**Applicability of Cultural Markers in Computer Network Attack Attribution**

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**Abstract:** Computer Network Attack (CNA) attribution presents on going challenges for information security professionals. The distributed nature of the Internet combined with various anonymizing technologies contributes to making the attribution problem more difficult, especially when traversing hostile networks. What is needed is a new way to assist in attribution performance; this method must be technology independent. Culture offers a technology independent vector for analysing CNAs. The human mind uses both conscious and unconscious thought, and both of these processes are culturally influenced. This researcher seeks to determine if those cultural influences leave traces in CNA choices and behaviours.

Geert Hofstede’s cultural dimensions provide a framework for evaluating and understanding various behaviours. Hofstede’s framework has been used in academia and business for research in order to better understand other cultures. Hofstede avails his data for researchers in all disciplines. The goal of this study is to determine if Hofstede’s framework can be applied to the cyber environment in order to understand CNAs with the hope of greater understanding of cyber adversary choices and behaviours.

The preliminary findings support the hypothesis: culture influences CNA choices and behaviours. Two sets of data were examined across all six cultural dimensions. The analysed data displayed statistically significant findings across three dimensions: power distance, individualism versus collectivism, and indulgence versus restraint.

The tests performed were quantitative and included means comparison tests for the first data set, and group comparison tests in the second data set. The findings revealed valuable data in both the easily seen visible results, and in the areas that lacked data. These findings suggest that culture not only influences CNA choices and behaviours, but may also influence non-behaviours. The results of this research study suggest the need for additional research targeted toward specific cultural dimensions.

**Keywords:**

**1. Introduction:**

Computer Network Attack (CNA) attribution, “determining the identity or location of an attacker” (Wheeler & Larsen, 2003, p. 1) continues to challenge security professionals due to the various “stepping-stone” (Zhange, Persaud, Johson & Guan, 2005, p.1) and anonymizing techniques and products. These anonymizing solutions have resulted in a game of “cat and mouse” between security professionals and attackers where no significant progress is made in solving the CNA attribution problem. New approaches are needed in order to change the dynamics of attribution. Attack attribution beyond IP addresses offers a paradigm change. This study examines the CNA attribution problem from a different perspective; culture.

Hofstede et al., (2010) defines culture as “software of the mind” or “the mental programming” that defines a group of people (Hofstede et al., 2010). Hofstede’s work is widely used by researchers in various industries. Most recently Doctor Dominick Guss (2011, 2004) used Hofstede’s data in order to determine the role of culture in complex problem solving and dynamic decision-making. Yu & Yang (2009) extended the model for technology innovation. This researcher seeks to build the foundation for additional research in the role of culture in CNA by examining some well-known attack behaviours through the prism of Hofstede’s cultural dimensions. Hofstede et al., (2010) quantified culture and operationalized data in six different dimensions: power distance (pdi), individualism versus collectivism (ivc), masculine/feminine (m/f), uncertainty avoidance (uai), long term orientation versus short term orientation (LTOvSTO), and indulgence versus restraint (ivr).

Two attack behaviours that are examined across the various dimensions are the aggressive, nationalistic, patriotic themed website defacements and an examination of individual hackers. The results of the collected data are compared with the values Hofstede associates with the general population in order to determine if statistically speaking, results correlate with certain ranges in various dimensions.

**2. Literature review**

Dijksterhuis (2004) observes, “a little introspection reveals that the processing capacity of consciousness is limited. People are not able to concentrate consciously on two different things simultaneously” (Dijksterhuis, 2004, p. 587). The nature of CNA attacks requires rapid complex thought; therefore, the attacker must rely on both conscious and unconscious thought.

Bargh and Morsella (2008) observed that culture permeates thought both conscious and unconscious. Baumeister & Masicampo (2010) blend the unconscious and conscious distinction, “conscious thought is for incorporating knowledge and rules for behaviour from culture. Over time, automatic responses then come to be based on that new input “ (Baumeister & Masicampo, 2010, p.948). Thus, many of the cultural influences over thought become engrained even as a part of conscious thought.

Buchtel and Norezayan (2008) observed the differences between eastern and western cultures along with the role of education in developing automatic behaviour. Buchtel & Norezayan (2008) noted the difference in contextualization between eastern and western cultures. Furthermore, Buchtel & Norezayan (2008) observed that culture influenced thought patterns. “The cultural differences are best conceptualized as difference in habits of thought, rather than differences in the actual availability of information processing” (Buchtel & Norenzayan, 2008, p. 219).

Guss (2004) also observed in microworlds simulations that culture played a significant role in problem solving. Guss (2004) stated “culture can influence the perception of the problem, the generation of strategies and alternatives, and the selection of one alternative” (Guss, 2004, p.6). Guess used Hofstede’s cultural dimensions in order to define culture.

Minkov (2013) says “culture has an independent existence, … [culture] can be studied independently of its carriers: the human beings” (Minkov, 2013, p. 15). This frees up the researcher to study culture as it relates to any issue. Hofstede’s dimensions make possible for this researcher to quantitatively determine the relationship between culture and CNA choices and behaviours. The study examines some general CNA behaviours in the context of all six cultural dimensions. An explanation of each dimension follows; with an emphasis on education, and technology use as this behaviour apply to each dimension.

## 2.1 The power distance index (pdi) dimension

The pdi dimension measures the measure of equality within a society. “Power distance can therefore be defined as the extent to which less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally” (Hofstede et al., 2010, p. 61). Problem in high power distance societies are resolved by a show of power and in egalitarian societies problems are solved by flexibility (Hofstede et al., 2010, p. 63). Minkov provides the following observation on power distance: “Generally speaking, power distance is about treating people differently, depending on their group membership” (Minkov, 2013, p. 414).

When pdi is examined in terms of hacker behaviour nationalistic, patriotic hacking has been observed by Chinese Hackers (London, 2011, Chan 2005, Qiu 2003). In a high pdi society the hackers depend more on each other than themselves (Chan 2005). Characteristics of high pdi societies are loyalty and protection. Hofstede et al. (2010) acknowledges the nation of this high power distance relationship, “the junior partner owes the senior respect and obedience, while the senior partner owes the junior protection and consideration” (Hofstede et al., 2010, p. 80). In cyber terms this implies that the hackers act out of a sense of loyalty against opposing nations while acting with the knowledge that their government will provide them with protection.

Searches on nationalistic, patriotic themed website defacements through scholar.google.com resulted in close to 20 countries being represented. Hofstede et al., provide pdi values for 78 countries. Of the 20 countries some had to be eliminated due to not being found in Hofstede’s list, and others due to a lack of supporting reports, such as academic studies, or even news stories. The following countries were identified as having participated in nationalistic patriotic themed website defacements, Bangladesh, China, India, Indonesia, Iran, Israel, Malaysia, Pakistan, Philippines, Portugal, Russia, Singapore, Taiwan, Turkey.

## 2.2 The Individualism Versus Collectivism (ivc) Dimension

Individualism versus collectivism deals with how the individual relates to the larger group known as the society. “Individualism pertains to societies in which the ties between individuals are loose; everyone is expected to look after him- or herself and his or her immediate family” (Hofstede et al., 2010, p. 92). In the individualist society, the individual is responsible for his or her own personal growth and success.

In the collectivist society the needs of the group, or the collective are always considered first and above the needs of the individual. “Collectivism as its opposite pertained to societies in which people from birth onward are integrated into strong, cohesive in-groups” (Hofstede et al., 2010, p. 92). Not only is the individual supposed to consider the group first, but also the individual must avoid direct confrontation. “In most collectivist cultures direct confrontation of another person is considered rude and undesirable. The word *no* is seldom used, because saying “no” *is* a confrontation; “you may be right” and “we will think about it” are examples of polite ways of turning down a request” (Hofstede et al., 2010, p. 106).

Collectivism provides a moderating influence over behaviours. “It seems clear that groups and individuals make different decisions in strategic games and, more often than not, group decisions are closer to the ‘rational’ solution (Bornstein et al., 2003, p. 604). While collectivism moderates behaviours individualism does not. “The research on experimental games has uncovered many instances in which individuals deviate systemically from the game-theoretic prediction” (Bornstein et al., 2003, p.604). Additionally, when forced to go against their cultural upbringing individualist perform worse. The American individualist participants performed best when operating individually and with their names marked but abysmally low when operating as a group and anonymously” (Hofstede et al., 2010, p.121).

In terms of technology, collectivism can be seen to interfere with creativity. “The Golden Mean value is advantageous for the construction of harmonious society. But it advocates maintaining present situation and denies transformation which seriously influences technological innovations” (Yu & Yang, 2009, p. 462). This relationship with creativity suggests that if innovation is a problem in collectivist countries, then improvement abilities by collectivist societies may be considered a positive outcome.

## 2.3 The masculine feminine (M/F) dimension

This dimension deals with gender roles in the society. “A society is masculine when emotional gender roles are clearly distinct: men are supposed to be assertive, tough, and focused on material success, whereas women are supposed to be more modest, tender, and concerned with the quality of life. A society is called feminine when emotional gender roles overlap: both men and women are supposed to be modest, tender and concerned with the quality of life” (Hofstede et al., 2010, p. 140).

This dimension can sometimes be misunderstood. Men from feminine countries are not effeminate, nor are women from masculine countries masculine. Instead, this dimension deals with how conflict is handled. “Masculine countries tend to (try to) resolve international conflicts by fighting; feminine countries by compromise and negotiation” (Hofstede et al., 2010, p. 173). This lack of negotiation along with escalation of attack activities might be viewed as masculine behaviour. Consider the on going cyberwar between the United States and China where neither side appears to be willing to negotiate and both countries share masculine scores, US 62, and China 66.

## 2.4 The uncertainty avoidance (UAI) dimension

The fourth dimension for examination is uncertainty avoidance. “Uncertainty avoidance can therefore be defined as the extent to which the members of a culture feel threatened by ambiguous or unknown situations” (Hofstede et al., 2010, p. 191). People in low uncertainty avoidance cultures view the new as curious in contrast to their counterparts in high uncertainty avoidance cultures that view the new as fearful.

One area where the dimensional differences can be clearly seen is in education. Hofstede compared learning in England to Germany. Germany scores in the middle to high range for this dimension and England has a relatively low score. German students preferred the learning environment more structured, and the British preferred open-ended (Hofstede et al., 2010). Hofstede further noted that one characteristic in the high uncertainty avoidance culture is precision. “Most Germans, for example, favoured structured learning situation with precise objectives, detailed assignments, and strict timetables. They liked situations in which there was one correct answer that they could find. They expected to be rewarded for accuracy” (Hofstede et al., 2010, p. 205).

This dimension offers some potentially interesting behaviour in the cyber environment. Consider the malware program Flame. Flame was allegedly a joint effort between the US and Israel (Zetter, 2012, Nakashima, 2012). One distinguishing feature of Flame was the use of a collision. Collisions are categorized by Mitre (capec.mitre.org) as a type of probabilistic attack. Probabilistic attacks inherently have an element of uncertainty built into them and not surprising the US has a low uncertainty avoidance score of 46. Even more interesting is the precision also associated with Flame, not surprisingly Israel has a high uncertainty avoidance score of 81. This dimension offers many additional research opportunities in Cybersecurity that this researcher hopes to explore.

## 2.5 The long-term orientation versus short-term orientation (LTOvSTO) dimension

“Long-term orientation (LTO) stands for the fostering of virtues oriented toward future rewards—in particular, perseverance and thrift” (Hofstede et al., 2010, p. 239). LTO focuses on the distant time horizon. Short-term orientation (STO) deals with a preference for more immediate gratification or returns.

In terms of thinking the differences between LTO and STO exists and have been documented. Hofestede et al. (2010) note the difference between the analytical Western thought process and the synthetic, holistic Eastern thought process. “Western analytical thinking focused on elements, while Eastern synthetic thinking focused on wholes” (Hofstede et al., 2010, p. 250). This statement by Hofstede et al. (2010) is consistent with the work by Buchtel & Norezayan (2008). Buchtel & Norezayan (2008) attribute the difference between analytical and holistic thinking to culture. This cultural dimension deals primarily with strategies, and provides an interesting research area but will not be a primary focus area for this research effort.

## 2.6 The Indulgence versus restraint (IVR) dimension

The final cultural dimension deals with indulgence versus restraint (IVR). “Indulgence stands for a tendency to allow relatively free gratification of basic and natural human desires related to enjoying life and having fun” (Hofstede et al., 2010, p. 281). The opposite pole of this spectrum deals with moderation or restraint. “The items that defined the positive pole of this dimension were ‘moderation’, ‘keeping oneself disinterested and pure’, and ‘having few desires’” (Hofstede et al., 2010, p. 288). Cynicism and other negative emotions are often times associated with the restraint pole of this dimension.

Certain behavioural consistencies have been observed. One such area deals with math, science and logical reasoning. “Societies whose children are better in mathematics are also societies whose children are better in science, in logical reasoning, and in reading. Success in all these domains is closely associated with weak monumentalism and strong flexhumility, even after taking into account the role of national wealth” (Minkov, 2011, p. 102). Conversely, a negative correlation exists between monumentalism and math performance. “The more monumentalist a particular society is, the lower its achievement in mathematics” (Minkov, 2011, p. 101).

Minkov (2011) suggests that the desire to finish first and be considered the best may lead to goals that foster superficial learning. Unlike intrinsically motived learning, superficial learning is extrinsically motivated (Minkov, 2011). Minkov (2011) provides a simple distinction between indulgent Americans and restrained Asians and Eastern Europeans. “Americans like to receive compliments. But in Japan and China, just like Eastern Europe, personal praise often causes embarrassment” (Minkov, 2011, p. 95).

Not surprising, most attacks that are named after their designers also coincide with indulgent societies. For example, the Kaminsky bug and the Morris worm were both authored by Americans one of the more indulgent societies. Certain type website defacements may also contain an indulgent behavioural component. An example of indulgent behaviour can be seen on the MI6 attack on an al-Qaeda website, where bomb making instructions were replaced by baking instructions. (Gardham, 2011),

The use of the Hofstede defined dimensions allows for a widely recognized framework for evaluating the behaviours, and a set of metrics for quantitative analysis. In spite of globalization and widespread use of the Internet the users are still educated within the context of their cultures. The statement by Hofstede et al., (2010) “software of the machines may be globalized, but the software of the minds that use them is not” (Hofstede et al., 2010, p.391), provides the launching point for the research, for if this statement is true, then a new vector for attack attribution may become available.

**3. Methodology**

This study consists of experiments using two different data sets being quantitatively compared and analysed for statistical significance using Z testing or Mann-Whitney U testing to obtain p-values. In order to test this hypothesis, culture and behaviours are decomposed into specific research questions. Two CNA activities are examined across all six dimensions.

The data used for comparison consists of primary and secondary data. The primary data, raw data, is provided by Hofstede and consists of his scoring results for 78 countries across six dimensions. Secondary data is used from academic peer reviewed articles, periodicals, news sites and web sites. One other source of data is Internet population data obtained from the Internet World Stats website. Additional information on the methodology will be explained in each subsection.

**3.1 Data set one**

The website [www.zone-h.org](http://www.zone-h.org) provides examples of website defacements and a starting point for collecting data on nationalistic, patriotic themed website defacements. The use of scholar.google.com as a search engine resulted in reports describing attacks by various countries. Because the reports were analysis of attack behaviours and choices, a country either engages in the behaviour or does not. Participation is only scored once. Testing for the p-value will rely on means tests.

The first research question asks, do nationalistic, patriotic-themed website defacements correlate with high power distance societies? The comparisons will be made to the mean score across each dimension. Resulting p-value scores will use the 0.05 rules for statistical significance measure. The following data will be used with the following equation Zn = (μ - x̅)/(σ/√n, unless the data is not normally distributed, then the Mann-Whitney U test will be used.

Table 1: Sample data set with Hofstede dimensional scores

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Country | PDI | IVC | M/F | UAI | LTOvSTO | IVR |
| Bangladesh | 80 | 20 | 55 | 60 | 47 | 20 |
| China | 80 | 20 | 66 | 30 | 87 | 24 |
| India | 77 | 48 | 56 | 40 | 51 | 26 |
| Indonesia | 78 | 14 | 46 | 48 | 62 | 38 |
| Iran | 58 | 41 | 43 | 59 | 14 | 40 |
| Israel | 13 | 54 | 47 | 81 | 38 | Null |
| Malaysia | 104 | 26 | 50 | 36 | 41 | 57 |
| Pakistan | 55 | 14 | 50 | 70 | 50 | 0 |
| Philippines | 94 | 32 | 64 | 44 | 27 | 42 |
| Portugal | 63 | 27 | 31 | 104 | 28 | 33 |
| Russia | 93 | 39 | 36 | 95 | 81 | 20 |
| Singapore | 74 | 20 | 48 | 8 | 72 | 46 |
| Taiwan | 58 | 17 | 45 | 69 | 93 | 49 |
| Turkey | 66 | 37 | 45 | 85 | 46 | 49 |
| Population Mean/Std Dev. | 59 21.25070 | 45 23.97152 | 49 19.32747 | 68 22.99296 | 45 24.2320162 | 45 22.29343 |

**3.2. Data set two**

The second data set deals with frequencies. A search was performed on the top 20 all time black hat hackers. Only those hackers from after 1993 were accepted because the Internet was not fully global before that time. The expected results are a representative sample created from the data found at [www.internetworldstats.com](http://www.internetworldstats.com) Table 3 contains the actual results, actual frequencies and the cultural dimension scores.

Table 2: Representative sample of countries and frequency

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Country | PDI | IVC | M/F | UAI | LTOvSTO | IVR | Frequency |
| China | 80 | 20 | 66 | 30 | 87 | 24 | 3 |
| India | 77 | 48 | 56 | 40 | 51 | 26 | 2 |
| Japan | 54 | 41 | 95 | 92 | 88 | 42 | 1 |
| Russia | 93 | 39 | 36 | 95 | 81 | 20 | 1 |
| Germany | 35 | 67 | 66 | 65 | 83 | 40 | 1 |
| UK | 35 | 89 | 66 | 35 | 51 | 69 | 1 |
| US | 40 | 91 | 62 | 46 | 26 | 68 | 2 |
| Iran | 58 | 41 | 43 | 59 | 15 | 40 | 1 |
| Brazil | 69 | 38 | 49 | 49 | 44 | 59 | 1 |
| Mexico | 81 | 30 | 69 | 82 | 24 | 97 | 1 |
| Africa West | 77 | 20 | 46 | 54 | 9 | 78 | 1 |

Table 3: Actual Top hacker’s country and frequency

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Country | PDI | IVC | M/F | UAI | LTOvSTO | IVR | Frequency |
| US | 40 | 91 | 62 | 46 | 26 | 68 | 6 |
| UK | 35 | 89 | 66 | 35 | 51 | 69 | 4 |
| Russia | 93 | 39 | 36 | 95 | 81 | 20 | 1 |
| Germany | 35 | 67 | 66 | 65 | 83 | 40 | 1 |
| Canada | 54 | 73 | 45 | 73 | Null | Null | 1 |
| Philippines | 94 | 32 | 64 | 32 | 27 | 42 | 1 |
| Greece | 60 | 35 | 57 | 112 | 45 | 50 | 1 |

**4. Results Figures and Tables**

Results from the tests for the first data set are presented in Table 4. These results were achieved by comparing mean scores. The Mann-Whitney test was used most often, to determine the Z score and the p-value.

Table 4: Data set 1 results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dimension | Z Score | p-value | Hypothesis | Alternative Hypothesis |
| PDI | 2.42 | 0.0281 | Reject | Accept |
| IVC | -2.35 | 0.015 | Reject | Accept |
| M/F | 0.5714 | 0.4247 | Accept | Reject |
| UAI | -1.33 | 0.123 | Accept | Reject |
| LTOvSTO | 1.15 | 0.1251 | Accept | Reject |
| IVR | -1.51 | 0.0655 | Accept | Reject |

Hypothesis: Nationalistic, patriotic themed website defacements correlate with low power distance societies. H0: u0 < 59 and

Alternative Hypothesis: Nationalistic, patriotic themed website defacements correlate with high power distance societies: H1: u0 >= 59

Figure 1: Actual and predicted PDI results

Hypothesis: Nationalistic, patriotic themed website defacements correlate with individualist societies. H2: u0 > 45 and

Alternative Hypothesis: Nationalistic, patriotic themed website defacements correlate with collectivist societies. H3: u0 <= 45

Figure 2: Predicted and actual IVC results

Hypothesis: Nationalistic, patriotic themed website defacements correlate with indulgent societies. H4: u0 < 45 and

Alternative Hypothesis: Nationalistic, patriotic themed website defacements correlate with masculine societies. H5: u0 >= 45

Figure 3: Predicted and actual IVR results

The second set of data deals with the frequency of individual “lone wolf” attacks, by examining the top hacker lists. The pooled estimate is represented by p̂, Table 5 contains the results for each dimension.

Table 5: Data set 2 Results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dimension | Z = | p-value | Hypothesis | Alternative Hypothesis |
| PDI | -2.03 | 0.0212 | Reject | Accept |
| IVC | 2.53 | 0.0057 | Reject | Accept |
| M/F | 0.04 | 0.484 | Accept | Reject |
| UAI | 0 | 0.5 | Accept | Reject |
| LTOvSTO | 0.85 | 0.1977 | Accept | Reject |
| IVR | 1.55 | 0.0606 | Accept | Reject |

**5. Conclusion**

The results indicate that culture does appear to play a role in CNA choices and behaviours. This initial analysis is simply a “proof of concept”. The PDI and IVC dimensions appear to support this initial hypothesis.

Often times what is not seen is equally as important as what is seen. This appears to be the case in this area of research. For example, when examining the IVC dimension with the first data set, not only did the results support the collectivist tendency, but also what was not seen was the lack of individualist results. The highest score in that dimension was below the cut-off for the top 1/3 range.

A similar finding also occurred with the second dataset and the IVR dimension. When both sets of scores a combined the finding suggests that lone wolf attackers are more likely to come from indulgent societies, *and* individual, “lone wolf” hackers are very unlikely to come from countries with strong restraint scores. When examining the first dataset, the restrained pole of the IVC dimension was dominant and representation the indulgent dimension was lacking. This is even more significant because the differences were close to opposite in response to the research questions.

The two simple CNA behaviours that were used in this study were chosen for expediency. This area of research holds a great deal of promise for both offensive and defensive uses. Specific attack types should be evaluated within Hofstede’s cultural dimensions framework in order to determine the validity of applying this framework on a much larger scale. Initial anecdotal evidence appears to support this suggestion, now a more formal study is needed.

The use of cultural markers in CNA attribution offers the promise of being able to augment existing solutions in order to find the true origination point of an attack. This research is in the very early stages and should not be viewed as a replacement to any of the existing attribution technologies. Instead, this research should be used as an additional piece in a very complex puzzle.

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