

Undergraduate Thesis Prospectus

Improving Latency for Secure Distributed Matrix Multiplication

(technical research project in Computer Science)

How Negative Gossip Enforces Social
Conformity in Vietnamese Communities

(sociotechnical research project)

by

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem

How is system security best maintained?

Security is a fundamental human right and individuals deserve to expect a level of protection in all aspects of their life (Jain, 2018). Whether it's storing sensitive information in an online account or taking a walk around their neighborhood, individuals are constantly interacting in systems that require their trust. A website must look credible if it wants access to an individual's credit card and a neighborhood must have security measures in place to strengthen a sense of community. Individuals notice these elements and act cautiously; thus, demonstrating the human need for safety.

When security is at risk, it is up to members of the system to find a solution. In a system of website managers, online sellers, and consumers, solutions for an untrustworthy website could be a customer deciding not to buy something, or the website developers improving their application's safeguards. In a system of neighbors and landlords, solutions for an unsafe neighborhood could be the community members reporting crime and organizing a neighborhood watch group, or landlords responsibly scoping out renters.

The technical research problem explores how those educated in computer science can optimize algorithms to make data storage online more secure. The sociotechnical research problem explores how gossip drives cooperation and prosocial behavior (Imada, 2021). When the people or leaders of a community gossip about someone straying from the norms, pressure on the individual to socially conform can make the majority feel safer. The topics explore who is responsible for monitoring system security, and how far safety measures can go before the drawbacks outweigh the benefits.

Optimizing Algorithms: Improving Latency for Secure Distributed Matrix Multiplication

What improvements can be made to secure distributed matrix multiplication methods to reduce latency for big data applications?

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Matrices are a simple way to represent data efficiently (Johnson, 2023), and they are used for virtually anything that can be solved numerically like processing images (Ansari, 2022). On a large scale, these matrix multiplication calculations become complex and less time-efficient. The most common solution is to use distributed systems and delegate the multiplication process to various worker nodes (Bui, 2022). This means that all processes go from being performed on the same machine with access to the same physical memory, to being distributed among many machines and sources of physical memory. When matrices containing sensitive information are applied to big data such as artificial intelligence, data science, and cloud computing, the data is no longer secure since it is not restricted to one machine. This introduces vulnerabilities because the data may be distributed to compromised nodes. During my Advanced Computing Systems Research Internship with the National Security Agency, I led a three-person scrum team and researched, implemented, and tested new avenues for secure distributed matrix multiplication.

The goals of the project were to research different secure distributed matrix multiplication methods and eventually select an algorithm, implement it with security measures, and test different methods to improve its efficiency. We researched algorithms such as Secure Mat-Dot Code, Gap Additive Secure Polynomial Code, and Linear Code (Makkonen, 2022). We settled on the Secure Mat-Dot Algorithm given its flexibility and complexity—striking the right

balance between security and efficiency without becoming overly complicated. The Secure Mat-Dot Algorithm is still used in recently published research and is one of the best algorithms for secure distributed matrix multiplication. We implemented the algorithm with the following security measures: secret sharing and polynomial code. We ran the algorithm on a 2048x2048 matrix and got an average run time of 207 seconds. To reduce latency and improve efficiency, the best optimization methods we found were multithreading, compiling the code with an optimization level, pre-calculating computationally heavy operations, optimizing interpolation, and transposing the matrix. These modifications reduced the run time for a 2048x2048 matrix by 92.3% (207s to 16s), proving the practicality and feasibility of secure distributed matrix multiplication with polynomial codes and shared memory. Continuing this research, I would like to try other optimizations such as removing modular arithmetic by implementing a Galois field or testing Lagrange's method in place of the Vandermonde matrix.

How Negative Gossip Enforces Social Conformity in Vietnamese Communities

In Vietnamese communities, how does negative gossip enforce social conformity?

In Vietnam, gossiping, in the traditional sense, means speaking ill of your family and neighbors (Linh, 2016). Researchers found that the prospect of gossip promoted prosocial behavior—specifically, participants displayed more generosity and it drove cooperation (Imada, 2021). The study demonstrates how the fear of judgment can influence an individual's behavior toward others. However, the study fails to differentiate the effects between negative and positive gossip on social groups in relation to ecological and cultural contexts. In Vietnam, gossip conventionally occurs in small rural towns where everyone knows each other, and it can be detrimental, leading to ostracism or social exclusion. Negative gossip instills fear in many and creates a feeling of hostility towards one another. Recently, social media has introduced a new way of publicizing gossip and has made subjects of gossip even more vulnerable to public opinion. Vietnamese communities demonstrate how the impact of negative gossip from media outlets and gossipers on an individual can lead to changes in the individual's behavior and how the individual interacts or is treated by others in the community.

VnExpress, one of the most popular websites in Vietnam that posts Vietnamese online newsletters, is an example of a media outlet that publicizes and spreads gossip. One such article's page is titled, "Cher's love affair with her boyfriend who is 40 years younger than her" with accompanying photos revealing how the newsletter attracts subscribers through dirt and embarrassing headlines (Giang, 2023). Some comments left on the article roughly translate to "Uhm. Very suitable, probably for a few months." and "still has no plans to have children. Oh oh oh!". These are examples of modern gossipers whose strategy is posting criticism online. The

comments demonstrate an agenda for enforcing more traditional ideals, such as the expectation for a woman to bear children. Another example from VnExpress is about a famous Vietnamese artist and actress, Linh, who is criticized by the internet for making arrogant comments during a press conference. A communications expert shares disappointment in Linh, saying “Linh should behave more carefully and show her respect towards the questioners” (Nhat, 2023). In this case, the modern gossipers have clear motives for enforcing 21st-century ideals. Following the media frenzy, Linh released a statement to audiences and the media, stating, “I understand that I am responsible for apologizing to the fans who have spent their love on me” and followed the apology with a promise to improve her behavior. Similarly, Vietnamese celebrities were criticized for their dubious intentions with money solicited for charitable activities. After receiving backlash, they began releasing bank statements and written statements that they would “make a summary of how [they] spent the donation, with information of sources and recipients written clearly” (Thu, 2021). Celebrities who are subjects of gossip often must release statements and conform to prosocial behavior, especially when their fame and occupation directly depend on their fanbase.

In contrast, everyday people who are subjected to gossip approach negative gossip differently. Stephen Turban, an individual who lived in Vietnam during COVID-19, shares how people openly shame, complain, and criticize others who did not wear masks (Turban, 2020). He specifically speaks about a patient in Vietnam who faced viral criticism for returning from Europe with a cough that was eventually linked to other cases of coronavirus. The patient experienced public shaming, including “dozens of media articles lambasting their lack of public consciousness”, and the person’s name, contact information, and address were leaked publicly. The patient’s doxing and social punishment turned them into a cautionary example for others. By

pushing their beliefs and criticizing the patient, gossipers achieved a collective ethos, where members of the community, like Stephen, who may have initially believed “[facemasks] have no use, they don’t protect you from contracting the virus”, changed their mindset to start “thinking [about] the impact on others before returning to oneself.” Organizations and individuals spread negative gossip with the intention of fixing behavior or sending a message. Subjects of gossip risk social exclusion and public punishment, and often need to change their behavior to regain social acceptance.

Traditional oral gossipers usually follow traditional ethics. This tends to be more gender-specific, where women more commonly feel unwelcome and judged. For example, Núi shares her experience of returning to her village and selflessly sharing her wealth with the villagers, only to be met with negative gossip. Núi describes the villagers as “narrow-minded, selfish and envious”, and their distaste for her donations was driven by a shared loathing for the rich, and, especially men, felt jealousy for the economic power she held. A lady, Thuy, even went up to Núi and addressed her “as a selfish old hag, [Thuy] claimed that Núi was a bad and immoral woman who had more than one husband and had used her wealth to shout at and scold villagers” (Binh, 2016). Following this incident, “Núi’s relationship with family members in the village soured” and she was “worried about losing the new identity and status that had been created through her interactions and acts of giving to the people and community”. The aftermath of Núi’s public scolding created hostility in the community towards Núi and her supporters, leading to the eventual end of her charity.

Modern and traditional Vietnamese communities demonstrate how the impact of negative gossip can lead to changes in an individual's behavior and how social groups can sanction those if they do not conform to their beliefs. The fundamentals of gossip aren’t restricted to Vietnam,

so conclusions here can loosely apply to all cultures. Gossiping can act as a social thermometer for improper behavior and create social change (Hitchcock, 2009), but when taken too far, it could be considered harassment (Shukri, 2018). Negative gossiping comes with its own positives and negatives, like in the case of Stephen Turban's accounts on the social punishment for patients who exhibited unsafe practices during the coronavirus. On the one hand, the negative gossiping could be seen as a positive because it potentially stopped others from doing something that could harm those around them; on the other hand, when the gossip spread like wildfire to the point of doxing and public shaming, this could have had a detrimental effect to the patient's mental health and physical safety. "Harrassed individuals exposed to negative and hostile interpersonal acts lead to devaluation, exclusion, and status loss of these individuals, as well as mental health problems, including depressive symptoms and suicidal behavior" (Thomas, 2023). The result of a community that gossips and capitalizes on others' fear of public shaming is a feeling of restriction towards individuals trying to develop and follow their own beliefs.

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