Getting Bored of Cyberwar: Exploring the Role of Civilian Participation in the Russia-Ukraine Cyber Conflict

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Abstract—There has been substantial commentary on the role of cyberattacks, hacktivists, and civilian participation in the Russia-Ukraine cyber conflict. Drawing on a range of data sources, we argue that the widely-held narrative of a cyberwar fought by committed civilians and volunteer ‘hacktivists’ linked to cybercrime groups is misleading. We collected 281k web defacement attacks, 1.7M reflected DDoS attacks, and 441 announcements (with 58k replies) of a volunteer hacking discussion group for two months before and four months after the invasion. To enrich our quantitative understanding, we conducted interviews with website defacers who were active in attacking sites in Russia and Ukraine during the period. Our findings indicate that the conflict briefly but significantly caught the attention of the low-level cybercrime community, with notable shifts in the geographical distribution of both defacement and DDoS attacks. However, the role of these players in so-called cyberwarfare is minor, and they do not resemble the ‘hacktivists’ imagined in popular criminological accounts. Initial waves of interest led to more defacers participating in attack campaigns, but rather than targeting critical infrastructure, there were mass attacks against random websites within ‘.ru’ and ‘.ua’. We can find no evidence of high-profile actions of the kind hypothesised by the prevalent narrative. The much-vaunted role of the ‘IT Army of Ukraine’ co-ordination group is mixed; the targets they promoted were seldom defaced although they were often subjected to DDoS attacks. Our main finding is that there was a clear loss of interest in carrying out defacements and DDoS attacks after just a few weeks. Contrary to some expert predictions, the involvement of civilian and volunteer ‘hacktivists’ in the conflict appears to have been minor and short-lived; it is unlikely to escalate further.

Index Terms—Web defacement; DDoS attacks; Cybercrime underground; IT Army of Ukraine; Russia-Ukraine conflict.

I. INTRODUCTION

Researchers, politicians, and journalists have long been fascinated by ‘cyberwar’ – the spectre of armed conflict between nations spilling over into attacks conducted over the Internet [1]. ‘Colder’ forms of inter-state conflict are characterised by espionage and intelligence gathering, which may facilitate the degradation of online systems once hostilities commence [2]. Alongside this there has been a thirty-year history of speculation around how the tools and techniques of the cybercrime underground – Distributed Denial of Service (DDoS) attacks, disruption and compromise of services, defacement of web pages, and similar techniques – might allow civilians to play a role in a ‘hot’ war between developed nations [3]. Much of this speculation, drawing from criminological models of low-level underground cybercrime groups and on links between this underground and well-organised ‘hacktivist’ movements, has argued that these groups would play a significant role, making the future of war hybrid, chaotic, and unpredictable [4]. The 2022 invasion of Ukraine by Russia provides an opportunity to assess what has happened in practice.

Russia and Ukraine have a long history of electronic information warfare and are among the most active cybercrime hubs [5]. Hence, when Russia invaded Ukraine on 24th February 2022, there was an expectation of civilian engagement in a ‘cyberwar’. Attacks targeting Russia and Ukraine connected to the war are regularly reported in the media [6], [7], [8]. A popular narrative is that the engagement of civilians and volunteers will be a game changer in the conflict. Some commentators have predicted it will be the “first full-scale cyberwar” [9] and that young people would be drawn into cyberattacks by joining the ‘IT Army of Ukraine’ – a group set up by the Ukrainian state to co-ordinate volunteer hacktivists and civilians to help disrupt and attack Russian assets. The security industry has suggested that there would be a “real cyber war”, predicting hacktivist attacks on Russia would escalate further throughout 2022 [10]. These narratives regularly appear in the press and play a role in shaping domestic policy responses to cybercrime. Although less likely to grab headlines, there is a contrary narrative around ‘overhyped cyberwar’, suggesting little impact of volunteer cyberattacks on the conflict. GCHQ commented the cyber conflict has not yet materialised [11] and point to the resilience of Ukraine’s defences [12].

We explore the role civilians have played in the Ukraine cyber conflict so far. Our study starts from quantitative longitudinal measurements on a range of datasets associated with the low-level cybercrime linked with civilian activities, including web defacement and reflected DDoS attacks (§IV). The findings are enhanced with an analysis of discussions from a pro-Ukraine volunteer group promoting DDoS against Russia (§V), then strengthened by qualitatively interviewing individuals responsible for a significant number of defacements targeting either Russia or Ukraine (§VI). This is the first academic work to explore, using a range of methods, the role of civilian engagement in a conflict in which both sides have substantial IT infrastructure, a thriving digital underground crime ecosystem, and significant access to offensive capacities.

We find remarkable geographical shifts of defacement immediately after the invasion (Figure 1). However, it appears that alarmist predictions of civilian participation have not come to pass. Our analysis challenges narratives of a ‘cyberwar’ producing organised, motivated, and technically skilled civilians and volunteer hacktivists. Instead, we find that most budding cyberwarriors used trivial attacks to take down meaningless minor targets and largely got bored after a couple of weeks.

Our data and scripts are available to researchers through the Anonymised Centre, see Appendix B. Our study was approved by our institutional Ethics Review Board, allowing us to collect, analyse the data, and conduct interviews while
minimising risks to participants, see more in Appendix A. A dashboard to monitor country-based defacement and amplified DDoS attacks over time is available at http://cyberstrikes.live/.

II. BACKGROUND

The development of Internet measurement scholarship in recent years has contributed to, and in some cases challenged, criminological understanding of the drivers of cybercrime. Measurement studies of the impact of externalities on cybercrime and policing have been explored; law-enforcement interventions in DDoS-for-hire markets have shown distinct effects for various kinds of interventions [13], [14]; the COVID-19 pandemic has affected illicit trading activities [15], scam and fraud [16], [17], [18], online victimisation [19], novel cybercrime vectors [20], listings on darkweb markets [21], [22], [23]; and cybercrimes have been connected to increased long-term psychological and financial consequences for victims [24]. Yet, there has been almost no empirical academic research looking at the relationship between armed conflicts and cybercrime. Some have been conducted in the private sector [25], [26]; the incident response team of a Czech university has reported negligible impact on their network after hundreds of their users launched DDoS attacks against Russia for a week after the invasion [27].

Information warfare has long been a routine part of armed conflict, especially around controlling communications. Cryptography has thousands of years of history and its contemporary usage in the NATO context includes a range of offensive cyber operations [28]. The enemy’s capability to spread news and propaganda can be impacted by targeting important websites, public services, broadcast and telecommunication infrastructure. Russia has blocked news and anti-war domains since the war started [29]. Attacks are not just online – Russian missiles hit TV towers in Kyiv in early March 2022 [30]. Censorship is often used during wartime [31]; governments block access to global services, especially social networks, news, and media platforms to suppress unwanted narratives.

An association between kinetic warfare and ‘nationalistic’ cyberattacks has been reported with various information operations. Ukrainian firms were hit by data wipers such as CaddyWiper and NotPetya [32], [33], DDoS attacks [34], [35] and phishing campaigns [36], while Ukraine supporters have used spam senders to distribute propaganda in Russia [37] and have stolen cryptocurrency from Russian wallets [38]. Ukrainian universities were hacked [6] and the Ukrainian electricity grid was hit by Industroyer2 [39], while Russian organisations received phishing emails from Chinese state-sponsored hackers [40]. Groups identifying themselves under the banner of the Anonymous movement 1 declared a ‘cyberwar’ on Russia [44] with attacks against a Russian Ministry of Defence database [45] and state TV channels [46]. Russian systems received DDoS attacks instigated by volunteer hackers from the IT Army of Ukraine – attacks they claim to have been significant enough that many important Russian websites adopted additional DDoS protection measures and in some cases have restricted access to just Russian IP addresses.

Routine acquisitive crime (e.g., malware and ransomware), has continued. ‘Big fish’ behind significant real-world attacks may not list themselves in public (which is also observable from our data and interviews). Yet, those crimes are reportedly state-sponsored; we are particularly interested in the engagement of many ‘small fish’, including low-level cybercriminals, civilian and volunteer ‘hacktivists’ instead of state actors. It is on the hypothetical ‘volunteer army’ of low-level cybercrime actors – and particularly their offensive tools for launching attacks – that we focus in this paper. Thus, we do not cover financial crime, fraud, data leaks or ransomware.

One of the attacks associated with the low-level ‘script kiddie’ cybercrime is web defacement. Adversaries (or defacers) gain unauthorised access using off-the-shelf tools and

1 A non-hierarchical online social movement, various factions of which have been involved in political activism and online mischief of different kinds, historically using ‘cybercrime underground’ techniques like DDoS and defacement but more recently focused on data leaks [41], [42], [43].
simple exploits, then alter websites’ appearance to demonstrate success. Defacers are often organised in groups [47] and have been using online defacement archives as a ‘hall of fame’ to show off their achievements, gain reputation, spread their messages, and make money [48]. Defacement is thus more akin to an online sport – like competitive graffiti tagging – than serious organised crime. It was widely used as the conflict started as it could deliver political messages and propaganda and because the tools allow for defacement at scale.

Another simple type of cyberattack is amplified DDoS, which floods targets with unwanted traffic, preventing them from servicing legitimate users. Tools and scripts for DDoS are widely available; in the case of the Russia-Ukraine conflict, they were tailored and provided to volunteers by a pro-Ukrainian group to attack Russia. Websites providing DDoS-as-a-service abound [49], so launching attacks is straightforward, even for those without much technical expertise.

### III. Methods and Datasets

We take a mixed-methods approach, enriching quantitative measurement-based evidence with complementary qualitative research. First, we drew insights and interpretations based on three quantitative datasets collected on a regular basis: web defacements, amplified DDoS attacks, and discussions from the IT Army of Ukraine’s Telegram channel. Defacement and DDoS attacks are often used by civilian and volunteer attackers, and we wanted to know whether they play a significant role in the conflict. Web defacements deliver political propaganda and taunt opponents with compromised websites, while DDoS was the primary method adopted by the ‘IT Army of Ukraine’. These attacks can be measured systematically with reasonable completeness. Our study does not cover state-level attacks as it is challenging to collect such data rigorously. Our datasets span 1 January to 30 June 2022, covering two months before and four months after the invasion. Second, we interviewed participants involved in these attacks – focusing on those engaging in defacing Russian or Ukrainian websites – to illuminate our quantitative findings and develop a better understanding of how the conflict influenced their activities.

#### A. Web Defacement Attacks

The most popular active defacement archives include ZONE-H, ZONE-XSEC, HAXOR-ID, DEFACER-PRO, and DEFACER-ID.2 The largest is ZONE-H, online for over two decades since March 2002. It provides cybersecurity news and self-reported defacements along with hacking content [51]. It holds over 15M reports (around 2,000 submissions per day, far more than the others). The others are more modern, but function similarly: ZONE-XSEC (since May 2020), HAXOR-ID (from November 2019), DEFACER-PRO (since June 2021), and DEFACER-ID (since February 2016) with around 220K, 90K, 70K, and 11M submissions, respectively. While not all compromised websites will be reported, measuring trends from the four most trusted archives is still informative. We identify the country of defaced websites based on ccTLD, IP geolocation, and geolocation of the AS hosting that IP, excluding CDNs (see Appendix F).

The defacement submission process is mostly automated; while ZONE-H requires authentication, other sites do not. Users specify a ‘notifier’, team name (except ZONE-H), defaced URL, type of vulnerability, and hacking incentives (except DEFACER-PRO and DEFACER-ID). New reports are kept ‘on hold’ (hidden from the main dashboard) until verified either by staff or bots, at which point a record is made with details of the compromised system, its IP address and location, and

2 Our participants confirm ZONE-H is the most trusted, while the others are less reputable. Smaller archives were historically active (analysed by existing work [50]), but are either no longer available (HAXOR and MIRROR ZONE) or have changed to host different content (HACK-CN and MYDEFACE).

### Table I: The complete collection of web defacement archives for the 6 months from 1 January 2022 to 30 June 2022.

| Home URL          | ZONE-H zone-h.org | ZONE-XSEC zone-xsec.com | HAXOR-ID hax.or.id | DEFACER-PRO defacer.pro | Overall |
|-------------------|-------------------|-------------------------|--------------------|-------------------------|---------|
| Authentication required | ✓                  | ✓                       | ✓                  | ✓                       | ✓       |
| Manual staff verification | ✓                  | ✓                       | ✓                  | ✓                       | ✓       |
| Automatic validity sanitisation | ✓                  | ✓                       | ✓                  | ✓                       | ✓       |
| Team information | ✓                  | ✓                       | ✓                  | ✓                       | ✓       |
| Country of targeted victims | ✓                  | ✓                       | ✓                  | ✓                       | ✓       |
| Originating country of defacers | ✓                  | ✓                       | ✓                  | ✓                       | ✓       |
| Reason and motivation | ✓                  | ✓                       | ✓                  | ✓                       | ✓       |
| Type of vulnerability | ✓                  | ✓                       | ✓                  | ✓                       | ✓       |
| Snapshots of defaced websites | ✓                  | ✓                       | ✓                  | ✓                       | ✓       |

Duplicated defacements and defacers within and across archives are unified

|                | Defacements (raw) | Defacements (unified) * | Valid defacements (unified) * | Invalid defacement (unified) * |
|----------------|-------------------|-------------------------|-------------------------------|-------------------------------|
|                | 164 312           | 164 312                 | 143 485 (87.32%)              | 20 827 (12.68%)              |
|                | 53 852            | 53 814                  | 53 705 (99.80%)              | 109 (0.20%)                 |
|                | 34 482            | 34 465                  | 34 439 (99.92%)              | 26 (0.08%)                  |
|                | 28 594            | 27 662                  | 26 379 (95.36%)              | 1 283 (4.64%)               |
|                | 281 240           | 249 879                 | 227 636 (91.10%)             | 22 243 (8.90%)              |

|                | Defacers (raw) | Defacers (unified) * | Defacers with valid reports (unified) * | Defacers with invalid reports (unified) * |
|----------------|----------------|----------------------|-----------------------------------------|------------------------------------------|
|                | 2 019          | 2 019                | 1 655 (81.97%)                          | 844 (41.80%)                             |
|                | 542            | 542                  | 541 (99.82%)                            | 24 (4.43%)                              |
|                | 445            | 445                  | 443 (99.55%)                            | 15 (3.37%)                              |
|                | 497            | 497                  | 486 (97.79%)                            | 147 (29.58%)                            |
|                | 2 713          | 2 713                | 2 019                                   | 986 (36.34%)                            |

✓ fully available; ✓ partly available; · not available; * duplicated defacements and defacers within and across archives are unified
a snapshot of the defaced website content is taken (often consisting of the defacer's messages, which may contain political and ideological propaganda [48]). Although 'notifier' can be arbitrarily entered, defacers are incentivised to use a consistent handle to build up fame and reputation. We therefore consider 'notifier' to be reliable enough to differentiate between defacers. We consider snapshots of defaced websites to be reliable, as they are captured at reporting time; they may contain hidden messages with the font colour identical to the background, but detectable by analysing the HTML.

We use web scrapers to visit the archives and collect defacements. The process, detailed in Appendix C, is not straightforward as we need to ensure data completeness and bypass blocking challenges such as CAPTCHA and IP blacklisting. Our collection includes ZONE-H, ZONE-XSEC, HAXOR-ID and DEFACER-PRO (see Table I), while excluding DEFACER-ID due to its unreliability: (1) its volume during the period is not large (less than 27K apparently valid reports); (2) no reliable validation, as staff verification is unclear, users are unauthenticated, no validity sanitisation on submission and no validity signal when viewing reports (in fact, over half of these have been deemed invalid by the site's own verification efforts); (3) snapshots of defaced websites are unavailable, so the messages left on defaced pages are missing; and (4) victim geolocation is mostly lacking and determining it after the fact is problematic since websites can be relocated after an attack.

Further steps are performed to enhance data reliability. First, many on-hold submissions are valid but were never verified; defacers in our later interviews confirmed the necessity to look at both the archives and on-hold submissions. We therefore perform a semi-automatic validation of on-hold reports using the messages left on the defaced pages (see Appendix D). Second, submissions may be reported to multiple archives to broaden their visibility and gain reputation. We de-duplicate across and within archives by hashing their content (see Appendix E). Third, as ‘notifier’ can be arbitrary, typos can give a single attacker multiple identities. So we correct typos by comparing handles’ similarity, and checking against messages left on the defaced pages (see Appendix E). This handle unification is done across all archives.

In total, 137,339 submissions were verified by the archives, 62,381 were automatically validated by us and a further 27,916 were semi-automatically validated. We consider 22,243 to be invalid or not decidable due to lack of evidence. ZONE-XSEC, HAXOR-ID, and DEFACER-PRO have high validity rates (99.80%, 99.92%, and 95.36%, respectively), suggesting their automatic sanitisation works well at reducing invalid submissions. The validity rate of ZONE-H is lower at 87.32%. As a cross-check, ZONE-XSEC and HAXOR-ID have low rates of defacers submitting at least one invalid report (only 4.43% and 3.37%) and high rate of defacers with at least one valid submission (99.82% and 99.55%, respectively). ZONE-H and DEFACER-PRO have high rates of at least one invalid submission per defacer (41.80% and 29.58%, respectively), but DEFACER-PRO has a higher rate of defacers submitting valid reports, 97.79% compared to 81.97% of ZONE-H. These figures once more suggest the automatic validity sanitisation is effective. Duplicate submissions are removed: 31,361 (11.15%) have been unified across all archives; the remaining are 249,879 with 227,636 valid defacements (91.10%) are used for our analysis, in which 2,880 valid handles are also unified to 2,345. Notably, two handles of a defacer who was very actively targeting Russia during our study period were unified.

B. Amplified DDoS Attacks

We use data on DDoS attacks gathered by a honeypot network deployed worldwide since 2014 [52]. The honeypots emulate UDP protocols vulnerable to reflected UDP amplification DDoS attacks and are discovered by people scanning for reflectors. The honeypots record this scanning traffic and subsequent attacks, but avoid forwarding amplified traffic toward victims. The nature of these attacks means that only victim information is recorded and the attack origin is not available. This dataset has good coverage for the protocols emulated, though there is a risk of honeypots being systematically avoided by attackers [52].

In 2022, the median number of honeypots contributing data was 50, 95% CI [34, 51]. A flow of packets is considered to be an attack if any sensor observes at least 5 packets intended for the same victim IP or IP prefix, and the attack is deemed to last from the first packet until the last packet preceding a 15 minute period without further packets. In 2022, the observed median number of attacks per week was 35,000, 95% CI [11,900, 271,000] and on IP prefixes of 438, 95% CI [0, 3,480]; the median duration of attacks was 1.53 minutes, while the maximum was 11 300 minutes. The country of DDoS victims is identified based on IP geolocation and geolocation of the AS hosting that IP, excluding CDNs (detailed in Appendix F).

C. Volunteer Hacking Discussions

Recent years have seen increasing use of messaging apps such as Telegram and Wickr to co-ordinate cybercrime activities, with underground communities supplementing traditional forum-based modes of organisation with a range of other channels, particularly for more sensitive conversations. A couple of days after the invasion, the Ukrainian government called on pro-Ukraine ‘hackers’ to join the ‘IT Army of Ukraine’ to support the war effort. The most tangible outcome is a public Telegram channel, largely used for news, pro-Ukraine messages, and to co-ordinate disruptive efforts against Russian web services. The channel asks to recruit and encourage those with relevant skills – whether employed in legal cybersecurity work or in more criminal ventures – to collaborate in attacking Russian infrastructure. They use a range of attack vectors (but mostly DDoS) to disrupt communication and financial systems by hitting banks, businesses, government, and logistics [53].

The Telegram channel, attracting more than 230K subscribers, provides access to guides and tools for launching DDoS attacks. Most days there are announcements in

3 IT Army of Ukraine: https://itarmy.com.ua/
4 Tools include software to run DDoS attacks by individuals, software namely ‘Death by 1000 needles’ to quickly fetch daily targets, and software for granting access to individuals’ cloud resources for later coordinated attacks.
Ukrainian and English advertising new lists of Russian targets (hostnames and IP addresses). This ‘cyber army’ has claimed that ordinary Russians have seen the impact when they hit banks, exchanges [54], and cinemas [55]. The channel suggested new ways of conducting attacks, including the use of VPNs, once it was determined that some important Russian websites (e.g., SberBank) had taken defensive measures (e.g., restricting access to Russian IP addresses only, using third-party DDoS protection services) after being hit by attacks. While alternatives exist, Telegram is extensively used for communication amongst Ukrainian civilians. Unofficial satellite groups have far fewer subscribers; the group we analysed was the primary one, with messages being forwarded to the others.

We use Telethon and Pyrogram5 to collect 441 announcements with 57,757 replies and 900K emoji reactions posted on the official Telegram channel of the IT Army of Ukraine from its creation until 30 June 2022. The tools interact with official Telegram APIs, so they can fully capture messages and metadata. We use this dataset to track the choice of targets and cybercrime activities of volunteers as the conflict progresses.

D. Interviewing Website Defacers

A handful of attackers were responsible for the majority of the web defacements that occurred once the war began; we interviewed two participants, each from teams responsible for defacing many Russian and Ukrainian websites. The interviews were designed to gain a qualitative understanding of defacement activities and motivations, how they shifted over time (particularly during the war), how victims are selected, and the impact of the conflict on choice of targets. We also approached other prolific defacers who did not target Russia or Ukraine during the period, but they either did not reply or declined to be interviewed — “They do not like to be famous or share their secrets; they are very silent”, explained one of our participants. We therefore extended our interviews to ask some further questions about the wider community’s opinions and behaviours relating to the war, as many defacers are active in a private chat group, and claim to know each other well.

We do not attempt to generalise the participants’ responses, but rather help inform the insights derived from our quantitative measurements. We found they help substantially in interpreting the movements and associations between and within our measurement datasets. They represent insights from individuals involved directly in the generation of our data. Thus, we present these qualitative interviews not as a robust sociological study of these communities, but rather as a way of gaining insight into our quantitative collections and analysis, in the tradition of previous social data science and digital phenomenological studies [56]. These use partial qualitative collections to enhance the analysis of quantitative evidence generated in complex environments with a range of potential determining factors [57]. As quantitative data can be explained in different ways, we incorporate qualitative interpretation to strengthen our conclusions.

5 Telethon: https://telethon.dev/ and Pyrogram: https://pyrogram.org/

We recruited our participants by reaching out to social media accounts of teams linked with defaced websites. The first to reply referred us to the second participant. Our participants were members of two ‘black-hat’ hacking teams (as they claimed), each supporting different sides (Russia or Ukraine). One identified themselves as the ‘team owner’, while the other claimed to be a key official member responsible for all of his team’s attacks. To establish trust, we explicitly let them know our identity as academic researchers, the reasons for our interest, and we did not ask questions that could potentially de-anonymise them. We used a semi-structured interview schedule, which included warm-up questions, followed by a lengthy interview in which follow-up questions are adapted flexibly based on previous responses (see Appendix G).

We followed a strict protocol for the safety and privacy of participants and researchers. First, we obtained ethics approval from our institution (Appendix A). We then contacted participants and invited them to the interview. An informed consent package introducing our research project was delivered prior to the interview, which clearly explained the topics to be covered and potential risks to participants. At the start of the interview, participants consented to be interviewed and for their team information to be explicitly disclosed in this paper. Interviews were conducted by text chat on Telegram only (no audio or video recording). Participants could refuse to answer any question. The interview responses were synthesised, then all chats were permanently destroyed. Participants were provided with a copy of our synthesised findings to check for misunderstandings or potentially identifying information.

The first participant is part of a Kurdish competitive defacement team founded in 2019. They said that they initially attacked government websites for political reasons, but then expanded to include businesses, banks and other government sites. The team has links with Kurdish nationalism; when Turkey and Iran were attacking Kurds, the team claimed to have hit many Turkish and Iranian targets and to have left messages to support their cause. This team is among the top 10 active defacers since January 2022, and they were the fourth most active team targeting Russia when the war began.

The other participant claims to be a member of the first Brazilian group acting outside of Brazil (founded in 2019, now disbanded). They said that they initially only attacked Brazilian targets, but then escalated to other countries, mostly focusing on government and educational sites. They have not been among the top ten defacers since January 2022, but when the war started they were the second most active team targeting Ukrainian websites.

IV. The Evidence of Cyberattacks

Having initially detected the increase in web defacements targeting Russia (Figure 1), we started to measure the shift of cyberattacks in more detail, both on the Russia-Ukraine and global scales. This section discusses the evidence we collected of defacements, DDoS attacks, and what we have learnt about involved actors as the war progressed. Only validated attacks are used and timestamps are normalised to UTC.
Figure 2: Defacement and DDoS attacks targeting Russia and Ukraine during the 6-month period (red stars mark the invasion day). Russia quickly became a big target, followed by Ukraine a few days later. However, both outbreaks were fairly short-lived.

Figure 3: Counts of web defacement and defacers (left); DDoS attacks and victims (right) targeting Russia and Ukraine by hour for four weeks around invasion day (indicated by red stars). The scales differ, but the larger the bubbles, the more attacks.

A. Attacks Targeting Russia and Ukraine

Figure 2 shows defacement and DDoS attacks observed on Russia and Ukraine over the six month period of our study. Figure 3 shows the hour by hour changes for the most active four-week period from 17 February for defacements, and from 24 February for DDoS attacks where the activity was almost entirely after 7AM (we count both DDoS victims and DDoS attacks as one victim can be associated with many attacks). We see the same pattern for both types of attack: Russia was the first to be attacked at scale, followed by Ukraine a few days later. The key observation is that in both countries, after a few weeks the number of attacks was back to pre-war levels.

The number of defacements targeting Russia peaked on the invasion day at 194 (15.36% of all defacements on that day, while it was 0.75% the day before): the first big wave occurred around 10AM (7 hours after the 3AM invasion) with 178 attacks caused by a single defacer, followed by smaller waves on the same day. Two follow-up waves occurred over the next two days at 1PM on 25 February and 12PM on 26 February with 43 and 25 attacks respectively. The number of defacers targeting Russia peaked two days later: while there were only five defacers responsible for the peak on 24 February, 14 attacked on 26 February. As to attacks on Ukraine, there were no significant changes on the day of the invasion, but we observe a peak of 69 attacks two days later (accounting for 7.81% of all defacements on that day, while it was 0.55% the day before). The largest wave occurred at around 7PM on 26 February with 50 attacks, followed by medium waves at 5PM on 27 February (26 attacks) and 10PM on 3 March (29 attacks). The number of defacers targeting Ukraine peaked on 27 February (one day after the largest wave) with 9 active defacers.

These results show waves of attacks against both countries directly after the invasion. The number of defacers involved was quite small, but nevertheless, at least momentarily these few defacers turned from indiscriminate targets (seeking out common vulnerabilities on websites), to more targeted attacks. From our interviews, there was a ‘call for hacking’ within the

| W1 | W2 | W3 | W4 |
|----|----|----|----|
| 50 | 178 | 52 | 511 |

| M1 | M2 | M3 | M4 | M5 | M6 |
|----|----|----|----|----|----|
| 754 | 700 | 511 | 52 | 50 | 178 |
defacers’ community after the initial flurry of activity; many were asked to chose a side to join in the attacks. We believe that this helps explain why the peak in the number of defacers does not coincide with the peak number of defacements.

There was an exceptionally high volume of defacements targeting Russia on 25 May with 771 attacks caused by five defacers. However, 764 of these were claimed by a single attacker, who had compromised a server hosting 760 websites – an outlier that appears to be unique in our dataset (that point is removed from the graph for better visualisation). The peak of defacements of Ukrainian sites on 1 February (187 attacks by four defacers) does not appear to have a single cause and it did not lead to a sharp increase in defacers in the following days; we are not aware of any particular reason why attacks occurred on that day, several weeks before the invasion.

DDoS attack activity lagged defacement by about a week. The number of both DDoS attacks and victims targeting Russia first increased on 2 March (six days after the invasion) with 853 victims, 511 of them at around 18:00 UTC. The attacks peaked 4 days after that with 1 135 victims on 6 March. High levels of activity continued through 23 March, with the biggest wave occurring at around 2PM on 8 March with 754 victims. Smaller waves continued regularly during the next few weeks.

Significant waves of DDoS attacks targeting Ukraine started around a week after Russia’s first big wave (we actually see some small spikes targeting Ukraine before Russia, but these were insignificant and short-lived) with the first notable spike on 10 March with more than 500 victims. Attacks became prevalent during two weeks from 18 to 31 March: big waves were on 18 March at around 12PM, 1PM and 4PM with 257, 476, and 700 victims, respectively. Other big and medium waves also happened until the end of March, with the biggest peak occurred on 31 March when 1 293 victims were hit.

Overall, while significant numbers of defacements occurred immediately after the invasion, this rise was rather short-lived; the increase lasted for only around two weeks before returning to the previous stable state. We learnt from our interviews that defacers had run out of targets and had lost interest in targeting Russia or Ukraine anymore, except this outlier.

B. Attacks in the Global Context

Thus far we have been discussing the number of attacks against Russia and Ukraine with significant changes connected to the war. However, these numbers are small when set against attacks occurring elsewhere in the world (Figure 4). Among 227 636 defacements being analysed, only 5 032 (2.21%) targeted the two countries (3 647 and 1 385 for Russia and Ukraine, respectively). We exclude sites hosted in the United States (US) by global scale vendors (Cloudflare, Amazon, etc., see Appendix F) but it is still the case that websites hosted in the US have consistently suffered the majority of defacements. Since the beginning of 2022, the US accounts for 29.08% defacements in total, followed by India (11.74%) and Indonesia (9.90%), while Russia and Ukraine only account for 1.60% and 0.61%, respectively. The top 10 countries account for 67.79% of all defacements; the same type of concentration is seen for DDoS, where the top 10 countries account for 70.72% of all attacks. The US still dominates, with 24.73%, followed by Brazil (11.94%) and Bangladesh (8.11%). Ukraine accounts for 1.54%, while Russia lies eighth at 3.58%.

There are some correlations between web defacements and DDoS attacks. Five of the top 10 countries for defacements are also top 10 DDoS targets, namely the US, Germany, France, Brazil, and Russia. During the last two weeks of March 2022 the number of attacks (both defacements and DDoS)
rose at the global scale, with many defacements targeting the US and unprecedented volumes of DDoS attacks targeting Bangladesh. They both increased sharply on 21, 24 and 27 March, but dropped significantly on 22, 26 and at the end of March. Our DDoS and web defacements datasets are collected independently and do not affect each other, but it would be necessary to control for factors such as overall Internet activity before considering these correlations to be significant.

A similar peak to that observed in Russia and Ukraine for DDoS attacks can be observed at the global scale in the aftermath of the beginning of the war. We observe notable differences in web defacements between the top-country global scale and the Russia-Ukraine scale. There was a short-lived decline in defacement attacks worldwide on invasion day (from around 1 200 to 1 000), while it peaked for Russia from nearly zero to around 200 (accounting for 15.36% of all defacements). This suggests that attention was shifted from elsewhere towards targets in Russia. The US is consistently the largest target, but only accounts for 24.94% on that day. The number of defacements on 24 and 26 February are also high in term of their corresponding proportion over all defacements in other countries. Russia and Ukraine have generally accounted for a far smaller percentage of targets historically even in the context of local peaks in activity; e.g., on 28 January, the number of attacks targeting Russia peaked, but it only accounted for less than 5% overall (meaning that the others also increased sharply). This suggests that a genuine change in the way defacers chose their targets was precipitated by the war in Ukraine. While defacements and DDoS attacks increased on a global scale in March, this was not observed for Russia or Ukraine. After a few weeks, observable attacks returned to their previously-stable state, with no lasting changes to the cybercrime underground and no significant evidence of further attacks targeting Russia and Ukraine. We are unable to provide any convincing explanations as to why there was an unusual peak of attacks against Brazil in June or Bangladesh in March.

C. Key Actors in the Defacement Community

Key actors play central roles in underground and hacking communities; a small number of actors are often involved in many activities [58], [59]. Reflective DDoS attacks lack attacker identifiers, so we are limited to investigating whether we can identify ‘key defacers’. Figure 5 shows the percentage of attacks versus the number of the most active defacers. The defacement community is highly centralised: over 6 months, 10 defacers accounted for 26.48% of attacks, while the most active of them contributed 8.73% (nearly 20K attacks). If we ignore the period before the war began, defacements targeting Ukraine show higher concentration: the top 10 accounted for 42.35%, while the most active was responsible for 10.62%. The effect is even more pronounced for defacements targeting Russia, where the numbers are 62.61% and 28.42%, respectively. This suggests the defacement activity related to the conflict was mainly performed by a relatively small subset of the community.

Some of the key defacers picked sides: two of the ten most prolific (over the entire period) participated in attacks against Russia after the war began: the 6th ranked 6th and the 10th ranked 4th. Another two were involved in targeting both Russia and Ukraine: the 3rd ranked 4th for attacking Ukraine and 9th for attacking Russia; while the 7th ranked 1st for targeting Ukraine and 3rd for targeting Russia.

We found some ‘new faces’ e.g., the second most active defacer of Russian sites first appeared in mid-February, peaked on the day of the invasion, stayed significant for 3 days then declined quickly. Some ‘old faces’ had a longer history of attacks on other countries, whilst not being in the top 10, but their attacks against Russia and Ukraine peaked when the war began e.g., the second most active defacer targeting Ukraine had performed very few attacks against Ukraine before then.

These figures show that although the conflict caught the attention of some prominent members of the community, it also drew in new players, and some minor players at the global scale made a a big contribution to the rise in attacks on Russia and Ukraine. The two most active defacers globally made only a trivial number of attacks against either country (less than 10). Our interviewees suggested that these leaders are mainly financially motivated – ’now they are busy with making money’, as one participant explained.

D. Motives for Defacement Attacks

Defacements are often organised into discrete campaigns [50], where defacers leave messages on the websites they have defaced for a range of purposes. Some acknowledge fellow attackers, or advertise their tools or hacking services to make money. But some express other motives: defacement may be a hobby, or a wish for community recognition, or they may have patriotic, religious or political views to express. The motivations of defacers have already been studied at a general scale [48]; we do not seek to verify earlier findings, but to gain insights within the context of the conflict. Hence we only look at the 5 032 attacks in our dataset targeting Russia and Ukraine (3 647 for Russia and 1 385 for Ukraine).

We find 980 groups of identical messages, then identify the motives of each group based on the message’s meaning. We consider there to be a political sentiment present and mark it as either supporting Russia or Ukraine if a support/objection is expressed e.g., ‘We stand with Ukraine!’. We consider a message to be for the purposes of amusement or gaining reputation if it consists of defacers’ signature e.g., ‘Hacked by
CoolHacker’ without a clear motivation, or just saying ‘Hi’ to other defacers. We exclude 974 messages where there is no evidence of the motive (e.g., empty or random messages). Messages advertising tools and hacking services or asking for ransom are considered financially motivated e.g., ‘contact me for tools and shells’, some relate to patriotic, sectarian or nationalistic conflicts. We label messages expressing favourite mottos or documenting the defacers’ mood as self-expression e.g., ‘Not much I want, hope my life will be better’.

We find diverse motivations, but although these attacks targeted Russia and Ukraine, most messages did not reference the war at all. 2283 were simply for amusement and reputation, 1219 self-expression, while 139 related to other conflicts (such as Israel-Palestine), 46 related to patriotism and 89 were financially motivated (mainly from the two most active defacers at the global scale mentioned above, who did not change their targeting because of the war).

However, some defacers did leave messages relating to the war: 179 messages supporting Ukraine, nearly twice the number supporting Russia (103). Notably, some defacers support Russia, yet also defaced Russian websites saying that they wished to alert administrators and help secure the systems (22 attacks) – ‘I have secured this domain, I love Russia’, was a message the third most active pro-Russia defacer left on a Russian website. Likewise, other defacers supported Ukraine yet defaced Ukrainian sites (6 attacks). For example, a message left by a pro-Ukraine defacer said, ‘Hello Volodymyr Zelensky, I’m sorry to hack your site. I just wanted to tell you that people need a president like you. We support Ukraine’.

Such messages can be signatures left over from exploiting tools or explicitly signalling about the war; it is not always easy to tell. But both our quantitative datasets and qualitative interviews suggest war-related messages during that period are intentional, as defacers did not usually target Russia or Ukraine beforehand (see more in §IV-A and §VI-C).

V. THE IT ARMY OF UKRAINE ACTIVITIES

The IT Army of Ukraine, which was stood up in an ad-hoc manner [60], has been promoting Russian targets most mornings with URLs and IP addresses posted on their Telegram channel. We analysed these announcements to explore the choice of targets, and the crossover with attacks seen in our datasets. We used regular expressions to extract IP addresses and domains, then combined data for the same domain (e.g. www.example.ru, smtp.example.ru). We found that the targets do not just have Russian and Belarusian ‘country codes’ (.ru, .su, .by), but also generic ‘top level domains’ (e.g., .tv, .com). We excluded URL shorteners such as t.me, goo.gl and popular services such as youtube.com. In total, we found 3845 targets promoted, including 2291 IP addresses (59.58%) and 1554 domains (40.42%). The domains and IP addresses are not necessarily distinct because targets may be described in different ways to make it easier to launch attacks: some DDoS tools require IP addresses be provided for target identification, and connecting to websites usually require the hostname.

Figure 6: The number of announcements and (re-promoted) targets in the IT Army of Ukraine Telegram channel by day.

Figure 7: Levels of user engagement daily in the IT Army of Ukraine Telegram channel. Values are min–max normalised.

A. Target Announcements and Community Reactions

We recorded a large number of announcements and targeted domains in the first couple of weeks after the invasion. Posts began on 26th February, peaking on 27th February with 40 announcements and 45 domains promoted (IP addresses were not regularly included until later), see Figure 6. However, the volume of announcements quickly declined to consistently less than 10 per day after two weeks with some days having no announcement (e.g., no new targets on the 24th or 26th April).

While the number of announcements decreased, the number of promoted targets has steadily increased, particularly in the last two months of data collection, with announcements containing multiple targets. Activities at that time were unstable with targets being promoted less frequently; occasional periods of several days had no promoted targets at all. We also find targets repeated on multiple days. During the first couple of weeks, most targets were fresh (both domains and IP addresses), but a considerable proportion were re-advertised later. For example, during 4–6 May, all advertised IP addresses and most domains were re-posted. A long with frequent zero-target days, this suggests the organiser may have run out of new targets or got bored with finding fresh ones.

Community reactions and engagement tell much the same story as with DDoS and defacement attacks. While more targets were promoted in the last two months of our data
collection period, volunteers appeared to have shown intense activity in the first few weeks but to have largely lost interest thereafter. Figure 7 shows the level of engagement. The decline in reaction was consistent across all types of engagement we could measure: views, emojis, forwards, and replies. Older announcements have had more time to accrue views as people scroll up the channel, but the emojis, forwards, and replies require user intent. We deduce that the figures reflect a genuine decline in engagement over time.

Along with targets promoted daily, the group also provided attack instructions such as tools, material, and guidance to carry out DDoS attacks. We further looked at user engagement with these instructions when they were introduced into the channel. The group first provided material to hit Russian payment system on 9 March (two weeks after the invasion), attracting lots of engagement: 240k views, 2.6k emojis, 1.2k forwards, and 421 replies from 197 users. The next was on 1 April: while the number of replies and forwards was quite similar to the first, other kinds dropped by about half. From mid-May to late June, the group posted instructions more frequently (4 times), yet users were much less engaged (around 4 times less than the first announcement in March), suggesting a loss of interest despite the operator’s efforts.

B. Crossover with Observed Attacks

The targets announced on the IT Army channel are often associated with a particular theme. These mini-campaigns are sometimes patterned around particular days of the week; food delivery services, entertainment, online news and propaganda are often targeted at weekends. Sometimes, the attack theme is set for the week with lots of old targets re-advertised for many days; this leads to wide variations in the number of new targets, particularly from May onwards (zero on some days), as shown in Figure 6. Although subscribers can also contribute to the target lists, the group owner posts most of them; but during the last two months they often stuck to promoting old targets via links to previous posts, where the announcement could be as simple as ‘we continue to work with yesterday’s targets’. This could suggest that the group organisers had some difficulty in coming up with new targets.

We use the categories linked with targets by default, but when they are unavailable, we identify them by considering their root domains (e.g., .tv and .gov likely belong to news and government websites). If they are generic (e.g., .ru, .com), we visit them (relaying via Russian IP addresses) or consult Internet archives if they were down. We found some targets were indeed down while they were previously active, suggesting that attacks might have been successful. For example, ksrf.ru (the constitutional court of the Russian Federation) has been down for some time, while data.gov.ru was both defaced and DDoSed. Although we can check targets’ online history on Internet archives, these may not be complete and so we did not attempt to measure what proportion had been taken offline for a substantial period. By examining the announcements, we were able to not only classify their categories, but also smaller sub-categories.

There is a wide range of categories, but five dominate, accounting for 80.21% of all targets (see Figure 9). ‘News, media and propaganda’ targets (including TV broadcasting)
have been consistently promoted since the war began, but only became the most common category in May when it overtook ‘IT solutions and services’. ‘Government and public services’, which includes military, state-owned websites, and public services for civilians such as parking and lighting – including governments imposed on occupied territories – have also been regularly targeted throughout, but they only grew rapidly towards the end of our data collection period, making it the second most common category overall.

Ranked third is banking and financial systems, including banks, stock exchanges, electronic payment, accounting, credit checking services, trading, bidding, investment platforms and funding agencies. ‘IT solutions and services’ ranked fourth, including software solutions supporting governments, digital signature providers, and information security services such as DDoS Guard. This category was actively promoted early on but was targeted far less thereafter. Fifth is logistics, including airlines and aviation, travel, shipping, and food delivery. Other categories (by popularity) include online markets and stores (e.g., job markets, real estate, e-commerce, drug stores), manufacturers and trading (e.g., military footwear, wood and roofing materials), education, insurance, telecommunications (e.g., Internet providers), businesses and state companies (e.g., energy and steel manufacturers), discussion forums, entertainment (e.g., cinemas), and some non-governmental organisations.

VI. PERSPECTIVES FROM THE COMPETITIVE DEFACEMENT COMMUNITY

Our quantitative observations reveal significant but fairly short-lived shifts of both defacement and DDoS attacks associated with the conflict, with distinct peaks on the invasion day. Yet, the raw numbers produced by Internet measurement are notoriously difficult to interpret. Large variations and trends can be caused by any number of factors, which may interact with one another. As we saw above and has been previously identified in the literature on concentration, apparently large effects can be the result of limited individual actions (e.g., a single mass defacement) [61]. To contextualise and explore our quantitative findings, we extend our study to include qualitative research in a relevant community of the cybercrime underground. We explore a snapshot of what was going on within the defacement community during the conflict, and whether there was any impact on the choice of targets, their motivations and patterns of behaviour. As explained in §III, two participants recruited from two different defacement teams give an instructive pair of case studies, although of course we cannot generalise from such a small number.

A. Participant Demographics

Although formed around a strong regional identity, both participants indicated their teams had a wider support base from a range of other countries, with a small number of official members and a larger community of supporters. One team had 3 members, while the other team was larger, with 10 members. Members of both teams are quite young, ranging from 15 to 26, mostly high-school and college students.

Skill levels and histories of illicit behaviour varied considerably between members. Some claimed a long history of illegal activity, largely based around low-level cybercrime activities, while others had a much shorter history of involvement. The teams had a financial structure common to many online cybercrime groups – essentially acting as groups of friends involved in an entrepreneurial project selling cybercrime services.

B. Participant Cybercrime Activities

Both teams were involved in a range of activities associated with the low-level ‘cybercrime underground’ – a loose array of entrepreneurial schemes involving monetising pre-made attack scripts and providing illicit services to customers – but competitive web defacement was the primary activity for both.

There is little evidence of a history of sustained targeted action for either group, with most defacement attacks automated and untargeted – for amusement or competition. Their attacks sometimes explicitly targeted public sector websites, although this appeared to be largely when these attacks were paid for by others (or occasionally on a whim). Generally, as has been identified in previous research, attacking public infrastructure was seen as too high-risk in the context of running a lucrative service [62], [63]. Despite this, the groups did occasionally take part in overtly political campaigns, spreading anti-government messages, or targeting other countries when their own was perceived to be under attack.

We do not attempt to comment in detail on their technical skill levels – which in any case are not particularly relevant, given the nature of the contemporary industrialised cybercrime economy. But it is that they are neither low-level cybercrime service customers, nor highly-skilled pentesting experts or clandestine vulnerability researchers. Instead, they appear to be classic cybercrime entrepreneurs, whose own use of their tools outside a business context occasionally takes a political dimension. They do not fit the classic model of the ‘hacktivist’,
as they are rooted in the competitive defacement scene, but they demonstrate more political interest than many in the cybercrime service ecosystem. Although neither group is based in Russia or Ukraine, they are precisely the sort of people, with access to cybercrime and cybersecurity skills and tools, who have been targeted by the Ukrainian (and Russian) calls for global participation in a cyberwar.

C. Participant Reactions to the Conflict

The IT Army of Ukraine mainly focuses on DDoS attacks, not system intrusion or defacement. One of our participants claimed their friends had initially tried to support the IT Army but subsequently ‘moved to the Russian side due to not being treated well’. Opinions of the IT Army were generally low – the targets were promoted by the group admins, but it was apparent that the volunteers were doing all the attacks, however ‘they were helping but they get no credits’. Neither team participated actively in the Telegram channel, but took part in self-directed mass defacement aligned with the war, largely for their own amusement. When the war began, although some teams within the competitive defacement community did attest to political motivations, as we have already noted above, the most prolific defacers did not engage by targeting either Ukraine or Russia but remained largely financially motivated.

Both participants obtained information about the war from social media news, claimed to be influenced and changed targets specifically due to the war – ‘Just the war, normally we do not target Ukraine’, one said. One team started defacing Russian sites with messages supporting Ukraine; they were at pains to argue that their issue was with the invasion, and that some of their Russian friends within the cybercrime community were similarly against the war. Sometimes they accidentally defaced news sites but they did not focus on any particular category (e.g., bank, government), which contextualises the relatively small overlaps between web defacement and targets promoted by the IT Army of Ukraine. As for the other team, the owner was reported to be pro-Russian, but the participant executed all attacks for his team and described himself as neutral, attacking Ukraine for amusement – ‘they misunderstood telling that I am Russian side supporter, but that is not true’. The overall picture suggests neither team has a strong political viewpoint on the war, so their activities cannot properly be described as ‘hacktivism’ – ‘Defacers have no political reasons, they do it just for fun or as a hobby in the start, later on, they convert access to different targets on money’, said one participant.

The participants mostly used traditional mass-defacement rather than specially-targeted methods. The use of ready-made tools explains the immediate peaks and the lack of important sites being defaced. While one team started defacing Ukrainian websites a couple of days after the invasion, the other started targeting Russia right after the war began (in a matter of just a few hours) and it was their sole focus for the next two days. However, the activities of both teams declined quickly as they ran out of targets and generally lost interest in the conflict – ‘I join fast and leave fast’. One participant became afraid of being arrested after their attacks were reported – ‘they stopped, then I stopped too’. While they were motivated to target Russia and Ukraine, their interest was fleeting.

D. Wider Community Reactions to the Conflict

Our participants described their corner of the cybercrime underground as densely networked, with considerable communication even between competing teams. They share information, techniques and interact with others in a private Telegram channel. They reported co-operating on some campaigns (depending on the targets, sometimes they needed help), especially those linked with more political causes – ‘we trust each others because we are all criminals’, one explained. Traditionally, cybercrime communities have centred around underground forums (and one participant was said to work as an admin on dark web forums), our participants reported little ongoing interest in these, rarely visiting them. Instead, most of our participants’ communication had shifted to private chats such as Telegram and Signal, as reported in the literature [66].

The defacement community was clearly influenced when the conflict began; they frequently commented on the situation. There was a ‘call for hacking’ to encourage them to choose a side and participate in attacks – ‘Both Russian and Ukraine hackers contact me for help’, one said. While some decided to be pro-Russia or pro-Ukraine, some did not care and some decided to remain neutral – ‘they were asking me to choose a side, but I told them I am neutral and that I will not get involved in a war that is not mine’. Some pro-Russian defacers actively targeted Ukraine, but also hit some Russian websites to help ‘secure’ them by demonstrating their vulnerability.

VII. THE ROLE OF CIVILIAN PARTICIPATION

Our quantitative observations show a significant but fairly short-lived impact of the invasion of Ukraine on activities of the civilian and the so-called ‘volunteer hacktivists’ as parts of the cybercrime underground ecosystem that we are able to reliably measure. Although it is impossible to generalise from two qualitative case studies, they do provide some insights and explanation as to why the peaks occurred.

Web defacement and DDoS attacks followed similar but differing trajectories at the start of the war. Our measurements indicate immediate effects on defacement activity, possibly due to the availability of existing tools to scan new targets for mass defacement. But the defacement activity has very little overlap with the targets promoted by the IT Army of Ukraine. The vast majority of attacks targeted harmless, defunct, or trivial websites with Russian domain names: victims were not intentionally targeted, and attacks were automatically executed by scanning with ready-made scripts. In many cases the web defacers did not stray far from their usual, financially motivated, cybercrime activity with adverts for their cybercrime services left on the defaced websites.

7 They are afraid that discussions on cybercrime forums will remain public and will be available to investigators. They also fear that by accidentally leaving traces behind, they might be linked across different forums [64], [65].
Our data shows that the rise in DDoS attacks did not happen until slightly later – a week after the invasion – and it is there that IT Army of Ukraine had considerable influence. We found that at least 30% of targets mentioned in the Telegram channel could be found as victims in our reflected DDoS attack database. However, our key result is that neither the rise in web defacement nor the increase in DDoS attacks was long-lasting. Defacement activity was concentrated in the first couple of days; DDoS activity continued for longer (possibly due to the widespread availability of cheap DoS-for-hire services), but was still fairly short-lived. Our qualitative data suggest that this can be partly explained by participants simply losing interest, although their targets were clearly influenced by the war. This is in line with other work suggesting that boredom is an important factor people leaving cybercrime [63].

Our findings fit with a more general pattern observed in the cybercrime ecosystem – one of a cybercrime underground increasingly characterised by an entrepreneurial, service-based economy which is becoming alienated from traditional hacker culture’s concerns with technical learning and dissent [67]. Rather than the committed, persistent attention needed for the prominent leak-based attacks observed throughout the war, the interest of low-level civilian attackers and volunteer ‘hacktivists’ appears to be fleeting, and easily diverted by trending news. This combination of deviant entrepreneurship and expressive juvenile delinquency suggests that the contemporary cybercrime underground is becoming far more like classic criminological portraits of offline street-level crime and disorder [68], [69]. Committed, effective hacktivism (for any cause) appears to be rather more separated from these low-level communities than prevailing narratives might suggest.

It is of course true that some cybercrime-related activities are contributing to the war effort. Leaks, especially of high-profile datasets gathered from Russian public services, have consistently made headlines. Much as with ransomware, they are few in number and have vast disparities in impact, which makes them far less ‘measurable’. They may or may not be connected to ‘civilian engagement’, to ‘hacktivists’, to dissidents within the targeted organisations, to state actors, or to other groups. Equally, our argument is not that all commentary on the conflict is ill-founded, with more nuanced perspectives evident from some researchers, security professionals and analysts. We draw attention to Rid’s ‘Cyberwar Will Not Take Place’ [70], his later comments on Russia-Ukraine which echo our own [71], and security blogs such as those run by the Grugq [72], Paddy Kerley [73] and Microsoft [74].

Our study has some notable limitations. First, datasets covering the whole cybercrime underground are never available; the use of defacement and DDoS attacks of course cannot represent the ecosystem. While other attacks are not included in our study (e.g., phishing, malware, ransomware), we believe our measurements are instructive and the two datasets reflect the engagement of civilian and the low-level criminals in the cyber conflict as they are common types of attack with the most mature economies – DoS-as-a-service, for example, can be purchased for as little as five dollars per month. Importantly, the two datasets are independent of each other but still show similar patterns. Second, our defacement collection covers only around 1500 reports per day, but collates all the defacements reported on the most popular archive websites used by the defacement community. Our DDoS attack collection is larger, but cannot track attack origins. It only covers reflected attacks, while some of the attacks will have been directly sent from botnets, compromised servers and misconfigured proxies. Our work reports only the first four months of the war, thus only give an early picture of the evolving conflict. Third, the interviews were conducted on a very small scale, thus have been limited to enriching interpretations of our quantitative data. Fourth, we assume that the defacements reported, including messages left on the defaced pages, are honest (correct countries, teams and handles) – a reasonable assumption as these reports are used to cultivate reputation. Although the defacers we interviewed have a clear incentive to overstate their own skill and importance, we have taken care to present their statements objectively. Our next step is extending our analysis to Russian-speaking cybercrime forums.

VIII. Conclusion

The participation of civilian and volunteer ‘hacktivists’ described in this paper – those which we believe are meaningfully measurable – are by and large trivial. These are trivial acts of solidarity, teenage competition, and expressive delinquency, not a ‘hard’ contribution to the cyber conflict. We have found very little measurable evidence to suggest that they are making any real ‘hard’ contribution to the conflict, even in a major war between two nations having long history of cyberwarfare. This analysis runs counter to widely-held popular narratives, which tend to collapse state hacking and political ‘hacktivism’ together with low-level cybercrime activities. This has broader consequences for our understanding of the role of civilian participation and its capacities in nation state conflict and for what we might expect to see in the future. It is particularly important to note that in cybercrime measurement data, what initially appears to be a large-scale movement can turn out on closer examination to be the result of a very small number of actors changing their behaviour.

We are not dismissing these activities as completely unimportant or uninteresting. Rather, they engage in the domain of cultural expression, not hard power; they are part of an information war, in a much older sense of the term. The history of the youth cultures which emerged during the cold war is instructive. For example, the punk movement alone was similarly engaged in graffiti and expressive protest, but had a real and lasting impact on global culture. These battles for ‘hearts and minds’ have long been considered to contribute to ‘soft power’; culture is seen by most nations as an important theatre of conflict and wider geopolitics. It is telling that much of the work of the IT Army of Ukraine has been the spreading of messages and propaganda. The people engaged with and encouraged to use the tools of the low-level cybercrime underground are employing those tools for much the same purposes, rather than participating on the ‘hard’ digital frontline.
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gave them the opportunity to be named as an incentive to participate. We originally limited participation to those aged 18 years and over, but as both participants claimed to be high-school students, we obtained a waiver from our ethics committee. For this, we relied on guidance from UKRI [76] which does not set age limits on when a young person can consent to research. It notes that while it is ‘good practice’ to secure permission from a responsible adult in addition to the child, in some circumstances (e.g., research into teenage sexuality or alcohol use), seeking consent from parents could place the participant at further risk.

Studies like this where there is an ongoing conflict, may harm the individuals whose attacks are reported, the participants whose responses are included, and the researchers who might face retaliation. For participants, we asked for permission before disclosing any of their responses and for feedback on our paper to ensure no unwanted information is disclosed. The interview records were permanently deleted after responses were aggregated. Although both participants claimed responsibility for unrelated criminal activities, we do not include this in the paper. We cannot confirm the veracity of such claims, and do not wish to boost their reputation.

We did not ask for consent from Telegram users or web defacers when using scraped data, as sending thousands of messages would be impractical. We assume they are aware that their messages are publicly visible after publishing. This approach accords with the British Society of Criminology’s Statement on Ethics [77], as all analysis involved aggregated data, without identifying individuals.

B. Data Licensing

Our quantitative data and code are available for researchers under a license agreement with the Anonymised Centre to prevent misuse and to ensure the data will be treated ethically, as sensitive data exposes both researchers and data subjects to a range of risks. We have robust procedures and long experience in making our data available in numerous jurisdictions.

C. Web Defacement Collection

Data completeness and reliability are critical for longitudinal measurements. Scraping complete snapshots, especially at ZONE-H, is non-trivial, and has not been guaranteed in prior work. We ensured complete collection in order to measure real trends, not artefacts. Some researchers have attempted to purchase ZONE-H snapshots [50], but this is not sustainable over time, and is ethnically questionable. Defacement archives are public, but gathering them at scale is still challenging as (1) ZONE-H adopts text CAPTCHA to prevent bots, (2) defacement dashboards set a limit of 50 pages with older data hidden, and (3) on-hold records may not appear on the homepage promptly, leading to potential misses when visiting the dashboard infrequently. The only way to get a complete scrape is by iterating through all submission IDs (this generated non-trivial workload) with the IDs of valid reports often mixed with invalid ones. Dealing with these issues, plus IP blacklisting and bot prevention mechanisms, is the main challenge to scraping.

We responded by (1) developing an efficient text CAPTCHA solver for ZONE-H utilising image-processing techniques, (2) routing our scraper through proxies, and (3) carefully iterating through all submission IDs to collect all attacks. We stored raw data in a database to avoid unnecessary requests in the future.

D. Validating On-hold Defacements

The way defacement submissions are validated is not clearly documented. While ZONE-H reports are kept on hold until manually verified by staff, ZONE-XSEC, DEFACER-PRO, and HAXOR-ID use automatic validation, insisting that messages left on the defaced pages contain keywords linked to hacking activities (e.g., ‘Hacked by Me’). All archives specify validation status explicitly when visiting defacement by ID, except ZONE-XSEC (where it only shows in the dashboard with a 50-page limit). Submissions to ZONE-H manually reviewed by staff may be slow to verify, while automatic verification of the others is error-prone. Unverified records may be kept on hold forever, leading to incomplete longitudinal data. Consequently, collecting only defacements shown in the dashboard is inadequate, thus a complete defacement dataset is challenging to gather. To enhance the completeness and reliability of our data, we perform a semi-automatic validation to confirm if unverified defacements are in fact valid.

Algorithm 1 shows our strategy. First, we consider reports verified by archives to be valid. Second, for on-hold ones, messages on the defaced pages are used to decide their validity (as defacers often leave something to gain reputation e.g., ‘Hacked by CoolHacker’). Among those defacements, we

| Algorithm 1 Semi-automatic defacement validation |
|-----------------------------------------------|
| 1: procedure VALIDATE_DEFACEMENTS             |
| 2: for each a ∈ verifiedAttacks() do          |
| 3: a.status ← 0                               |
| 4: end for                                    |
| 5: for each a ∈ filteredAttacks() do          |
| 6: a.status ← 1                               |
| 7: end for                                    |
| 8: P ← pendingGroups()                       |
| 9: V ← verifiedGroups()                      |
| 10: for each p ∈ P do                         |
| 11: T ← {}                                    |
| 12: for each v ∈ V do                         |
| 13: d ← levenshtein(p, v)                    |
| 14: T ← topSimilar(d, T)                     |
| 15: end for                                   |
| 16: showAssistance(T)                        |
| 17: s ← manualDecision()                     |
| 18: for each a ∈ p do                         |
| 19: a.status ← s                              |
| 20: end for                                   |
| 21: if isVerified(s) then                     |
| 22: V ← V ∩ p                                |
| 23: end if                                    |
| 24: end for                                   |
| 25: end procedure                            |

Defacers may game the system by putting comments on blogs, or submitting search queries e.g., ‘Search=Hacked by Me’. This can sometimes get through automatic sanitisation, but our further validation excludes them.
filter for submissions where the message specifically contains common hacking terms: ‘hacked by’, ‘h4ck3d by’, ‘h4cked by’, ‘p4wn3d by’, ‘pwn3d by’, ‘pwned by’, ‘owned by’, ‘touched by’, and ‘kissed by’ then consider to be valid if those messages also include a defacers’ handle. For example, a message ‘This website was hacked, contact me t.me/coolkhacker’ posted by a notifier ‘CoolHacker’ is considered valid. This method is looser than an exact comparison with ‘Hacked by CoolHacker’, but is still accurate; all 100 randomly checked examples were correct. Third, the remaining reports are manually validated, looking for the defacers’ signature. While some messages are obvious, others are complicated to decide. To speed up the annotation, candidates are grouped by handles and messages (normalised, redundant spaces removed); for each case, ten validated defacements with the most similar messages are suggested to the annotator. Levenshtein distance is used to estimate the similarity between two text $s_1$ and $s_2$. We found this helpful as defacers often modify messages slightly from existing templates. In case no splash page message is available (instead images, iframes, or javascript), or if it is challenging to spot defacers’ signature (some messages are messy and hard to read), a web browser is popped up for the annotator to view the defacement.

This assistance considerably reduces the required human effort. One difficulty with verification is dynamic redirects to a defacer’s webpage, as this can be modified later; when the defacer’s page is down, the defacement appears to point to a non-existent site, but a careful check could reveal evidence of a defacer’s domain name. We ignore cases that lack evidence, so as to ensure that those flagged ‘valid’ are indeed valid. We do not use complex machine learning techniques as message texts contain lots of noise; given a small number of samples (10K), ML does not seem to be more promising than a rule-based approach. Sometimes defacements appeared to be already verified at the time of collection, but became invalid afterwards; we re-validate all of them months after collection to make sure their status has been finalised by the archives.

E. Unifying Defacements and Defacers

Defacements are hashed based on (1) reporting date, (2) original handle of defacers, (3) root domain of victims, and (4) original message left on the defaced pages. The reporting date may be problematic if the defacer waits a few days to resubmit to other archives; but excluding it may lead to spotting matched records where they were submitted on different days due to repeat victimisation. As the unifying process needs to be precise and the number of unique defacers is just a few thousand, fully automatic analysis (e.g., ML) is not appropriate. We therefore adopt a semi-automated approach combining automated handle similarity analysis with manual review of messages to identify typos in handles. First, similar pairs of handle are extracted using the Levenshtein metric, constrained so that the distance does not exceed 25% of the handles’ length. Then, 10 sample messages left by defacers in each pair are automatically shown to the annotator; if the messages are semantically closed enough, the pair can be unified under a single nickname. The decision relies on various aspects: message patterns, stylometry, synonyms, the inclusion of handles in the messages, typos in the handles, team, nationality, messages’ semantics, language, and even the rarity of handles (rare usernames like ‘cj2ks’ are more likely to be used by a single person, while common ones like ‘glory’ are more likely to be shared by multiple individuals [78]). Messages left are diverse: some are identical, some are relatively similar, some are rather distinct and contain the defacers’ name, and some come with phone numbers which may link to their country. We only confirm where there is sufficient evidence, and leave uncertain pairs unmatched. Many different typos occur e.g., missing characters, order of characters, case-sensitive. We find many different handles who leave similar messages used across different archives, making it hard to identify overlaps without unifying handles. When we are unsure, we may ask our participants specifically.

F. Determining Attack Geolocation

Accurately mapping IP addresses to countries is challenging, as IP geolocation is not always stable and trustworthy [79]; providers prefer locating servers in countries with cheap hosting [80]. Attack geolocation might thus be determined differently by different archives e.g., Zone-H may say an IP is in Germany, while Zone-Xsec goes for Singapore and Defacer-ID cannot tell. Geolocation services are more reliable at the country level [81], but this is only part of the truth as websites are nowadays commonly hosted on content delivery networks (CDNs). The original IP addresses are typically hidden and the geolocation is of the CDNs.

For example, a ‘.ru’ website is supposed to be Russian, but it might be physically hosted in Vietnam, operated by a person living in Hong Kong, while proxied through Cloudflare with an IP address in the US. Relying on only one aspect might be risky, as both IP and domain can lie. We use data fusion to enhance the accuracy, prioritising: (1) top-level domain; (2) IP geolocation at collection time (MaxMind GeoIP2 [9] for web defacement, and a database we maintain based on Regional Internet Registry data for DDoS attacks; (3) geolocation of the AS hosting the IP address. If a website’s IP address belongs to a CDN, its geolocation is determined solely by ccTLD, as any geolocation of IP address or ASN will be unreliable.

The top three CDNs are Cloudflare, Amazon Web Services, and Akamai, serving around 89% of customers [82]. We ignore the trivial market shares of their competitors, but we count DDoS Guard as it is based in Russia, which may affect the infrastructure hosted there. We expect the four can cover nearly 90% of customers. In total, we found 5.55% of defacements are hosted on these CDNs by 14 262 prefixes as of the writing date: 1 698 of Cloudflare; 7 483 of Amazon WebService; 5 056 of Akamai; and 25 of DDoS-Guard (these prefixes and AS number mappings are collected on Hurricane Electric Internet Services [10]. For defacements, we prefer ccTLD over

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9 GeoIP by MaxMind: https://maxmind.com/
10 Hurricane Electric Internet Services: https://bgp.he.net/
G. Interview Material

1) Warm up questions:
- Have you read the information sheet? Do you have any questions about us and about the interview?
- Do you consent to the interview terms, that the responses will be kept for some time but will be permanently destroyed after transcription?
- Have you defaced websites and posted these on online archives? If yes, which archives you often use, why do you choose them, and why do you submit/not submit to multiple archives?

2) Demographic and Organisation:
- Do you deface websites as a team, or as an individual? If so, what is your role? Do you know each other offline?
- How was the team formed? When did you join the team? What does your team name stand for?
- What is your gender, employment status, level of education, and age range (also of your team members)?
- What geographic area of the world are you located in e.g. continent or country? A specific location is not required.

3) Cybercrime Activities:
- How long have you been doing hacking? What type of hacking activities do you or your team often do? And how long have you been doing defacement in particular?
- Do you have a hacking community for discussion? Which forum or other platforms do you mainly use for that?
- Why do you deface sites? What do you gain from defacing websites (motivation and benefit)?
- What are the popular web defacement archives you use to post defaced sites to? Do you mirror defacements on multiple archives?
- How, and what types of target do you select for defacement? How has this changed over time? Do you particularly target important websites like government, military, or education (and why)?
- Are there any targets that you would avoid? And why?
- Do you automate any part of website defacement?
- Do you know other people who also deface websites? Do you exchange contact? Are they your friends? Do they do other types of crime?
- How did you start defacing websites? How old were you when you did (age range fine)? How did you learn the skills? How have your methods changed over time?
- What vulnerabilities do you often exploit? What types of websites often have those (e.g., Wordpress, Drupal)?
- Have you committed other types of cybercrime linked to the conflict, or just web defacement?
- Do you get involved in other types of cybercrime such as DDoS, or only web defacement?
- How do you decide what to post on defaced sites e.g., team introduction, politics?
- Do you cooperate with other hackers? Have you faced any challenging target that you could not get through where you needed others’ help?
- How morally wrong/serious do you think defacement is? How serious do you think the police consider defacement to be? Do you have any fear of being targeted by police?

4) Perspective on the Conflict:
- Do you have a particular political point of view? What is your opinion about the conflict? Do you support a particular side, or you are neutral?
- Where do you source your news/information about the conflict? How has the conflict impacted your activities, and the activities of other hackers in your community?
- Do you see a cyberwar? Were you and your community aware of the conflict beforehand or of any preparations?
- Do you know the IT Army of Ukraine? Are you a member of that groups? If yes, why did you participate?
- Have you committed other types of cybercrime linked to the conflict, or just web defacement?
- Do you cooperate with other hackers? Have you faced any challenging target that you could not get through where you needed others’ help?
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