Automating Privacy Policy Extraction And Summarization

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Privacy policies are the sole method through which users of a website are notified of their privacy rights. Privacy policies are often long and complex documents that are difficult for users to read and understand; as a result, users often accept these privacy policies without reading them. This paper presents a prototype that can extract and summarize privacy policies from websites using natural language processing techniques. The summaries produced by the prototype are relevant and concise, proving that machine learning can be used to make privacy policy comprehension easier. Furthermore, ideas and suggestions on how to develop the prototype into a fully functional application are also presented.

Additional Key Words and Phrases: Data Collection, Web Crawling, Text Mining, Natural Language Processing

1 INTRODUCTION

Privacy is a fundamental human right. To protect this fundamental right on the internet privacy legislation such as General Data Protection Regulation (GDPR) and California Consumer Privacy Act (CCPA) have been developed. They aim to protect the privacy of the user by forcing companies to adopt a notice and consent system. Where the user has comprehensive control over the data they share and can explicitly select the information they want to share with these companies. Privacy experts argue that while notify and consent allows the user control over their privacy, it is not completely effective as users are not rational thinkers and can often end up giving away more data than required when using these systems [6]. User interface for managing user policies is often inconvenient and unnecessarily complex. This is intentional and it is basically an attempt to make the user give up by wasting their time[7].

Additionally, privacy policies are often non-compliant with policy regulation and law. This is often due to a lack of transparency and a lack of explicit disclosure of policy elements. How certain user information is processed is sometimes casually omitted from these policies[7, 15]. A user's privacy is often further compromised when the companies with incomplete and lax policies have data breaches[13]. Additionally, policies often contain a lot of text with ambiguous wording and legal jargon, which makes them quite difficult to read, and users are not willing to spend additional time trying to understand these policies so that they can protect their privacy.

Due to the above stated reasons, I will be researching and analyzing techniques to data mine and extract privacy policies so that the privacy of the user can be adequately protected.

2 RELATED WORK

Privacy policy extraction and abstraction has already had some work done, which will be used as a basis for this research paper. In [3] researchers analyze the effectiveness of different natural language processing techniques for abstraction and summarization of privacy policies. They were able to effectively summarize the policies into shorter paragraphs that were easier to read due to the reduced length and omission of unnecessary information, making it tremendously easier for the user to comprehend the policy. They used a data set of 60 policies where each policy was manually divided and annotated. They tested different machine learning models on the data set; these models ranged from traditional models such as KNN (K-nearest neighbors) to deep learning neural networks. Their benchmarks found deep learning neural networks to be most effective at summarizing policies.

Similarly, In [11] researchers describe the challenges present in understanding a privacy policy, such as ambiguity and structure. Techniques to make privacy policies more understandable are also described.

Additionally, In [16] authors describe how machine learning can be used to extract text from a website. They describe and compare the performance of different features that can be used to extract the text, such as text length and CSS selectors.

3 TECHNOLOGY OVERVIEW

This section describes the technology used in this research:
Selenium: Selenium is a web testing library. Used to automate web browser activities.
BERT: Bidirectional Encoder Representations from Transformers is a transformer-based machine learning technique for natural language processing (NLP). In 2020, A literature survey concluded that "BERT has become a ubiquitous baseline in NLP experiments and inspired numerous studies analyzing the model and proposing various improvements" [4, 12].
SBERT: SBERT is similar to BERT but processes one sentence at a time. We can think of this as having two identical BERTs in parallel that share the exact same network weights [10].
Rouge: Rouge is a set of metrics and a software package used for evaluating automatic summarization and machine translation software in natural language processing.
RougeL: Variant of Rouge that computes the longest common subsequence (LCS) between two pieces of text [8].
Trafilatura: Trafilatura is a python package that can download and parses/scrape web page data. It can extract text while preserving text formatting. It also discards any irrelevant text that might be present on webpage elements such as on banners or navigation bars.

4 PROTOTYPE STRUCTURE

The prototype right now consists of 4 interconnected parts, these parts being; finding the policy using web scrapping, extracting the policy, and then summarizing the extracted policy and evaluating the quality of summarized text. Performance of various summarization models and techniques is analyzed and compared. Figure 1 depicts

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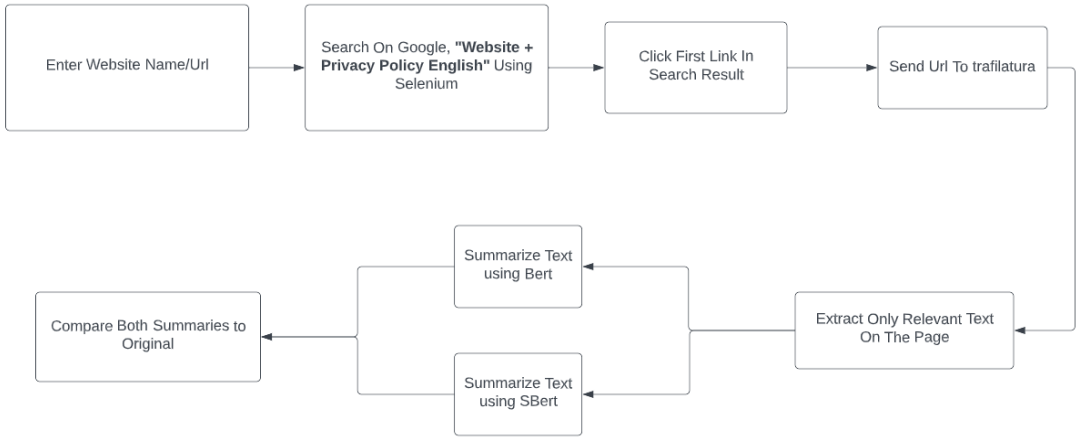

Fig. 1. Flow Chart depicting the overall flow of the prototype

Table 1. Performance of multiple extraction libraries tested against 750 documents, 2236 text & 2250 boilerplate segments in Python 3.8

Python Package	Precision	Recall	Accuracy	F-Score	Diff.
raw HTML	0.527	0.874	0.546	0.658	0
html2text 2020.1.16	0.486	0.709	0.481	0.577	7.6x
html_text 0.5.2	0.529	**0.958**	0.554	0.682	2.2x
inscriptis 2.2.0 (html to txt)	0.534	**0.959**	0.563	0.686	3.5x
newspaper3k 0.2.8	0.895	0.593	0.762	0.713	12x
justext 3.0.0 (custom)	0.865	0.650	0.775	0.742	5.2x
boilerpy3 1.0.6 (article mode)	0.814	0.744	0.787	0.777	4.1x
baseline (text markup)	0.757	0.827	0.781	0.790	**1x**
goose3 3.1.9	**0.934**	0.690	0.821	0.793	22x
readability-lxml 0.8.1	0.891	0.729	0.820	0.801	5.8x
news-please 1.5.22	0.898	0.734	0.826	0.808	61x
readabilipy 0.2.0	0.877	0.870	0.874	0.874	248x
trafilatura 1.2.2 (fast)	0.914	0.886	0.902	0.900	4.8x
trafilatura 1.2.2 (precision)	**0.932**	0.874	0.905	0.902	9.4x
trafilatura 1.2.2 (standard)	0.914	0.904	**0.910**	**0.909**	7.1x

the overall flow of the program in brief detail; minor information is omitted from the flowchart for easier readability.

4.1 Web Scraping

Finding the url for the webpage is done in python using Selenium. Upon running the python program, the user is asked to input the name or url of a website for which they would like to read the privacy policy for, and then the program proceeds in the following fashion:

(1) Input the website address or name.
(2) Sanitize the URL so that it only contains the domain name.
(3) Using Selenium, the website is googled with addition of keywords privacy policy english to the sanitized url, e.g. facebook.com is turned into facebook privacy policy english.
(4) Then the first link in the google search is clicked.
(5) The url for now clicked page is fed into Trafilatura.

4.2 Extracting the text from the policy webpage

For extracting the text, Trafilatura is used. Trafilatura has a great balance of speed and accuracy. Table 1 compares the performance of Trafilatura with other similar extraction libraries [14].

4.3 Summarization

The summary generator receives the text extracted by Trafilatura. Then the text is summarized using BERT or SBERT and different models for both of them. Both BERT and SBERT are extractive summarizers; they only extract important sentences present in the text, discarding the rest; this creates a shorter text.

4.4 Summary analysis

The produced summaries are then analyzed using Rouge. Specifically, the Rouge LSum variant of rouge is used because Rouge LSum is effectively the same as RougeL, but it splits the sentences on new lines. Splitting the sentences on new lines is required as the text is automatically extracted, and not doing so may cause issues where a sentence in the next paragraph or line is considered a continuation of the previous sentence rather than a different sentence.

5 EXPERIMENTAL RESULTS

5.1 Aim and Methodology

The goal of this research is to serve as a basis for a more complete program that can be used by users to read privacy policies easily. The current prototype is successfully able to find privacy policies for a given website and subsequently extract and summarize these policies. The quality of these summaries is analyzed both quantitatively and qualitatively in the following section.

5.2 Data and Models

Privacy policies of 10 websites were extracted using the methods described previously. These policies were then summarized using different techniques and models. 3 different models were used for testing for both BERT and SBERT. Table 2 describes these models in brief detail.

Table 2. Model Description. First 3 models are BERT models and last 3 models are SBERT models.

Model	Description
BERT-base-uncased [4]	Baseline BERT model
BERT-base-uncased-contracts [2]	BERT model trained on contracts. Chosen Because privacy policies are a contract.
sciBERT-scivocab-uncased [1]	BERT model trained on scientific texts. Chosen because privacy policies are similar in structure and writing style to scientific papers
all-mpnet-base-v2	Baseline model and best performance.
all-MiniLM-L6-v2	Upto 5x as faster than base
paraphrase-MiniLM-L6-v2	Specific model for paraphrasing.

5.3 Quantitative Analysis

Table 3 and Table 4 describe the results of the analysis. For SBERT the model paraphrase miniLM performed the best with an average recall of 0.197. For BERT the model BERT base performed the best with an average recall of 0.176. Summaries of 10 websites were generated and compared to the original text using Rouge LSum. However, Microsoft's privacy policy has intentionally been excluded as the length of Microsoft's policy as shown in 5 is an outlier and would affect the average results.

(1) **Word Count**: Number of words the generated summary has.
(2) **Ratio**: Number of words in generated summary divided by number of words in the original summary.

Table 3. Performance of BERT models for 9 websites. All of the statistics measure average performance.

BERT Model	Results		
	Recall	Word Count	Ratio
BERT-base-uncased	0.176	741	0.179
BERT-base-uncased-contracts	0.170	717	0.171
sciBERT-scivocab-uncased	0.174	740	0.175

Table 4. Performance of SBERT models for 9 websites. All of the statistics measure average performance.

SBERT Model	Results		
	Recall	Word Count	Ratio
all-mpnet-base-v2	0.184	749	0.178
all-MiniLM-L6-v2	0.181	787	0.187
paraphrase-MiniLM-L6-v2	0.197	829	0.196

The performance of the 2 best performing models was then analyzed on every website individually. Table 5 describes these results. SBERT model almost always has both a higher recall value and a higher word count. Recall value is correlated to the word count as BERT/SBERT extract full sentences and as a consequence higher word count means more sentences present in the extracted text that are also present in the original resulting in a higher recall value.

5.4 Qualitative Analysis

Table 6 contains the summaries generated by the best BERT and SBERT model. The summary generated by both BERT and SBERT are both significantly shorter in length than the original, 473 words for the BERT model and 460 for the SBERT model, compared to 2379 words for the original summary. The results generated by the models are both comprehensible and cover a significant amount of points present in the original text. Both summaries talk about deleting your account, sharing data with 3rd parties and cookies. SBERT summary also talks about sharing your data with the government, while BERT summary makes no such mention; this might be an important policy concern for some that might be antagonistic towards a government. SBERT summary also explicitly states to not share any information you would not want 9gag to have.

The content of the summary largely covers most of the broad points but both of the summaries have included a useless table of contents section that explicitly states that "You can use this table of contents to move through our privacy policy and find what you need.". This might cause some confusion for readers for the summary. Additionally, information from some sections is not included; one of these sections is Our Policy on Children's Information. This section might be of great value to a guardian who is concerned for their child's privacy.

Furthermore, the structure of the generated summary also has 2 main issues. The sentence structure of the text generated is suboptimal. Some sentences might be chosen by the summarizer to

be included in the summarize, while some may not. In some cases, connective sentences might be removed. Another issue is with the formatting of the generated text. The generated paragraphs are not adequately separated and some sentences are connected without any separation making the summary difficult to read.

Some of these issues are mitigated by using other models, but as none of the models tested in this paper are specifically tailored towards summarizing privacy policies. Different models introduce their own set of issues, such as some sections being omitted or irrelevant sections being extracted.

6 RELATED RESULTS FROM OTHER STUDIES

There are existing studies that have tried to summarize privacy policies; one such study that I referenced earlier is Pocasum [3]. Pocasum is quite relevant to this study as they also summarize the policies extractively. They tested different machine learning models and the best performing models were found to be artificial neural network models. Table 7 shows a comparison between the results generated by Pocasum's ANN and the results generated by the best performing BERT and SBERT models.

Summarization of the first text by both BERT and SBERT is quite wrong due to summarized text missing the word "not". This makes the resulting summary give the impression that the original policy intends to collect the information when they explicitly state that they do not collect this information. Pocasum ANN does not run into this issue.

Summarization of the second text yields better results by both models. All 3 Summaries talk about relevant topics of collections and usage of the information. Pocasum's summary focuses more on what information is collected. BERT summary focuses more on how this collected information maybe used, and SBERT summary is a good balance as it states both how the collected information is used and what information is collected. SBERT summary also explicitly mentions the third party website Facebook, while the other 2 do not.

Overall BERT and SBERT seem to perform well if the length of the text is large enough but in cases where the text is too short there is the possibility of an omitted keyword, which may result in a changed meaning of the summary. This problem still persists in larger texts but is less prevalent.

7 LIMITATIONS OF THE STUDY

The results shown in this study are not conclusive and have a few glaring issues. Most of these issues stem from the limited scope and budget of the study.

Firstly, Rouge metric is designed to be used against a reference summary, but in this case it is being used against the original text. This effectively only tests the recall of the summary because only extractive summarizers are being used the precision is always 1 as the summarized text cannot contain any new words by definition. While recall is an important metric, it does not tell us the full story, but this is a limitation due to the scope of this study. Privacy policies are difficult to read, "Twitch's Privacy Policy scores 1,450 in reading complexity. For reference, a competent lawyer is expected to be able to read at 1,440 and a successful university student at 1,300." [9]. Privacy policies are difficult to summarize and a larger scale study would be required to summarize and peer review summaries and then compare them against automatically generated summaries.

Additionally, another issue is the limitations of the summarization techniques tested. Only extractive summarizers were tested in this study and only a few models. For more concrete results, a larger array of techniques and model testing is required. Furthermore, instead of testing generic preexisting models, a model tailored for summarizing privacy policies could be created; this would require more resources than testing preexisting models but would potentially lead to better summaries.

Lastly, currently the whole text is summarized all at once by the model, but there is a different approach possible where the text could be split up into multiple sections using keywords. Techniques employed in [5] could serve as a basis for splitting up the text into different categories. Splitting and then summarizing would allow usage of different models tailored to each section; this would possibly yield in a more coherent and clear summary.

8 FUTURE WORK

There are two ways in which the idea/prototype proposed in this research can be improved upon. First, being the language processing aspect of the project for this as stated in the previous section the easiest solution is to conduct a large scale study that takes the previous limitations into account and attempts to remedy them by

Table 5. Performance of best performing BERT and SBERT model for each individual website. WC = Word Count.

Website	BERT Performance				SBERT Performance			
	Recall	Original WC	Summary WC	Ratio	Recall	Original WC	Summary WC	Ratio
Discord	0.172	4974	861	0.173	0.199	4974	989	0.199
Microsoft	0.184	37688	6949	0.184	0.205	37688	7760	0.206
9gag	0.183	2499	461	0.184	0.211	2499	522	0.209
Business Insider	0.158	6310	997	0.158	0.205	6310	1294	0.205
Reddit	0.162	2376	395	0.166	0.203	2376	486	0.205
Twitter	0.196	4200	820	0.195	0.202	4200	845	0.201
Google	0.186	6360	1185	0.186	0.206	6360	1306	0.205
Amazon	0.133	3428	460	0.134	0.142	3428	491	0.143
Linkedin	0.185	4998	926	0.185	0.223	4998	1109	0.222
Twitch	0.229	2468	568	0.230	0.162	2468	425	0.172

testing other possible summarization techniques, splitting the text into different sections and comparing the auto generated summaries against reference summaries created by legal experts.

Secondly, the user experience of the prototype is currently quite lacking. The prototype currently requires the user to download and install python, then run the python script which takes a long time (2+ minutes) especially, if the user is running the script for the first time. The interface is a basic command line where a user has to enter the name or the URL of the website and after processing the results are outputted to the console. Instead of doing all of the above steps, most users would instead opt to accept the policy, so ideally the complete program would instead be a browser-based extension where users could just press one button and be presented with the summary of the website they are currently on. This complete program would process the information in the same way as the current prototype but instead of the user processing the text on their end, a request to a server would be sent where the server would either process the data if the website is not already present in the server database or website's privacy policy has been updated. Otherwise, the server would return the summarized text, which would then be displayed by the browser.

9 CONCLUSION

The aim of this research paper was to create a program that can automatically find and summarize any privacy policy to create a shortened version that is easier for the user to read. All of this was successfully achieved to an extent. The current iteration of the program can successfully find the summary, extract the text, and summarize the extracted text. One type of summarization technique was tested along with different models for this technique. The summaries generated by this technique proved to be readable and significantly shorter in length. The results overall show promise; however, the program performed poorly in some cases where a missed extraction of a word changed the whole meaning of the text. The results are also inconclusive as only a small set of preexisting models were tested. A larger study analyzing similar techniques could result in better summaries.

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A TABLES

This section contains the summary comparison tables.

Table 6. Summary comparision of 9gag.com's privacy policy

Model	Summary
BERT	= Privacy Policy = **Last Modified:** May 17, 2022 == Table of Contents == You can use this table of contents to move through our privacy policy and find what you need. Our mission is to make the world happier. When you use these services, you'll share some information with us. == How We Collect Information == === Information You Choose To Give Us === When you use and interact with our services, we collect the information you choose to share with us. To make it easier for others to find you, we may also ask you to provide us additional information that will be publicly visible on our services, for example a profile picture, a name, or other identifiable information. For example: How you interact with our services, such as what sections you look at, what you search for, what posts and comments you upload, or what posts and comments you upvote or downvote. For example: Post upvotes and downvotes Comments and comment upvotes and downvotes **Device Information. ** Most web browsers are set to accept cookies by default. Identifiers associated with cookies or other technologies that may uniquely identify your device or browser. If you interact with one of our advertisers, they may share information with us to help target or measure ad performance. Here's what we use this information for: To develop, maintain, improve, deliver, and protect our products and services. Monitor and analyze trends and usages of our products and services. Enhance and enforce the safety and security of our products and services. Enforce our Terms of Service, Community Rules, and other usage policies. We may share your information with third parties. We may share information about you with service providers who perform services on our behalf. With third parties as part of a merger or acquisition. When you use our website, we share information that we collect from you, such as your email (in hashed form), IP address or information about your browser or operating system, with our identity partners/service provider, LiveRamp. For example: We store your basic account information, including your name, username, and email address until you ask us to delete them. We store location information for different lengths of time based on how precise it is and which services you use. We are constantly collecting and updating information about the things you like or dislike, so we can provide you with more relevant data, more relevant ads, and a better user experience. If you decide to stop using 9GAG, you can ask us to delete your account. We hope you remain a 9GAG user for life, but if you want to delete your account, please contact us. If we need to rely on consent as a legal bases for processing your information and your country requires consent from a parent, we may require your parent's consent before we collect and use that information.
SBERT	= Privacy Policy = **Last Modified:** May 17, 2022 == Table of Contents == You can use this table of contents to move through our privacy policy and find what you need. Click on a link for a specific section and you'll jump right to it. Our mission is to make the world happier. When you use these services, you'll share some information with us. Please don't share content you wouldn't want someone to save or share. Lastly, when you contact us or communicate with us in any way, we'll collect any information you give us. For example: The images, videos, and text you upload We also collect information about the content you create. With your permission, we may also collect information about your precise location using methods that include GPS, wireless networks, and Wi-Fi access points. ** We may use cookies and other technologies such as web beacons, web storage, and unique advertising identifiers to collect information about your activity, browser, and device. Most web browsers are set to accept cookies by default. Removing or rejecting cookies may affect our service function and availability. ** Here's what we use this information for: To develop, maintain, improve, deliver, and protect our products and services. Examples include using e-mail to respond to support inquiries, or to share information about our products, services, and promotional offers that we think may interest you. Verify your identity and prevent fraud, or other unauthorized and illegal activity. Information about how you interacted with our services, such as the content you post, the comments you post, and the content you upvote. We may share information with all 9GAG users, our business partners, and the general public. Examples include: To comply with any valid legal process, governmental request, or applicable law, rule or regulation. Through these links, third-party integrations, and co-branded or third-party-branded services, you may be providing information, including personal information, directly to the third party, to us, or to both. You acknowledge and agree that we are not responsible for how those third parties collect or use your information. Some companies, including our affiliates, may use information collected on our services to measure the performance of ads and deliver more relevant ads, including on third-party websites and apps. For example: We store your basic account information, including your name, username, and email address until you ask us to delete them. We are constantly collecting and updating information about the things you like or dislike, so we can provide you with more relevant data, more relevant ads, and a better user experience. If you decide to stop using 9GAG, you can ask us to delete your account. We may let you know by revising the date at the top of this privacy policy, which is available on our websites and mobile applications.

Table 7. Summary comparison between Pocasum, BERT and SBERT.

Original	Pocasum Summary	BERT	SBERT
'A. WHAT KIND OF INFORMATION WE COLLECT a. Personal Information. We do not collect Personal Information. "Personal Information" is information that identifies you or another person, which may be transmitted or received when you use an Application, the Services and/or the Site. ion includes your names, physical addresses, email addresses, telephone, fax, SSN, information stored within your Device and other information you transmit or receive using an Application, the Service and or the Site which identifies you or another person.b. Non-personal identification. We may collect non-personal identification information about installed application s, application usage information and device information.The information you give us, for example, when you give us your opinions to our application and services v is our feedback channel, such as your email address, and names;'	'Personal Information. We do not collect Personal Information. A. WHAT KIND OF INFORMATION WE COLLECT a. We may collect non-personal identification information about installed applications, application usage information and device information.The information you give us, for example, when you give us your opinions to our application and services via our feedback channel, such as your email address, an d names; Non-personal identification.'	' A. WHAT KIND OF INFORMATION WE COLLECT a. Personal Information. ion includes your names, physical addresses, email addresses, telephone, fax, SSN, information stored within your Device and other information you transmit or receive using an Application, the Service and or the Site which identifies you or another person.b.	' A. WHAT KIND OF INFORMATION WE COLLECT a. Personal Information. Personal Information" is information that identifies you or another person, which may be transmitted or received when you use an Application, the Services and/or the Site.
[1] Information We Collect and Use: The Personal Information you provide is used for such purposes as answering questions, improving the content of the Services, customizing the advertising and content you see, and communicating with you about Company's products and services, including specials and new features.Personal Information You Provide to Us: We receive and store any information you enter on our Services or provide to us in any other way, including via any third party site or service through which you authorize us to access your information (e.g., Facebook). The types of Personal Information collected in this fashion may include but are not limited to, an individual's name, phone number, credit card or other billing information, email address and home address. This Privacy Policy in no way limits or restricts our collection of aggregate or anonymous information. In this Privacy Policy, we refer to all information collected from or about you, including personal information and non-personal information, as "Your Information." Use of Applications: When you launch any of our applications, we collect information regarding your device type, operating system and version, carrier provider, IP address, Media Access Control (MAC) address, International Equipment Mobile ID (IMEI), whether you are using a point package, the game version, the deviceś geo-location, language settings, and unique device ID. In addition, we create a unique user ID to track your use of our Service. This unique user ID is stored in connection with your Account profile information to enable us to move Your Information to a new device at your request. In addition, it may be used to link a character with which you play our games to your username on the Forums. When you play our games, we also collect information about your play and interaction with other users and the Service.'	'In this Privacy Policy, we refer to all information collected from or about you, including personal information and non-personal information, as "Your Information." When you play our games, we also collect information about your play and interaction with other users and the Service. The types of Personal Information collected in this fashion may include but not limited to, an individualś name, phone number, credit card or other billing information, email address and home address. This Privacy Policy in no way limits or restricts our collection of aggregate or anonymous information. In addition, it may be used to link a character with which you play our games to your username on the Forums.'	Information We Collect and Use: The Personal Information you provide is used for such purposes as answering questions, improving the content of the Services, customizing the advertising and content you see, and communicating with you about Company's products and services, including specials and new features. In addition, we create a unique user ID to track your use of our Service.	Information We Collect and Use: The Personal Information you provide is used for such purposes as answering questions, improving the content of the Services, customizing the advertising and content you see, and communicating with you about Company's products and services, including specials and new features. Personal Information You Provide to Us: We receive and store any information you enter on our Services or provide to us in any other way, including via any third party site or service through which you authorize us to access your information (e.g., Facebook).