Actors and Security Strategies in Malware Domains

EoS Assignment 3, Group 11

1. Countermeasures

For this report, we take a look at three of the actors involved in the security issue of malware domains and what countermeasures they could take to mitigate the problem. The actors we consider are the hosting providers, customers of hosting providers (we assume only customers with good intents. In this report we refer to them as ‘customers’ for the sake of brevity) and domain registrars since we believe that these actors are either close to the problem or, in the case of the customers, are needed for a complete picture of what is happening.

1.1 Concrete countermeasures per actor

In this section, we will discuss concrete countermeasures the actors could take to mitigate the security issue of malware domains. These countermeasures, while concrete, might not necessarily be the best and should often be combined with other countermeasures.

Hosting providers

As stated in [1]: "*...although hosting providers are a key actor in fighting website compromises, their ability to prevent abuse is constrained by the security practices of their own customers*". Therefore, it might be more effective for hosting providers to direct their security efforts towards the security of their customers. A countermeasure to mitigate risks would be to automatically update security patches. Another measure could be to recommend the hosting provider customers to update their software as soon as an update becomes available. This can be communicated on a regular basis via channels such as email or can be stated when the customer opens an account at the hosting provider.

Customers of hosting providers

Customers can mitigate the security issue by applying software patches as soon as they become available. They should also only use software that is considered safe by the industry. By downloading the latest updates, the systems the customer is hosting are not vulnerable to known exploits.

Domain registrars

Domain registrars can mitigate the security issue by scanning for malicious use of domains, using a detection system. Multiple of such systems have been proposed [2, 3, 4]. These systems aim to detect malware domain either by analysing URLs with linguistic tools or by analysing other domains to derive new malware domains. The benefit is that malware domains are actively being found, rather than being reactively found, as with standard blacklists.

1.2 Distribution of costs and benefits

In this section, we look at both the costs and the benefits of the defined actors with respect to the suggested countermeasures.

Convincing customers to update their software

Hosting providers convincing their customers to update their software would lead to a decrease in the vulnerabilities cybercriminals can exploit to place malware. This would mean that there will be less malware in the domains hosted by the hosting provider.

This would be a benefit for the hosting provider in question as there is a cost associated with removing malware. We expect that convincing the customers will take some time and therefore the benefit for the hosting provider will increase over time until a certain saturation is achieved in which all customers that can be persuaded in updating their software have done so. The benefit for customers depends on both the threat frequency and the threat capability that is applied to their application. The distribution can be assumed to have a high benefit after the first patch cycle if it has been a long time since the customer has updated its software. Then, for every next patch cycle, there will be some benefit for the customers, as it is applying the latest security updates. Then the benefit will lower over time because new vulnerabilities will be found in the software that is used. This effect will repeat itself after every software update.

The cost for this countermeasure is low for the hosting provider, as communicating with customers is a trivial task. We expect some initial costs on researching techniques to persuade customers or implementing a solid reminder policy, but after that, the costs should be negligible. One could argue that reminding customers to update security could be seen as annoying by customers, or it might create a feeling of safety because the hosting provider is perceived responsible with concerns to security. We do not consider these factors. Domain registrars do not have any cost associated with this countermeasure. The actor that has the highest cost is the customer if he chooses to listen to his hosting provider. Not only the updating itself takes time, but systems may also break because of software updates, causing extra costs for making the system function correctly again. The cost distribution has peaks corresponding to update periods. The costs will be a bit lower after, but they will not be negligible because the update

might have introduced bugs that need to be fixed. After this, the cost is zero until the next patch cycle.

Updating the software

Here, the customer is the actor that decides on updating the software, regardless of whether the hosting provider stimulates this. The situation is almost the same as described before, with an exception to the cost of the hosting provider, as this cost will be zero.

Deploying detection systems

When domain registrars deploy detection systems, they are the only ones that pay a cost. There is an initial cost, as the technology has to be bought first. Then, there are sunk costs as the staff of the registrar needs to be trained in order to use the technology, as there is always some manual handling needed. Last, there are recurring costs, as the technology will need to be maintained. In this case, it is logical to assume that the system has to be updated from time to time since cybercriminals will find ways to bypass the detection system. The benefits for the hosting providers is that they can respond earlier to infections. The customers do not have any benefit from this countermeasure.

1.3 The incentive to take the countermeasure

A question one could ask is whether an actor has the incentive to take the countermeasure. In the cybersecurity world, the entities that are in the position to mitigate a problem are often not the people that experience the problem [5].

Hosting providers

Reputation damage could be a huge loss for a hosting provider and an incentive to opt the countermeasures. A customer chooses a hosting provider by its value in the market. A customer might not want to compromise on choosing a hosting provider with a large number of services but low market value. As the market value defines how the hosting provider has sustained in the market all this time. The other incentive could be the finances expended from the hosting providers' end. To achieve the financial gains, a hosting provider first has to invest in the security of its customers. For this reason, the hosting provider prefers risk mitigation strategy over other strategies because it is cheaper to mitigate risk than to transfer it.

Customers of hosting providers

In case the application of the customer gets targeted by cybercriminals, there are multiple possible scenarios. The first scenario is that the cybercriminals may choose to take down the website and put up their own one that contains the malware. In this case, the customer's website is no longer available. In the second scenario, the cybercriminals are able to put the malware on the website of the customer. In this case, visitors of the website might download

malware, which, if traced back to the website, might affect the reputation of the website owner negatively. Also, services like Google Search will eventually remove the website from the search engine. In both of these cases, the customer of the hosting provider is affected negatively by the security problem. Because of this, he has the incentive to apply the countermeasure as described in section 1.1.

Domain registrars

Domain registrars have the incentive to prevent visitors from visiting infected URLs as it could damage the visitor's computer with malware. It could also lead to severe damages like domain transfer where the visitor unknowingly shares all the credential information. If there is regular monitoring and scanning on all the URLs in the domain and the detected evil URLs are blacklisted, it would create a safe network for the visitors and account holders.

1.4 The role of externalities

Externalities are the aftereffects that an entity has to bear, though they did not intend to. These externalities could cause good or harm depending upon the outcomes. Negative externalities result in an overuse or overproduction compared to the social optimum whereas positive externalities lead to an underuse or underproduction of the resource afflicted with the externality [6]. In other words, a negative externality is any harm that is imposed on a third party as a consequence of another's actions while a positive externality is a benefit to a third party that is the consequence of another's actions. The role of externalities also defines the need to implement the appropriate countermeasures to internalise the existing or upcoming risks.

Hosting providers

If a hosting provider is unable to provide software security patches to its customers, the customers might have to face the unwanted intrusions at some point. Also, the hosting providers will have to face negative externalities such as reputation damage or decline in market value. A higher number of users getting infected by visiting the malicious website can lead to a lesser number of new customers creating an account on that hosting provider. In case of severe damages, where the hosting provider is accountable for the customer's loss, it might fail to get new customers. To internalise this, the hosting provider can block the account that is used by the attacker for sending spams, stealing credentials of a user or for uploading abusive content.

Customers of hosting providers

If the customers do not update their software to enhance the security and mitigate risk, they could face distinct externalities. It could be a major or a minor one. The major externalities caused by the malware attacks could be identity theft, monetary damage, political issues or character assassination and minor externalities such as unwanted interruptions or system slow down. Such externalities (both major and minor) influence customers to invest their additional

time in cleaning up the infection and fixing the problem. Even when there is no monetary damage or material loss, that is, the infection is benign from the customer point of view, still time is invested to fix flaws to avoid further interruptions by the attacker. Sometimes it is not up to the customers to update the software as the system is provided by the hosting providers itself. In that case, the customers must keep a regular check if any security patches are made available by the hosting providers or not.

Domain registrars

Domain registrars, like already mentioned, can mitigate the risk by scanning and monitoring the domains or URLs. They do this because of the externalities they encounter. An infected domain (or domains) can redirect the visitors to different malicious domains where the visitors might infect their computer with malware. Since domain registrars are in possession of the master database of all domain names registered in each top-level domain (TLD), they can internalise the externalities by running scanning tests over existing domains or URLs and output the results, such as Warning, Alert, Info, Error or Notice, for the suspected URLs. This can reduce the vulnerability of the risk and prevent users from visiting malicious websites.

2. Variance in the metric

In this section, we aim to understand the variance in the security metric by exploring the impact of different factors.

2.1 Responsible factors

In this section, we will give an overview of factors that might be responsible for variances in the security metric.

Country

The country of the ASN can have an impact on the security performance of the hosting providers and other actors, take for example the legislation in the country. Legislation can influence certain measures an owner of an ASN has to take and how liability is defined. The incentive to improve security comes with liability. The liability can be at the hosting providers, customers of hosting providers or domain registrars depending on the local legislation.

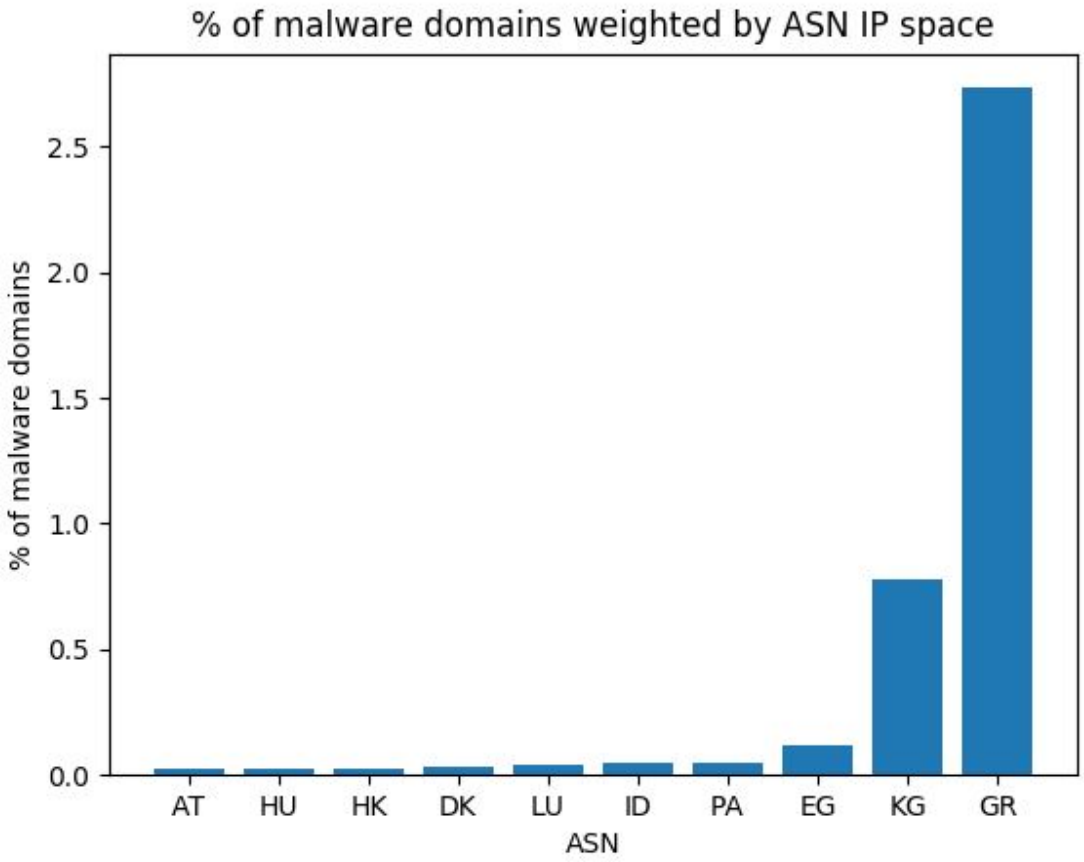
Quantifying legislation is very difficult, therefore we opt to test the correlation between the GDP per capita and the ASNs. This enables us to check if there is a relation in the security performance of the ASNs and the economic performance of their country of origin. We predict a negative relation; a lower GDP per capita relates to higher infection rates.

Size of the ASN

One explanation of the variances in our security metric could be the influence of the ASN size on the infection percentage. We suspect larger ASNs to have a lower infection rate. Due to the large economies of scale in information security, it should be easier for large hosting providers (and thus ASNs), to mitigate the security risk. Also as we have learned, similar security risks often occur at the same time. Together with information asymmetry, a large hosting provider should be able to perform on our security metric. We, therefore, hypothesize that the size of the ASN has a negative correlation with the percentage of malware infections in the ASN.

2.2 Data gathering

In the previous assignment, we looked at the incident rate per ASN weighted by their IP size. This time we will accumulate all ASNs of a country, that occur in our data.

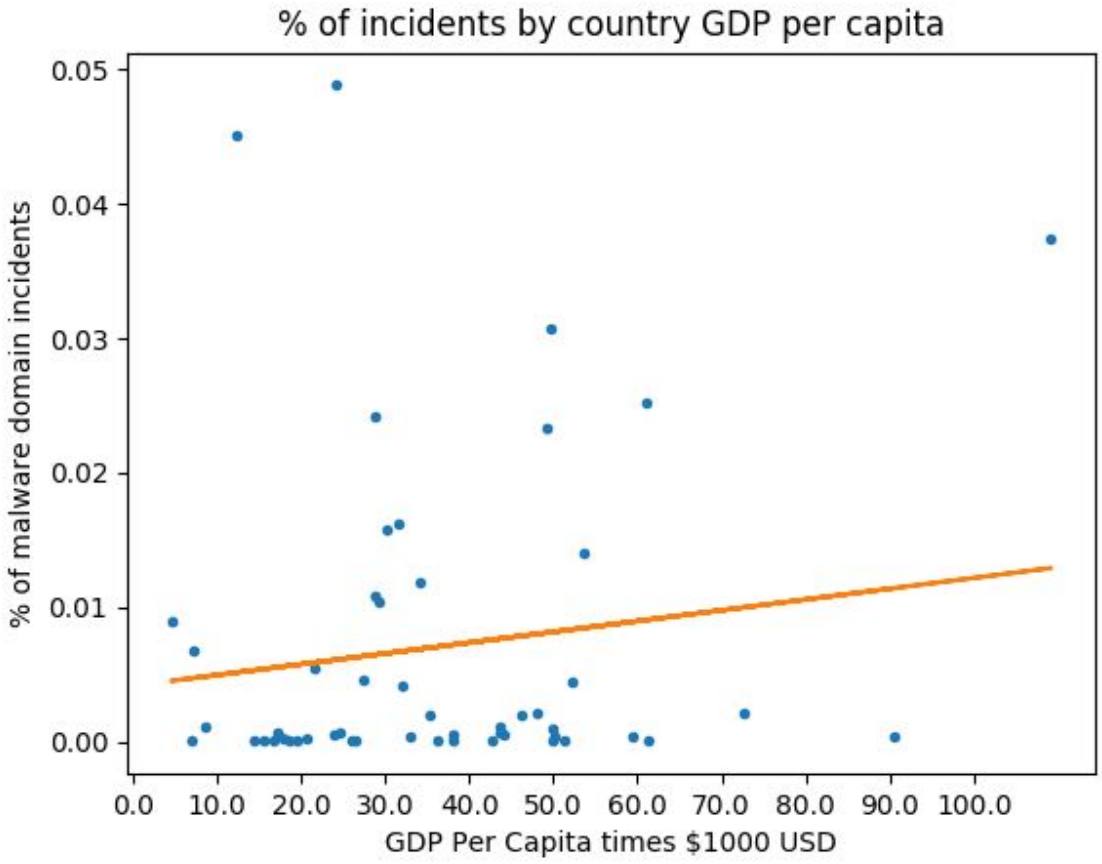


As can be seen in the chart above, there are some big outliers. This is not because KG or GR is very special, it is mostly because there is only 1 small ASN in our dataset for GR. To prevent these kinds of outliers of distorting our analysis, we filtered out all results whose values differ more than two times the standard deviation from the mean.

2.3 Statistical analysis

For our analysis, we look at the incident rate of ASNs ordered by country. In total there are 61 countries hosting malicious domains in our dataset. We used Numpy to calculate the statistical values. In this section, we will investigate in the correlation between the GDP of a country and their average incident rate from our data set.

As part of the analysis, we made a scatter plot. Above is a chart of the incident percentage plotted against the GDP per capita of the country. Using linear regression analysis we deducted a slope from our data.



As you can see, there is a small upwards slope. However, the scatter points do not paint a clear picture. Partly because the variance is quite high, but also because there are more low GDP countries in our dataset then high GDP countries.

To test if there is a correlation between the two variables, we use the Pearson R test. This is also known as the Pearson correlation coefficient. This value lies between -1 and 1, being negative linear correlation and positive linear correlation respectively (0 means no correlation).

Using the Python library SciPy we calculated the Pearson r value. SciPy also returns a p-value which is useful to get an idea of how correlated our dataset is. The Pearson r value of the countries GDP and incident percentage is 0.1389. This would mean there is a small positive correlation (similar to what we found with linear regression). However, the corresponding (two-sided) p-value is 0.3278, which is not statistically significant. This means that we can not prove this (slightly) positive correlation.

3. Conclusion

Based on the scatterplot and the calculated r value, there appears to be a small positive correlation between GDP per capita and incident rate. We expected a negative relation, based on the evidence we cannot confirm our hypothesis for now. Furthermore, the r value is too low to make any sound conclusions.

4. References

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