Research Challenges in Management and Compliance of Policies on the Web

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Abstract

In this paper we argue that policies are an increasing concern for organizations that are operating a web site. Examples of policies that are relevant in the domain of the web address issues such as privacy of personal data, accessibility for the disabled, user conduct, e-commerce, and intellectual property. Web site policies—and the overarching concept of web site governance—are cross-cutting concerns that have to be addressed and implemented at different levels (e.g., policy documents, legal statements, business processes, contracts, auditing, and software systems). For web sites, policies are also reflected in the legal statements that the web site posts, and in the behavior and features that the web site offers to its users. Both policies and software tend to evolve independently, but at the same time they both have to be kept in sync. This is a practical challenge for operators of web sites that is poorly addressed right now and is, we believe, a promising avenue for future research. In this paper, we discuss various challenges that policy poses for web sites with an emphasis on privacy and data protection and identify open issues for future research.

Keywords: Internet, legal factors, compliance control

1. Introduction

“There is hardly a government in the world that does not have some form of policy about the World Wide Web.”
– Difflly [11]

In this paper, we want to raise awareness that policy issues for web sites have to be addressed during the site’s whole life cycle, including requirements, design, development and maintenance. Policy compliance and management are parts of web site governance. Web sites are challenging from the perspectives of governance and policy, because they operate in a highly homogeneous environment (e.g., multiple languages, corporate entities, and jurisdictions) with diverse users. There are increasingly complex sites (web 2.0 sites and sites of e-tailers) that offer functionality that rivals shrink-wrapped consumer products—and site complexity translates to policy complexity. Furthermore, there may be a number of different stakeholders involved that have different goals and objectives for the site. One can distinguish three important groups of stakeholders: the web site operator, the web site’s users, and lawmakers.

Understanding and addressing policy issues and requirements from the beginning has a number of potential benefits for the development of web sites. Policy requirements for the web site’s domain can be elicited during requirements engineering, thus making them a part of the entire software life cycle. This way, issues such as privacy and security that may impact the system’s architecture and design can be addressed early on. Thus, addressing policy issues from the start can prevent costly changes in subsequent development or maintenance activities.

Policies and software have to be kept in sync. A policy can evolve for various reasons (e.g., changing business needs, lobbying by stakeholders, or legal developments) and there needs to be process and tool support to trace policy changes down to the code. Conversely, changes in the code can (unwittingly) implement behavior that contradicts a policy. Hence, there should be static and dynamic checks to verify policy compliance and to detect policy violations.

It should not be taken lightly by an organization if its web site violates a policy. Generally policies such as privacy and terms of use statements can be seen as binding contracts between the operator of the site and its users. If the policy touches on users’ rights, a violation may result in a loss of reputation and trust, causing users to abandon the site. For example, studies show that users are often concerned about their privacy [5], and as a result may be outraged about a violation of the site’s privacy policy. If the policy is mandated by law, violations can cause lengthy and costly legal actions, severe penalties, and temporary shut-down of the site. Thus, risk mitigation demands that operators of web sites have to re-evaluate constantly the conformance of the behavior of their site with respect to various policies.

The rest of the paper is organized as follows. In Section 2 we start out with a primer on information technology...
governance in general and web site governance in particular because both topics are closely related to policy management. In Section 3 we give an overview of the diversity of policy issues that web sites have to address. In Section 4 we focus on privacy policies as an example to expose issues that need to be addressed in policy management and compliance for web sites. Privacy policies are an opportune example because organizations are free to define their own policies, but they are also constrained by national laws and consideration of users’ trust. Furthermore, privacy needs to be addressed for internal operation, but it also needs to be communicated to users of the web site. Based on the discussion of privacy policies, we discuss in Section 5 the complexity of policy management for different kinds of web sites (brochure-ware, e-commerce, and web 2.0), and describe in Section 6 implications and research challenges that organizations have to tackle for policy management and compliance. Section 7 closes with conclusions.

2. IT and Web Site Governance

“Compliance with regulations regarding internal controls, financial reporting, and privacy is now a substantial catalyst for companies to understand and invest in addressing information risk challenges.”
– Ernst & Young Global Information Security Survey [12]

Policy management and compliance of software systems are increasingly important activities that need to be addressed by most organizations. One of the trends identified by the Ernst & Young Global Information Security Survey is that “the impact of compliance continues to grow” [12].

Policy management and compliance is typically an integral part of information technology (IT) governance, which is driven by the realization that an organization’s software systems are the hub around which its business activities revolve. Consequently, an organization’s IT capabilities can no longer be treated as a black box by the companies stakeholders [44]. Instead, various stakeholders across the organization have to coordinate and resolve policy issues. One key challenge for stakeholders is “balancing compliance at all costs, compared to compliance at an affordable cost” [30].

Web sites are part of an organization’s IT infrastructure and as such have to be incorporated into IT governance. Furthermore, web sites are an organization’s interface to the public. Many organizations and businesses use web sites to post information for, and to interact with consumers. The term web site governance [11] has been suggested to emphasize the importance of web sites and to stress that web sites pose particular challenges for governance. In fact, policy compliance of a web site (e.g., a banking portal) is equally important to a (backend) software system (e.g., a financial transactions system). Furthermore, there may be complex interactions between them.

Depending on the nature of an organization, governance can be more lightweight or heavyweight. Diffily believes that web site governance “does not require a huge and unwieldy bureaucracy, just some plainly written guidelines and clear executive oversight” [11, p. 288]. Diffily suggests to have a web site management team (WMT) that is in charge of the web site and (1) defines the organizations web strategy, (2) sets the site’s high level goals and ensures the achievement of the goals, and (3) monitors overall performance. The WMT is also responsible to ensure that processes for site management are in place and that these processes address policy issues adequately. In order to enable the WMT to operate effectively, there should be dedicated tool support that assists in the tasks of policy management and compliance checking. These tools should probably operate at different levels of granularity, including high-level dashboards [24] and lower-level information such as policy goals and ontologies.

3. Policy and Legal Issues of Web Sites

“No longer an information ‘wild, wild, west,’ the Internet increasingly is influenced by legal considerations.”
– Baker in [18]

Policy issues for web sites touch on many diverse areas. An organization may have a security policy, privacy policy, corporate identity policy, ethics policy, customer care policy, etc.

Often policy issues interact with laws or regulations. For example, an increasing number of countries have data protection laws that web sites have to adhere to; however, even if a country has no such law it may still make good sense for a web site to address this issue in their privacy policy to increase consumer trust. Another cross-cutting issue is jurisdiction because web sites are accessible by users worldwide. Depending on the nature of the site (e.g., financial or healthcare), domain-specific policy and legal issue may emerge. An extreme example is a gambling web site, because it targets a domain that is heavily regulated by most states and countries.

Examples of typical policy issues for web sites that are influenced by legal considerations are [11] [19] [18] [38]:

- **Criminal damage**: A web site may (inadvertently) cause harm to a site’s user. A site may host a virus (e.g., in a web page’s JavaScript or a downloadable file) that deletes data on the user’s computer. In this case, the site operator may be liable for negligence. To give another example, courts have applied trespass law to prohibit frequent, unwanted spidering of a web site if
a meaningful harm to the site’s computer system (e.g., resource drain) could be shown [34].

freedom of expression: Certain kinds of content on web sites raise the issue of free speech and its restrictions (e.g., product defamation, slander and libel, company secrets, and hateful ideas). Generally, it is often difficult to decide if free speech applies or not. For example, is unwanted but harmless email protected by free speech, or could such email be prohibited based on trespass law? Since the freedom of expression varies significantly by jurisdiction, the decision where to operate a site may be significant.

intellectual property: The content, design, functionality, and domain name of a web site may be protected by intellectual property (i.e., copyright, trademarks, and patents). On the one hand, a web site has to protect its own intellectual property; on the other hand, the site has to ensure that it does not violate the intellectual property rights of third parties. In the context of copyright (and freedom of expression) it is significant that posting material to a web site is considered an act of publishing.

electronic commerce: E-commerce refers to the trading of goods and services over the Internet. In response to the large volume of commerce on the Web, legislation has introduced rules to govern online transactions. As a result, agreements made via the Internet and electronic signatures are legally binding, consumer rights protection applies to goods purchased on the web, purchases on the web are taxable, etc.

accessibility for the disabled: A web site should be accessible to users with disabilities. The U.S. has amended the Rehabilitation Act to require Federal agencies to make their web site accessible (Section 508). As a result, persons with disabilities may file administrative complaints or bring civil actions in Federal court against agencies that fail to comply with the requirements of Section 508. There are commercial web sites that have chosen to address accessibility in their web sites. For example, General Electric posts an explicit statement on its site that states its current accessibility features (www.ge.com/accessibility.html).

The above issues are meant to illustrate the broad range of policies that interact with legal requirements. There are certainly other policy considerations that a web site needs to address. Another important topic is privacy and data protection, which is discussed in detail in Section 4.

4. Data Protection and Privacy Policies

“Traditionally, policy specification has not been an explicit part of the software development process. This isolation of policy specification from software development often results in policies that are not in compliance with system requirements and/or organizational security and privacy policies, leaving the system vulnerable to data breaches.”
– He et al. [16]

Privacy can be defined as “the ability of an individual or group to seclude information about themselves and thereby reveal themselves selectively” [45]. In the context of information technology, an important concern is data protection of digitally stored information (e.g., health, criminal, financial, genetic, ethnic, and location information). Importantly, more low-level data should be also considered private such as stated user preferences (e.g., language setting) and interactions with the system (e.g., executed search engine queries, and visited web pages and sites).

In response to growing privacy concerns, many countries have passed laws that govern the treatment of sensitive data. As any software system, web sites have to meet legal obligations. The European Union has enacted Directive 95/46/EC in 1995 [40], which requires organizations that collect personal data to register with the government and to take precautions against data misuse. Furthermore, organizations have to inform individuals about the reasons for collecting information about them, to provide access to the data and to correct wrong data. This directive has to be implemented by states that are members of the EU. For example, the UK has the Data Protection Act (1998), and Germany has the Bundesdatenschutzgesetz (2001). Examples of non-EU countries with data protection laws are Canada (2004), Australia (2001), Japan (2005), and Switzerland (1993). In the U.S. there is no single act or law that addresses privacy. Instead, there are different laws that touch on privacy and data protection. For example, the Health Insurance Portability and Accountability Act (HIPAA) establishes regulations for the use and disclosure of health information, the Gramm-Leach-Bliley Act regulates the privacy of customers of financial institutions, and the Children’s Online Privacy Protection Act of 1998 (COPPA) addresses privacy issues for children under 13.

What constitutes private data is not easy to decide. Knight and Fitzsimons give the following example: “Some people regard receiving a flood of ‘junk mail’ as an invasion of privacy, others regard it as just a part of modern living, or even a chance to be informed” [21]. An important, but unresolved, question in law is who owns the (private) data of users. According to Taipale, “a fundamental issue, as yet not fully resolved to everyone’s satisfaction in

1http://ec.europa.eu/justice_home/fsj/privacy/law/implementation_en.htm
the context of emerging technologies, is whether data about an individual (whether disclosed by that individual or otherwise obtained) should ‘belong’ to that individual in any kind of sense that would invoke legal mechanisms of ongoing control—i.e., some notion of property—or perhaps even a renewal of ‘expectations’ of privacy for secondary uses—after it [is] shared or otherwise becomes known” [37, p. 154]. For example, if a web site collects information about a user (e.g., search queries), does the user own that data or the collecting entity?

There are potential legal concerns whenever a web site collects, processes and stores data that contains information of or about its users. In the following, we briefly give examples of web site features that are interacting with privacy policies.

logging of data: The log files of a web site may store information about the interactions of a user with the system. Weitzner et al. advocate policy-aware transaction logs that are responsible for “recording information-use events that may be relevant to the assessment of accountability to some set of policies” [43]. There is often a clash between privacy protection on the one hand, and security and auditing concerns on the other.2 On the one hand, there may be legal requirements that make it necessary that data about users is retained for a certain period of time. On the other hand, logged data may have to be anonymized in order to protect the privacy of users. For privacy protection it is important whether the logs guarantee certain properties such as complete anonymity [13].

profiling and personalization: Many commercial web sites collect data of user interactions to personalize pages [22] [42]. For example, Amazon generates recommendations of books that are personalized by the user’s own history of viewing and buying books as well as the buying habits of other “similar” users. Google is working on personalized searches that take a person’s search history into account [36]; the user’s search history is kept in the Google Web History. For such services, web sites have to ensure that the site’s privacy policy is communicated to users, that the site does not expose private data to other users, and that users have a certain control over the collected information (e.g., correction of wrong information).

distribution and transmission of data: Users of a web site will potentially access it from all over the world. However, certain countries have policies that govern the transmission of personal data across borders. The EU privacy directive mentioned above prohibits the exporting of personal data to a country that does not provide an adequate level of privacy protection. So far the EU has recognized few countries, among them Canada and Switzerland. For countries not recognized by the EU, the user would be required to explicitly give consent to the web site operator.

communication of policies to the user: Last but not least, web sites have to post their privacy policy. These policies are important for users to understand how their data will be treated by the site operator. Antón et al. say, “often, the only guide users have as to how an institution will use, disclose, and store sensitive information is via its online privacy policies. Thus, users should expect these privacy policy documents to accurately describe an institution’s privacy practices in a clear and easy-to-understand manner” [4]. The following is an excerpt a legal notice from the web site of a large American corporation in 1998:4

“All visitor to the Valero web site who provides information to Valero agrees that Valero has unlimited rights to such information as provided, and that Valero may use such information in any way Valero chooses. Such information as provided by the visitor shall be non-confidential.”

Even though an organization is free to fashion its own policy, in practice there are many legal and ethical constraints that need to be taken into account. For example, web sites of healthcare providers have to reflect the legal requirements of HIPAA in their privacy policies [4]. It seems rather unlikely that the above legal notice would be considered as adequate nowadays.

There are probably many more policy issues that need to be addressed besides the examples given above. However, these examples are sufficient to expose the complexity of managing privacy policies for web sites.

Furthermore, the interactions of policies and web sites increase with the complexity of the site. This issue is discussed in more detail in Section 5.

5. Policy Complexity of Web Sites

Policy issues are typically more pronounced for more complex web site is. For discussion, we define three kinds of sites with increasing sophistication in terms of functionality and user interactions:

2http://ec.europa.eu/justice_home/fsj/privacy/thirdcountries/index_en.htm
3http://web.archive.org/web/19980530081620/www.valero.com/html/legal_notice.htm
brochure-ware: These sites provide information that users can browse (e.g., to obtain information about products and services that they can obtain off-line) [39]. User do not have to log on to the site and the site is static in the sense that it looks the same for all users.

e-commerce: These sites are run by companies that sell products online. They may be pure online retailers (e-tailers) or have a clicks-and-bricks hybrid business model [32]. To place orders, users have to create an account.

web 2.0: These sites are characterized by sophisticated functionality that often rival shrink-wrapped software products (e.g., Google GMail\(^5\) and Adobe Photoshop Express\(^6\)). These sites typically offer a participatory and interactive user experience [10], which is typically realized with technologies such as AJAX, mashups, blogs, Wikis, and RSS [27].

The above classification is an idealization because concrete web sites typically have features that blur into other groups. For example, a brochure-ware site may have a form or questionnaire that users can fill out to provide feedback to the site operator, and e-commerce sites often have some kind of personalization (e.g., Amazon’s wishlists) or user-generated content (e.g., book reviews of users).

The simplicity of brochure-ware sites makes policy management and compliance comparably easy to accomplish. Since all content is supplied and maintained by sources within the organization, processes can be defined that mandate compliance checks by a central authority. For example Diffily suggests that “all ideas for new information or applications must be approved by a WMT before work commences. ... In order to get a development approved, a proposal must be submitted and a collective decision made about whether it is suitable for the site (perhaps based on advice from the editor).” [11, p. 294]. As a result, tracking and assessment of content-related issues such as intellectual property, accessibility, and freedom of expression can be implemented in a straightforward manner. Since a brochure-ware site can be realized with static HTML, many security threats are mitigated or do not exist (e.g., script-based and SQL injection attacks). Furthermore, since brochure-ware sites do not ask for personal information from users, there are only privacy issues of tracking the movements of users on the site.

Policy issues of e-commerce sites are significantly more difficult to handle than those for brochure-ware sites. The web site itself is more complex because it needs functionality to manage user accounts and purchasing. As a consequence, e-commerce sites have to manage personal data of users such as address and billing information. Furthermore, they store—permanently or temporarily—sensitive information about users such as purchased items and defaults in payments. As a consequence, the site has to adhere to data protection laws of various jurisdictions. For example, organizations may be required to report stolen data to affected people. Following California in 2002, many states in the U.S. have adopted security breach notification laws.\(^7\) These laws require an organization to notify all residents within the law’s state if it believes that personal, non-public information of residents has been stolen. The EU is considering a similar law—amending EU Directives 2002/22/EC and 2002/58/EC—that would force telecommunications companies to tell customers when personal data security has been breached.\(^5\) Since e-commerce sites do business with users, they have to adhere to consumer protection laws, handle taxation, and deal with fraudulent transactions. Even though complexity increases, it appears that many policy aspects can still be managed by a central authority.

Web 2.0 sites add further complexity for policy management and compliance due to several characteristics. These sites have typically user-generated content where users are conducers, that is, they “both consume creative works and simultaneously add creative content to those same works” [33]. As a result content is no longer created exclusively within an organization and as such policy compliance of content is difficult to enforce. Specifically, web sites have to address liability issues for users’ misuse of intellectual property (e.g., copyright infringements), misinformation, slanderous comments or other harmful data. Web 2.0 sites are realized by using web browsers as thin clients where most of the application logic and data storage is performed by distant Internet servers. This approach is discussed as cloud computing [15] and Platform-as-a-Service (PaaS) [23]. Hayes points out that cloud computing “raises awkward questions about control and ownership: If you move to a competing service provider, can you take your data with you? Could you lose access to your documents if you fail to pay your bill? Do you have the power to expunge documents that are no longer wanted?” [15].

From a privacy perspective, the service provider has to establish policies on how to manage and protect personal information entrusted by its users. In contrast to e-commerce sites, web 2.0 may collect personal data on a much larger scale. This is especially the case for consolidated information service providers such as Google that accumulate huge amounts of personal data depending on the extent of services used by a particular user (e.g., various kinds of searches, emails, appointments, contacts, documents, news alerts, and financials) [9]. Web sites that store personal

\(^5\)http://mail.google.com
\(^6\)https://www.photoshop.com/express/landing.html
\(^7\)http://www.ncsl.org/programs/lis/ci/pri/prive/ breachlaws.htm
\(^8\)http://www.out-law.com/page-8741
data also have to be prepared on whether and how they defend their users’ privacy rights. Hayes describes the following scenario: “a government agency presents a subpoena or search warrant to the third party that has possession of your data. If you had retained physical custody, you might still have been compelled to surrender the information, but at least you would have been able to decide for yourself whether or not to contest the order. The third-party service is presumably less likely to go to court on your behalf” [15]. In fact, the Department of Justice in the U.S. ordered Google in 2005 to hand over two month of search queries. Google refused—primarily on the grounds of trade secrets, but also because of privacy concern—and a court decided in Google’s favor.9

From the users’ perspective, published policies of web sites are important because they spell out the users’ rights and obligations. Examples of such statements are a site’s privacy policy and terms of use. With increasing complexity of the web site, these policies also increase in complexity. While brochure-ware sites can be satisfied by covering only general issues (e.g., license to use, disclaimer, linking, and intellectual property), e-commerce sites also have to address issues such as order acceptance, pricing information, exporting of goods, and disclaimers for special goods such as medicines. Web 2.0 sites are also more complex than brochure-ware because they have to address complex user interactions with the site involving personal data.

To summarize, web sites have to define policies that cover a diverse range of issues. Increasing complexity in a web site typically translates into increasing complexity of policy management. Also, a subset of a web site’s policies has to be communicated to users in the form of statements posted on the site.

6. Implications and Research Challenges

The implementation and management of policy issues is a major challenge for an organization. Many of the policies have to be reflected in the organization’s web site and kept in synch with internal policies and the web site’s functionality. Also, policies can be complex to define and maintain. For example, Antón et al. have analyzed the Privacy Rule of HIPAA, formalizing its content as restricted natural language statements [6]. They found 46 rights and 80 obligations that need to be addressed. Presumably, most of these rights and obligations apply to the web site’s content and application logic. In another study, Antón et al. show that privacy policies of web sites have indeed changed significantly after HIPAA came into effect [4]. Antón et al. also have evaluated web site policies in the financial sector; they concluded that “compliance with the existing legislation and standards is, at best, questionable” [3].

Policies have to be managed at different levels of abstraction and in different representations. Figure 1 groups policies into three tiers: high-level policies that apply to an organization as a whole, policies that are specific to the organization’s web site(s), and the implementation of these policies. Antón et al. introduce a framework for online privacy policies that is also based on three tiers; they distinguish the top tier (principles of privacy practices), middle tier (security policies), and bottom tier (enforcement in the physical layer) [2].

At the top tier in Figure 1 there are documents that define policies at a high level of abstraction and in natural language. Examples of such policies are legal texts (e.g., Acts enacted by the U.S. Congress), standards (e.g., W3C accessibility guidelines), and internal policies of the organization. The latter can be in natural language or a dedicated policy language.10 Such high-level policies have to be substantiated into web site policies that are posted on the site.11 These policies are expressed in natural language so that users can read them, but also in formal languages for automated processing. Transforming a legal text into a formal language such as a goal model can be (partially) automated (e.g., [20]). An example of a dedicated formal language is the W3C’s Platform for Privacy Preferences (P3P), which is an XML-based format that enables web sites to encode their data collection and data-use practices. Finally, policies have to be encoded in the web site’s content and functionality. For example, an operator that decides not to collect personal information from children (in response to COPPA) may decide to post notices and to implement safeguards in their web site that communicate and enforce this particular policy. More generally, policies concerning data protection of personal information that are communicated to users, have to be faithfully reflected in the site’s behavior. This means for instance that the part of a database that stores private information has to be safeguarded with access control mechanisms (e.g., Oracle supports row-level security with its virtual private database feature [28]). Similarly, the application logic needs access control mechanisms (e.g., implemented with OASIS’s eXtensible Access Con-

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9http://googleblog.blogspot.com/search/label/privacy

10For example, Google’s organizational goals with respect to privacy are outlined in its Code of Conduct available at http://investor.google.com/conduct.html#1:

“As we develop great products that serve our users’ needs, always remember that we are asking users to trust us with their personal information. Preserving that trust requires that each of us respect and protect the privacy of that information.”

11For example, Google has a general Privacy Policy (about 1900 words) that is augmented with service-specific privacy policies. For AdWords, Google claims that its “conversion tracking server complies with P3P privacy policies” (http://adwords.google.com/support/bin/answer.py?hl=en&answer=6358).
### Standards

An Organization’s High-Level Policies

| Legal Texts  | Standards  | Org.-Internal Policy |
|--------------|------------|----------------------|
| (natural language) | (natural language) | (formal/natural language) |

- **synchronization**
- **vertical transformation**

#### Privacy Policy

An Organization’s Web Site Policies

| Privacy Policy | P3P Specification |
|----------------|-------------------|
| (natural language) | (formal language) |

- **synchronization**
- **vertical transformation**

#### Low-Level Implementation of Web Site Policies

| Access Control | Logging/Auditing |
|----------------|------------------|
| (Oracle VPD and XACML) |                     |

- **...**

**Figure 1. Policies at different levels of abstractions and transformations of these policies**

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trol Markup Language (XACML) or IBM’s Enterprise Privacy Authorization Language (EPAL) [1]). Furthermore, logging and auditing data that contains private information must not violate the privacy policy (e.g., by anonymizing the data).

If policy issues are considered for web sites, they affect their whole life cycle and other cross-cutting concerns:

#### requirements analysis and policy representation:

Policies have to be treated as first-class entities in requirements engineering. Furthermore, they have to be formalized so that it is possible to analyze and reason about them. This may be accomplished with general formalisms such as goal models [41] or domain-specific representations such as P3P and EPAL. Policies have characteristics of both quality attributes (e.g., security) and functional requirements (e.g., data retention for a certain amount of time). Also, since policies are often fuzzy and ambiguous it must be possible to model degrees of uncertainty.

Currently, approaches such as P3P are too limited to describe fine-grained privacy rules [2]. It is an important research challenge to come up with a suitable representation, which may be customized from a general approach or developed bottom-up specifically for the web.

**Policies and design models:** It is quite likely that policies are impacting the design of web sites. A trivial example would be a requirement that the privacy policy is accessible (via a hyperlink) from each page of the site. A more complex example is the impact of users’ privacy settings on the data visible to other users. Policy requirements should be reflected as constraints and other annotations in the web site’s application, navigation, and presentation model. For example, depending on privacy settings, the navigation model may enable or disable navigation paths to particular sensitive content, and the presentation model may replace one widget with another (e.g., a name alias instead of the user’s real name with his or her picture). In order to represent policies during design, web-design methodologies such as WebML [8] or OOADM [35] have to be suitably augmented.

**Testing for compliance:** Web sites have to be tested for policy compliance before they are deployed. In fact, there are many examples of privacy violations caused by wrong implementations of privacy features. For
example, in Facebook supposedly private annotations were made visible to all users [14]. Testing for policy compliance is complicated by the fact that web sites have to support diverse user and environmental profiles, resulting in highly varied behaviors at the client side [29].

Generally, testing of user interactions of web sites exhibits similar problems than GUI testing [25]. It is an open research problem how to effectively specify test cases for policy compliance and how to (automatically) evolve these tests if the web site evolves.

**monitoring for compliance:** In addition to off-line testing, web sites should be monitored at run-time for compliance. A large corporate presence may be composed of multiple web sites that are administered by different entities in different countries. As a result, such sites may resemble systems of systems or even ultra-large scale systems in some respects [31]. For such systems, “policies will have to reconcile diverse and competing objectives while providing complete and unambiguous semantic content sufficiently to govern distributed system development, evolution, and operation” [31, p. 119]. For web sites that cannot be centrally controlled and tested, run-time monitoring becomes increasingly important. A simple example would be a crawler that periodically checks whether accessibility guidelines, linking policies, and content do conform to company policies and legal requirements.

Ideas from autonomic computing could be adapted to monitor web sites in terms of their data, operations, and communication [26]. Furthermore, if a failure occurs in the web site (e.g., because low-level access control has detected a privacy policy violation), strategies for reconfiguring and self-healing could be employed (e.g., to gracefully degrade the site’s functionality, or to achieve the desired functionality without violating a particular access control path).

**policy transformations:** Policies have to be represented at different levels of abstraction. As a result, it is necessary to implement vertical transformation of policies between the three tiers identified in Figure 1. For example, general privacy policies of the organization that are stated in natural language in the top tier have to be reflected in the middle tier (e.g., the web site’s privacy policy, its privacy seal, and P3P specification) as well as the low-level implementation (e.g., database and client/server-side code).

There are also horizontal transformations (e.g., translation of a policy encoded in a formal-language representation into a human-readable web policy in the middle tier). It is an open question how to transform policy requirements into policy constraints. Furthermore, policy constraints should be automatically translated into testing code and run-time checks.

**policy synchronization and traceability:** Because policies are encoded in different forms at different levels of abstraction (cf. Figure 1), they have to be re-synchronized if one policy changes. Synchronization is facilitated if policies are formalized in machine-readable representations and if they can be automatically transformed. However, natural language policies may not be fully automated. Furthermore, seemingly unrelated changes in the behavior and operations of the web site may contradict certain policy rules as an undesirable side-effect. For example, a low-level data replication features (that is transparent to upper layers) may be in violation of privacy law if the replication involves data transmissions that cross borders (e.g., to a data center that is located in another country).

To effectively synchronize polices and to handle errors, policies have to be traceable. For example, it should be possible to trace a high-level natural language policy to its formal representation (e.g., part of a goal model) and further down to the code. Conversely, if a fault occurs because a low-level policy check is violated, traceability should facilitate the maintainers to rationalize which higher-level policies are responsible for this particular check.

**policy negotiation:** If a web site requests a service of another entity (e.g., in a service-oriented setting) there needs to be some form of policy matching and negotiation. For example, the requested service has to guarantee (e.g., in a service level agreement) that personal data is processes in accordance with the requesting web site’s policies. Policy negotiation may be fully automated (e.g., communicating web services) or human-involved. In the latter case, dedicated tool support is needed that facilitates negotiation. SPARCLE is an example of such a privacy management tool [7]. The W3C has developed A P3P Preference Exchange Language (APPEL), [12] which allows users to describe privacy policies that are acceptable to them and to check whether a given web site accommodates them.

Since different users and services may have different policy requirements, a web site has to be prepared to accommodate different policy settings. In this scenario, different privacy preferences of users may result in different behavior of the web site. 

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[12]http://www.w3.org/TR/P3P-preferences/
Another important concern besides the above challenges is how to make existing web sites more policy-aware. For simpler web sites, it seems feasible to reimplement them, but this may not be an option for complex e-commerce and web 2.0 sites. When migrating a web site, policy-aware features can be injected incrementally. For example, the code of the web site can be reverse engineered to extract stakeholder goal models and to establish traceability between the existing code and the goal model [46]. The goal model can then be augmented with policy-aware requirements and the code evolved to reflect the changes in the goal model.

7. Conclusions

“Security is an emergent property of a system, not a feature. … Because security is not a feature, it can’t be bolted on after other software features are codified, nor can it be patched in after attacks have occurred in the field.”

– Hope et al. [17]

Hope et al. in the above quote stress that security is not a set of immovable features [17]. The same is true for policy compliance, which is a moving target because of various forces that an organization is confronted with. These forces can be internal ones such as changes in strategy that affect policy as well as external ones such as new regulations. Given that policies will evolve, there have to be mechanisms in place to enable a policy-aware evolution of the site. Policy-aware evolution has to be addressed in the whole life cycle of the web site starting with requirements.

In this paper, we have discussed policy management and compliance for web sites, giving examples of concrete policy and legal issues. We have then explored one particular policy issue in more detail, namely privacy and data protection. This issue exposes the complexity of policy management: web sites have to address it in logging of data; profiling and personalization; distribution and transmission of data; and in communicating their privacy policy to the users of the site. Furthermore, policy issues are more pronounced with increasing complexity of the site.

We believe that the policy issues that we have identified show that web sites can no longer be developed in a vacuum without consideration of policies and legal constraints. Treating policy requirements as first-class entities is justified by the potentially severe adverse consequences of ignoring them. This paper has exposed a number of policy challenges, which can serve as a starting point in formulating a research agenda to advance the current state of policy management and compliance for web sites.

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