [FuTi87,176]:

"Game theory has had a deep impact on the theory of industrial organisation. ... The reason it has been embraced by a majority of researchers in the field is that it imposes some discipline on theoretical thinking. It forces economists to clearly specify the strategic variables, their timing and the information structure faced by firms. As is often the case in economics, the researcher learns as much from constructing a model as from solving it because in constructing the model one is led to examine its realism."

It is thus the integration of the analytical tools of game theory at an intermediate level of economic abstraction that provides the most adequate approach for analysing the economic problem outlined in section 1.1.

1.3.3 Public policy perspective - Law and economics

There is another factor that distinguishes IO from microeconomics. In contrast to microeconomics, IO is profoundly concerned with policy questions, i.e. government policy toward business. Cooter and Ulen [CoUl88,1-12] and Martin [Mart94,1-2] give an overview of the application of IO models in public policy decision-making. Examples include antitrust policy, regulation, public ownership, etc. Public policy reaction is also highly relevant in the context of the problem discussed here, since the DRM protection strategy selected by a media firm can involve substantial investment in DRMS installations and possibly later be found to violate law ex post. In light of this, it is important for media companies to anticipate government reaction toward certain levels of technical copyright protection, in order to avoid investing in technology that is not supported by lawmakers.

Since IO is concerned with the structure and behaviour of firms (i.e. market structure and internal organisation), it is useful not only for academic economists and public policy makers, but also for business and resource management professionals [Tiro02,3]. The study of IO models and concepts enables managers to analyse the determinants and structure of the industry in which their firm operates, as well as the reaction of public policy makers that can in turn influence business strategy. As a result, IO models provide valuable insights for all of the above-mentioned fields.

For the public policy analysis, a normative law and economics methodology will be used. The fact that intellectual property law,

including copyright law, is based on an underlying economic rationale makes this approach particularly suitable [LaPo89]. The natural rights concept of copyright, where the deontological idea of ownership of the work by the author supersedes utilitarian interests [MoSa02], will not be pursued in this analysis.

Legislation will be analysed from a normative law and economics perspective, in which policy recommendations are based on the economic consequences of various policies. Rowley describes this as "the application of economic theory and econometric methods to examine the formation, structure, processes and impact of law and legal institutions" [Rowl89,125]. This approach assumes that laws pursue the primary objective of maximising "social wealth" or "aggregated utility". Based on classical IO research, this methodology is strongly influenced by New Institutional Economics and by the increasing integration of other perspectives [Merg00]. The economic analysis of laws can assist in guiding legislative action with regard to revising copyright laws in the light of technological change, thereby helping to make media markets as efficient as possible and to enable society to maximise the creative efforts of its members.

A key concept in normative economic analysis is market efficiency. According to the concept of Pareto efficiency, an outcome is considered more efficient if at least one individual benefits and no one is disadvantaged [Tiro92,6]. In contrast, Kaldor-Hicks (KH) efficiency is based on the premise that a more efficient outcome may disadvantage some persons. In this case, an outcome is considered to be efficient if those who benefit can compensate those who are disadvantaged through a side payment [Posn98,14-17]. However, since the KH concept of efficiency does not require such compensation to be made, this type of economic efficiency does not necessarily make each party better off (or at least no worse off). Thus, while every Pareto improvement in efficiency represents a KH improvement, many KH improvements are not Pareto improvements [ScOt95,29-35]. The KH efficiency criterion is widely accepted in welfare economics and is used as a standard for cost-benefit analyses.

Despite its widespread use in the USA in particular, due to key figures such as Ronald Coase and Richard Posner, the normative law and economics approach may be criticised from a number of points of view [Treb99]. First, not every aspect of a market can be evaluated by means of economic analysis. Often too little information is available concerning the aggregate utility functions of the stakeholders involved, since these may not depend solely on

purely monetary aspects [ScOt95,37-47]. Moreover, although economic analysis can provide insight into possible effects on private incentives and social benefits in markets for creative works, it ignores questions of distributive justice and other norms of equity and ethics [Posn98,16;Kins01,12]. A growing body of literature emphasises the importance of considering the effects of moral views on economic behaviour [Andr95;AnPa03]. The policy option recommended will therefore be a combination of what is "efficient" and what is "fair".

1.3.4 Technical perspective - Reference modelling

A descriptive analysis of the technical foundations of a DRMS will be realised with the aid of meta analyses referred to as "reference modelling", a method commonly used in German information sciences [BeRS99]. Based on the protection functions identified from the descriptive reference model, a normative model will be proposed that recommends how a DRMS can be designed with a given level of protection.

A reference model can be broadly defined as a high-level representation of an information model [KHHS93], which synthetically represents the object system of a particular company [BeSc96]. A reference model is constructed by a modeller using standardised notation, in order to make recommendations for application system and organisation designers, thus creating a point of reference for an information system [Schü98]. More technically, reference models can be said to consist of partial models, which can be subdivided into structural models (for data, functions or object classes) and behavioural models (for processes) [TzHe02].

The specification of a reference model serves two purposes. First, it provides a conceptual framework that aids in the classification of domain-specific application models. The similarities between real-world business problems and the models that describe them facilitate the examination of the underlying relationships and circumstances [Beck04]. Secondly, reference models can provide a foundation for the elaboration and design of real-world systems [Goek04].

Reference models should meet certain quality requirements. Due to their abstract and idealised nature, such models should be re-usable; in other words, as many company-specific models of the problem domain as possible should be derived from a reference model for the construction of an individualised model. In addition, reference models should be designed with a sufficiently high level of technical quality, having a modular design, universal validity and

adaptability [Schü98]. A further requirement is that employment of the reference model should be economical for potential users.

Based on the objectives stated in Section 1.2, the scope of the reference model to be constructed in Section 3.2.2 will now be specified. This can be done by means of the morphological box illustrated in Figure 1.3/3.

Feature	Characteristic			
	Description perspective	Data	Functions	Organization
Level of description	Objects		Technical Specification	Implementation Blueprint
Validity	As-is model		To-be model	Ideal model
Level of individuality	Domain dependent model		Domain independent model	
Degree of abstraction	Attribute-level	Type-level	Meta-level	Meta-Meta-level

Figure 1.3/3: Specification of reference model [Rose96]

The "description perspective" feature defines the view of a reference model. In this case, the focus will be on the functional perspective. Based on the problem requirements, a high-level functional description of a DRMS will be presented. Since software implementation is not the focus of this thesis, it is not necessary to present more technically oriented concepts such as technical specifications or implementation concepts. Furthermore, the aim of the model is to represent an ideal state or target model of the entire functional scope of a DRMS. The construction of an ideal model can serve as a reference, yielding recommendations for improvements starting from an initial position. The model is oriented to the specific domain of the media industry, and thus exhibits a high level of individuality, since it cannot be transposed to a broader industry context. This design choice also affects the overall level of model abstraction. As is customary, this reference model refers to the "type level" and describes types such as content, billing data, etc. A description at an attribute level would make sense only for company-specific models, where concrete instances of the types are known. The meta level is chosen for the description of the modelling syntax, the semantics of which are defined by a model on the meta meta level. Thus, an attempt is made to establish an idealised, high-level functional reference model of a DRMS, oriented to the media domain.

The reference model will be abstracted from an analysis of three DRMSs available in the marketplace. In order to overcome the disadvantages related to the small sample size and limitations of inductive reasoning, a careful selection is made of exemplary, state-of-the-art solutions.

In Section 3.2.2, a reference model of the logical data flow in a DRMS will be specified. Clear orientation is further enhanced by means of data flow charts using the notation of Mertens et al. [MBKP04,176]. Such graphical representations are helpful for illustrating the information flow of an application or a functional model. Standardised symbols are used to show how data is processed, what types of processing function are employed, the repositories utilised, and the general direction of data flow.

1.4 Related literature

The problem structure, objectives and methodology have been formulated in the previous sections. This section examines past research presented in related literature. Unfortunately, very little collaborative work on this subject has yet been done. One reason for the relative scarcity of such studies may be that academic and research organisations are based mainly within departments, in various disciplines. As a result, the subject of content protection is studied separately within the fields of economics, security engineering and legal sciences, and interdisciplinary research is rare. However, some efforts to bridge the gap between two disciplines have been made in the areas of Law and Economics, Law and Informatics, and Management Information Systems Research. Five contributions are highlighted below, in chronological order. These contributions will be cited throughout the thesis.

The book "*The Digital Dilemma - Intellectual Property in the Information Age*" [CSTB00], published by the Computer Science and Telecommunications Board, is the first book to analyse the issue of content protection from an interdisciplinary perspective. It includes a clear, well-structured analysis of the implications of new information and communication technologies with regard to the media industry and its individual stakeholders. The book also discusses diverse content protection strategies and makes public policy recommendations. It touches on the most important aspects of the subject, providing a good foundation for this dissertation. The breadth of its scope accounts for the lack of depth, particularly in the technical and economic sections.

The work "*Digital Rights Management*" by Rosenblatt et al. [RoTM02] focuses more on the business and technological aspects of content protection. It has a very practical orientation and was written with the objective of helping media managers select suitable technical installations with the aid of requirement lists and implementation options. It also discusses some of the solutions which currently exist in the marketplace. However, it should be kept in mind that the content of the book will quickly become outdated as technology evolves.

Bechtold [Bech02], in his Ph.D. Thesis "*Vom Urheber- zum Informationsrecht*" (From copyright to information law), uses a legal and law and economics approach to assess the implications of Digital Rights Management with respect to the existing copyright regime. He provides a coherent, objective, insightful view of the issues involved, including the technical foundations.

The work "*Digital Rights Management - Technological, Economic, Legal and Political Aspects*" by Becker et al. [BBGR03] aims to provide a comprehensive interdisciplinary overview of Digital Rights Management. Considerable depth is provided, especially in the technical and legal sections.

"*Digital Rights Management Systeme – Einführung, Technologies, Recht, Ökonomie und Marktanalyse*" by Fränkl and Karpf [FrKa04] presents a broad, in-depth market overview of currently existing technical solutions, combined with a legal and public policy analysis. This work is very useful for understanding the market status quo and the segmentation associated with various products.

In addition to the interdisciplinary works presented above, the literature also contains research focused solely within particular fields. The contributions cited in the following paragraphs are valuable in providing deeper insights into the various fields related to the present thesis. It is possible to differentiate with regard to: (i) technical literature concerning security engineering, core DRM security technologies and reference modelling, (ii) economic literature in the field of microeconomics and game-theoretic industrial organisation, (iii) legal and law and economics literature related to intellectual property law and the associated legal institutions, and (iv) media economic research concerning the particularities and scope of the media industries.

In the field of security engineering, the works of Anderson [Ande01] and Schneier [Schn01] can serve as useful introductory texts. The core techniques of a DRMS are addressed by Burnett and Paine [BuPa01] and Nash et al. [NDJB02] in the area of applied

cryptology, and by Dittmann [Ditt00] and Cox et al. [CoBM02] in the domain of digital watermarking. From a technical perspective, the theory and practice of reference modelling is discussed by Becker et al. [BeRS99] and the theory of information systems by Mertens et al. [MBKP04].

In the economic domain, basic texts concerning microeconomic and industrial organisation theory include those of Varian [Vari96], Tirole [Tiro02], and von Böventer and Illing [vBI03]. Theoretical and applied game theory are addressed by von Neumann and Morgenstern [vNMo44], Gibbons [Gibb92], and Osborne and Rubinstein [OsRu94].

In the field of law and economics, standard contributions are those of Cooter and Ulen [CoUl88], Posner [Posn98], and Schäfer and Ott [ScOt95]. With regard to the economic analysis of intellectual property law, the recent publications of Landes and Posner [LaPo03] and Reich [Reic04] can be recommended.

For an analysis and interpretation of the legal framework in the new media era, reference can be made to the research of Lehmann [Lehm97;Lehm02], Moritz and Dreier [MoDr02], and Gounalakis [Goun03]. In addition to intellectual property law, these contributions also review the implications of competition law, data protection law, and business law in a European context. These works are also suitable for media professionals who do not have a law background.

For literature on the economics and management of the media industries, the contributions of Schumann and Hess [ScHe02], Shapiro and Varian [ShVa99] and Wirtz [Wirt01] can be recommended. These books provide an orientation to media industries, with a strong emphasis on implications with regard to new media.

1.5 Thesis outline

There are two possible approaches to structuring this work that could be used in order to meet the objectives.

The first possibility would be to organise the thesis chronologically, based on the decision-making process carried out by a media manager.

As indicated in Table 1.2/1, a media manager would first examine the scope of existing techno-legal protection mechanisms, then assess the ideal level of protection taking into account the probable decisions of lawmakers, and finally determine how to implement the protection level selected. The advantage of this organisational structure is that it closely follows the decision-making process that the dissertation is designed to support. However, the main drawback of this approach is that it would be necessary to change the perspective of the analysis several times (e.g. the techno-legal perspective), making it difficult to maintain the continuity of the discussion.

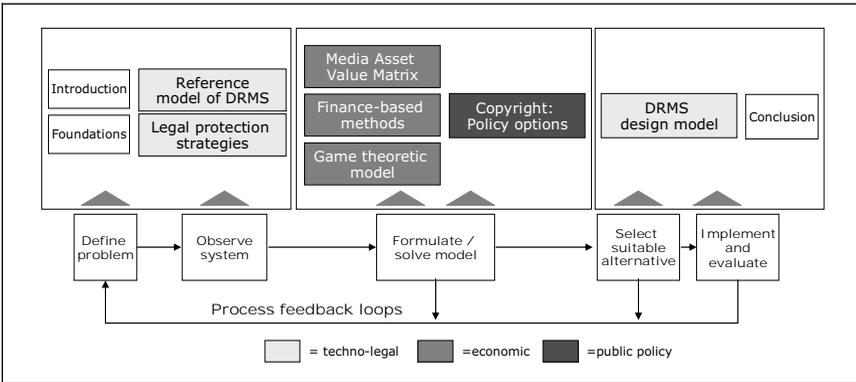


Figure 1.5/1: Hypothetical thesis structure based on decision-making process

The second option, which is the one that will be adopted, is to structure the dissertation according to the four perspectives described in Section 1.2: the technical, legal, economic and public policy perspectives. The technical and legal perspectives will be analysed jointly, since protection mechanisms can be established only by combining these two aspects. The advantage of this thesis structure is that continual changes of perspective are unnecessary.

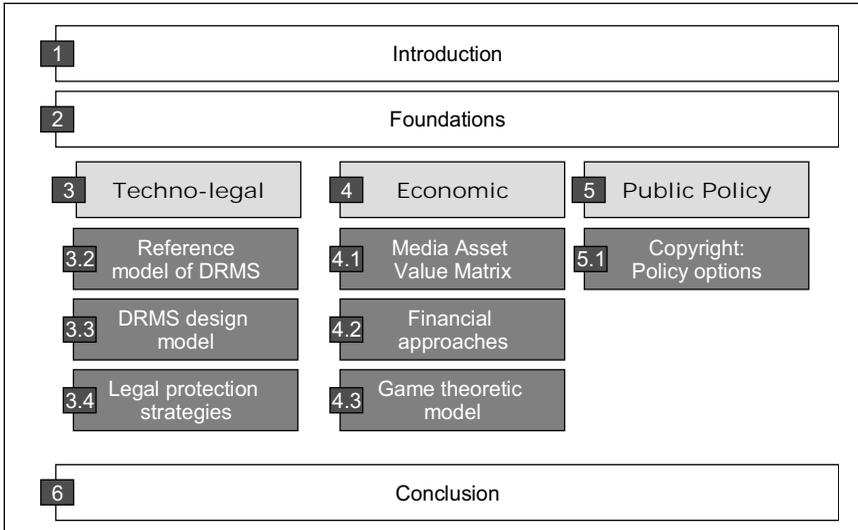


Figure 1.5/2: Thesis structure based on research perspectives

This preferred approach results in the following plan for the thesis.

Chapter 2 provides the foundation for the following sections. First the key terms are defined, as is necessary in interdisciplinary research. A stakeholder analysis is used to identify relevant stakeholders, their attitudes toward protection measures and their relative power. The following section analyses the structural changes that have led to the current situation and discusses the need to re-establish and enforce property rights through legal or technical means. The chapter concludes with definitions of DRM and DRMS.

Chapter 3 examines the techno-legal foundations of a DRMS. In Section 3.2 a functional, technical and architectural reference model is constructed on the basis of three exemplary solutions. Based on the functional model, a framework is suggested that permits the technical implementation of an optimal level of content protection. In Section 3.4, legal protection mechanisms that are closely connected with security technologies are analysed. The close relationship between the technical and legal aspects is particularly evident at a contractual level. For example, the use of mass market licenses helps to improve the legal position of media companies. Technology licenses are an important means of enforcing security standards for consumer electronics playback devices.

The economic aspects are discussed in Chapter 4. First a heuristic approach is presented, based on Media Asset Value Maps. This is

followed by classical financial approaches based on Net Present Value and Value at Risk methodologies. The game-theoretic base model is then developed in Section 4.3. It is used to calculate the optimal level of copyright protection. Three model extensions and a comparative static analysis aid in understanding how the optimal level alters with changing premises.

Chapter 5 focuses on the policy implications of a DRMS from a law and economics perspective. Finally, Chapter 6 concludes the dissertation and proposes some further research contexts for future exploration.