Graph-Based Modeling of Elemental Reactions in Genshin Impact: A Damage Output Comparison Using Graphs and Hypergraphs

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***Abstract*—Genshin Impact is a free-to-play open-world RPG developed by miHoYo Co., Ltd, which features a combat system that revolves around elemental reactions. This paper models the relationships between elements and their reactions using graph and hypergraph theory. A Python-based calculator was developed and used to simulate and assist in analyzing as well as comparing the outputs of Damaging Reactions based on a dummy character profile. The results are then reflected in weighted reaction graphs to highlight differences in damage potential. This study shows how discrete mathematical structures can effectively represent real-time systems in games.**

***Keywords*—Discrete Mathematics, Elemental Reactions, Genshin Impact, Graph Theory.**

I. Introduction

Genshin Impact is a free-to-play action RPG developed and published by miHoYo Co., Ltd. Released on September 28th 2020, the game features a fantasy open-world environment and a real-time action combat mechanic that lets players swap between 4 different characters in their party to quickly combo their attacks and elemental abilities, along with a gacha monetization system that allows players to obtain new characters, weapons, and other resources. While single-player gameplay is the focus of the game, a limited multiplayer mode is also available, allowing up to four players to coexist in the same world.

One of the core mechanics of the game's combat system is elemental reactions. Elemental reactions occur when different elements are applied to a target (enemies, player, or objects) that is already affected by another element within a certain combination. These reactions are not merely visual but have a mathematical basis as formulas and multipliers that govern their damage output, involving variables such as Elemental Mastery, character level, and enemy resistance. For the purpose of this study, only damaging elemental reactions are considered, as they involve quantifiable outputs that can be analyzed mathematically.

To model these interactions, this study uses methods from discrete mathematics, specifically graph and hypergraph theory. Directed weighted graphs are used to depict simple two-element reactions, such as melt or vaporize, where the edges show the strength and direction of the interaction. More complex reactions—namely, Hyperbloom or Additive effects like Aggravate and Spread—require modeling beyond binary connections. For this, weighted hypergraphs are used, allowing hyperedges to represent multi-element relationships that cannot be fully captured by traditional graphs. Within this model:

- Vertices represent the element types,
- Edges or hyperedges represent elemental reactions,
- And weights correspond to theoretical damage outputs derived from in-game formulas.

To ensure accuracy and clarity, reactions are categorized and modeled separately as Amplifying, Transformative, and Additive hypergraphs, each reflecting the distinct mechanics and prerequisites of its respective reaction group. A dummy character with fixed stats (e.g., level and Elemental Mastery) is used to simulate the theoretical damage values under standardized conditions. These results are computed using a custom-built Python calculator that applies the relevant formulas per reaction type.

Ultimately, this paper aims to demonstrate the practical application of discrete mathematics—especially graph theory—in modeling real-world systems found in digital games. It seeks to both depict the complexity of Genshin Impact's elemental system and quantitatively analyze the theoretical damage potential of its reactions.

II. Theoretical Framework

A. *Graph Theory in Game Development*

Graph theory has a wide range of applications in different fields, particularly within game development and analysis. A presentation done by Clara Nguyễn called "Graph Theory Applications in Video Games" (2020) provides a compelling overview of key use cases:

- Graph structures in 3D graphics: Mesh structures made up of vertices and edges, like triangular polygons, are essentially graph-based and are frequently used to create gaming environments in the field of 3D graphics. These graph structures play a crucial role in how objects are rendered and how visual elements are organized and processed by the game engine.
- Race lap detection: In racing games, lap counting is

a pinnacle element where the game needs to keep track of player lap count, player position, and distance between players. To do so, they use a graph representation of track checkpoints to ensure players follow valid lap paths, which relies on the Hamiltonian circuit concept to verify lap completion.

- Maze-generation algorithms: Additionally, there are many games that feature procedurally generated mazes or dungeon layouts. These are typically created using algorithms that rely on disjoint-set data structures (also known as union-find) combined with graph traversal techniques, so that it ensures the maze is not only fully connected but also solvable.

B. Hypergraph Theory

The fundamental idea behind hypergraphs, which are structures composed of finite sets and forms, is to treat sets as generalized edges, where a group of these edges, referred to as hyperedges, creates a hypergraph. These hyperedges, in contrast to traditional graphs, can connect more than two elements simultaneously, allowing for the representation of more complex relationships. A set of vertices V and a family of non-empty subsets $E \subseteq P(V)E$ make up a formal hypergraph $H = (V, E)$, where each hyperedge is a subset of V. This exact field has seen significant growth particularly in the latter half of the 20^{th} century thanks to developments in computer science. According to Claude Bretto's *Hypergraph Theory: An Introduction* (2013), hypergraphs have been used to simulate computational logic systems, relational databases, and biological networks—areas where simple pairwise interactions fall short.

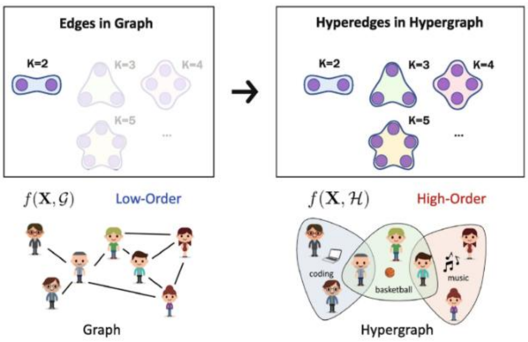

Figure 1. A Visual Comparison of What a Graph and a Hypergraph Are
Source: https://link.springer.com/chapter/10.1007/978-981-99-0185-2_2

C. Genshin Impact

Genshin Impact is a free-to-play action RPG published by miHoYo Co., Ltd. that was released on September 28, 2020, for Microsoft Windows, PlayStation 4, Android, and iOS platforms. Only after sometime later would it get released for PlayStation 5, the Xbox Series, and on the Epic Games Store. The game takes place in the world of Teyvat, which is home to seven major nations: Mondstadt, Liyue, Inazuma, Sumeru, Fontaine, Natlan, and Snezhnaya. Each of these nations is governed by deities known as Archons who are part of a group of gods called "The Seven," and each of them is associated with one of the seven elements of Teyvat. The player can choose to play as either one of the "star traveler" twins of who got separated from their other half by an ancient god blocking their path as they were trying to flee Teyvat due to the chaos and destruction that was ravaging the land at that time. This then becomes the player's main goal to finally reunite with their lost twin while exploring the world and defending it from various evils.

Figure 2. Game Opening Scene When the Twins Fight the Ancient God
Source: https://kotaku.com/genshin-impact-gets-a-lot-better-after-the-lengthy-firs-1845244351

The game features a real-time action combat mechanic that lets players swap between 4 different characters in their party to quickly combo their attacks and elemental abilities, with each character having mastery over one of seven natural elements: Anemo, Cryo, Dendro, Pyro, Electro, Geo, and Hydro. These characters then apply those elements through their Elemental Skill and Elemental Burst, and when two or more compatible elements interact on a target, an Elemental Reaction is triggered—one of its most distinctive combat mechanics.

D. Elemental Reactions and Their Mechanics

Elemental reactions occur when different elements are applied to a target (enemies, player, or objects) that is already affected by another element within a certain combination. In Genshin Impact, each of the seven elements can trigger at least one type of elemental reaction. There are, however, some restrictions to these reactions as certain elements cannot interact with others.

Table 1. Elements and Their Reactions Against One Another

<table>
<tr><th></th><th>Pyro</th><th>Hydro</th><th>Electro</th><th>Cryo</th><th>Dendro</th><th>Anemo</th><th>Geo</th></tr>
<tr><td>Pyro</td><td>-</td><td>Vaporize</td><td>Overloaded</td><td>Melt</td><td>Burning</td><td rowspan="4">Swirl</td><td rowspan="4">Crystalize</td></tr>
<tr><td>Hydro</td><td>Vaporize</td><td>-</td><td>Electro-charged</td><td>Frozen (+Physical or Geo = Shattered)</td><td>Bloom (+Pyro = Burgeon) (+Electro = Hyperbloom)</td></tr>
<tr><td>Electro</td><td>Overloaded</td><td>Electro-charged</td><td>-</td><td>Super-conduct</td><td>Quicken (+Dendro = Spread) (+Electro = Aggravate)</td></tr>
<tr><td>Cryo</td><td>Melt</td><td>Frozen (+Physical or Geo = Shattered)</td><td>Super-conduct</td><td>-</td><td>-</td></tr>
<tr><td>Dendro</td><td>Burning</td><td>Bloom (+Pyro = Burgeon) (+Electro = Hyperbloom)</td><td>Quicken (+Dendro = Spread) (+Electro = Aggravate)</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Anemo</td><td colspan="4">Swirl</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Geo</td><td colspan="4">Crystalize</td><td>-</td><td>-</td><td>-</td></tr>
</table>

These reactions themselves can be divided into two main categories, Non-Damaging and Damaging, which can be split up into three types: Amplifying Reactions, Transformative Reactions, and Additive Reactions. It must be noted that the effect of certain elemental reactions is dependent on the order in which the elements are applied, while others are indifferent to it. For instance, Overload yields the same outcome whether Pyro or Electro is applied first. In contrast, reactions such as Melt are order-sensitive, producing different damage multipliers depending on which element acts as the trigger. To clarify this distinction, the community uses the terms **"Aura"** (the element already present on a target) and **"Trigger"** (the element applied to activate the reaction).

In addition, the timing and manner of each elemental reaction are dictated by internal rules. The Elemental Gauge (Unit) Theory is one such rule that describes how an attack applies elements in different strengths, measured in units, which determines how much of an elemental aura is consumed during a reaction. The effectiveness of aura consumption is influenced by elements such as trigger types (strong or weak), and the strength is determined by predefined values linked to certain skills rather than damage dealt. Alongside this, the Internal Cooldown (ICD) system places a hidden restriction on how often a single skill or burst can apply its element. While certain abilities have modified or no ICD whatsoever, the majority of them follow a standard ICD pattern—applying elements once every three hits or every 2.5 seconds.

Non-Damaging Reactions are Frozen, Crystalize, and Quicken, where instead of dealing damage, they provide other attributes with associated elements. Here is a breakdown of those reactions and what they do:

a) Frozen

Frozen is a reaction triggered when Cryo and Hydro meet, which temporarily immobilizes characters or enemies. The reaction consumes the weaker of the two auras, and its duration is determined by the strength of the elemental application—measured in gauge units—as well as the target's resistance to the effect. In this state, the afflicted can receive a follow-up reaction by applying another element that will remove or reduce Frozen aura duration or completely clear the aura on the target.

b) Crystalize

Crystalize is triggered when a target that is afflicted with Pyro, Electro, Cryo, or Hydro takes Geo DMG, creating a Crystallize Shard nearby. This shard will then grant the player a shield of a certain strength—calculated based on Character Level for the base shield HP and EM for bonus shield HP—when picked up. There can only exist up to three shards on the field, as creating a new one then removes the oldest. They will remain on the ground for 17 seconds and form a shield lasting 15 seconds when picked up. This shield absorbs 250% of damage from its corresponding element and gives resistance to interruption. However, only one Crystallize shield can be active at a time, as picking up another replaces the existing one, and it must be noted that these shields don't stack with other shield sources since all shields absorb damage together.

c) Quicken

Quicken occurs when Dendro and Electro are applied to a target, placing it in a Quickened state that lasts as long as both elements are active (approximately 11 seconds). When in this state, using another Dendro attack will trigger the Spread reaction; meanwhile, using Electro will trigger Aggravate, both of which deal extra damage. Since these reactions require the target to remain Quickened, the state is frequently refreshed through continued application of Dendro or Electro. Although not an aura, the Quickened state behaves similarly in its interactions. Using Dendro or Electro on a Quickened target triggers Spread or Aggravate reactions, respectively, both adding bonus damage without consuming the state. However, applying Pyro or Hydro instead will trigger Burning or Bloom, which reduces the state's duration.

Damaging reactions can be further classified as three archetypes:

i. Amplifying Reactions

Amplifying reactions multiply the damage of the triggering attack with the EM Bonus and a special multiplier, 200% for Vaporize triggered by Hydro and Melt by Pyro, as well as 150% for Vaporize triggered by Pyro and Melt by Cryo. Reactions that apply the 200% multipliers are often referred to as "strong", whereas those that use 150% instead are labelled as "weak". In short, they have something more to do with the interaction and sequence of the application of the elements rather than the damage output. As such, a "weak" trigger consumes less of the existing elemental aura than a "strong" one, assuming both the aura and trigger are similar in strength. As a result, weaker reactions use only half the aura, allowing multiple reactions to happen in sequence before the aura is fully consumed. Here is the damage formula along with other related formulas and data.

$$Damage_{Amplified} = Damage \times Amplifying\ Multiplier$$

$$Amplifying\ Multiplier = Reaction\ Multiplier \times (1 + \%EM\ Bonus_{Amplifying} + \%Reaction\ Bonus)$$

$$Reaction\ Muliplier = \begin{cases} 2.0\ for\ Melt\ if\ Pyro\ triggers \\ 1.5\ for\ Melt\ if\ Cryo\ triggers \\ 2.0\ for\ Vaporize\ if\ Hydro\ triggers \\ 1.5\ for\ Vaporize\ if\ Pyro\ triggers \end{cases}$$

$$\%EM\ Bonus_{Amplifying} = 2.78 \times \frac{EM}{EM + 1400} \times 100\%$$

ii. Transformative Reactions

Transformative reactions deal damage separately from the triggering attack and may include additional effects like area damage or elemental application. They can't crit (give critical hits), are unaffected by general damage bonuses, and ignore enemy defense. Instead, their damage is influenced by the player's level, Elemental Mastery, reaction-specific multipliers, and the target's elemental resistance. Each level has its specific multiplier, but the most notable ones are 1077 and 1446 for levels 80 and 90, respectively. The damage formula for these reactions is as written below, as well as other related formulas and data needed for the calculation.

$$Damage_{Transformative} = (1 + \%EM\ Bonus_{Transformative} + \%Reaction\ Bonus) \times RES\ Multiplier_{Target} \times Level\ Multiplier_{Character} \times Reaction\ Multiplier$$

$$Reaction\ Multiplier = \begin{cases} 0.25\ for\ Burning \\ 0.6\ for\ Swirl \\ 1.5\ for\ Superconduct \\ 2.0\ for\ Electro-charged\ and\ Bloom \\ 2.75\ for\ Overloaded \\ 3.0\ for\ Shattered, Burgeon, and\ Hyperbloom \end{cases}$$

$$EM\ Bonus_{Transformative} = 16 \times \frac{EM}{EM + 2000} \times 100\%$$

Here is a further explanation on the reactions within this category:

a) Burning: occurs when Pyro and Dendro react, dealing AoE Pyro damage and applying a Burning aura that deals continuous Pyro damage until it eventually fades.
b) Swirl: occurs when Anemo and Pyro/Electro/Cryo/Hydro react, dealing AoE damage of the swirled (non-Anemo) element to the affected target and nearby enemies. When Swirl is triggered on two or more enemies simultaneously, each enemy affected will take damage from their reaction and also from one nearby target's reaction, resulting in two instances of Swirl damage per enemy. Although there is an exception for Hydro—swirling it only applies the Wet state and damaging the target it was triggered on. Triggering a swirl is considered a "weak" interaction, therefore allowing further reactions as the aura would not be fully cleared from the enemy.
c) Superconduct: happens when Electro and Cryo react, dealing AoE Cryo damage and reducing the Physical Resistance of all enemies hit by 40% for 12s.
d) Electro-charged: happens when Electro and Hydro react, dealing Electro damage once per second to the target and nearby enemies that have the Wet state until either the Hydro or Electro aura wears off.
e) Bloom: triggered when Dendro and Hydro react, creating Dendro cores that deal AoE Dendro damage after exploding (within 6s or when 5 new cores are created). Each enemy can't take damage from the Dendro cores more than twice every 0.5s, and when the character takes damage from a core, they'll only receive 5% of it. If Dendro is the reaction trigger, then the Hydro aura will be completely cleared; meanwhile, if Hydro is the trigger instead, it'll only clear half of the Dendro aura.
f) Overloaded: triggered when Pyro and Electro react, dealing AoE Pyro damage and causing a strong explosion which clears all of the Pyro and Electro aura.
g) Shattered: occurs when a Frozen enemy is hit by a heavy attack (claymore and plunging attacks, explosions, Geo damage, etc.), ending the Frozen state and then dealing Physical damage.
h) Burgeon: happens when a Dendro core comes into contact with Pyro, dealing AoE Dendro damage.
i) Hyperbloom: triggered when a Dendro core comes into contact with Electro, where it will then transform the cores into a homing Sprawling Shot that deals Dendro damage upon impact. Has a very small AoE, but it can hit multiple enemies if they're close enough.

iii. Additive Reactions

Additive reactions enhance the base damage of the ability that triggers them with a fixed bonus. These reactions can only happen on enemies with the Quicken state. Applying Dendro causes Spread, while Electro causes Aggravate. The bonus damage they apply scales with the character's Elemental Mastery, level, and a specific multiplier (125% for Spread, 115% for Aggravate), and also benefits from other standard damage modifiers like CRIT, damage bonus, resistance, and defense reductions. Below is the formula, including related data needed in the calculation:

$$Additive\ Base\ Damage\ Bonus_{Quicken} = Reaction\ Multiplier \times Level\ Multiplier_{Character} \times (1 + \%EM\ Bonus_{Quicken} + \%Reaction\ Bonus)$$

$$Reaction\ Multiplier = \begin{cases} 1.15\ if\ Agravate\ is\ triggered \\ 1.25\ if\ Spread\ is\ triggered \end{cases}$$

$$\%EM\ Bonus_{Additive} = \frac{5\ \times EM}{EM + 1200} \times 100\%$$

Additional Notes. The *%Reaction Bonus* within these formulas is are effects obtained from certain artifact sets, such as the 4-piece set bonus of the Crimson Witch of Flames artifact, where its 2-piece and 4-piece effects amplify Pyro DMG and reactions like Overloaded, Burning, Vaporize, and Melt. Furthermore, the RES multiplier applied to reaction damage is not static—it depends on the target's elemental resistance. The game applies different formulas depending on the resistance range:

Table 2. RES Multiplayer Formulas and Their Corresponding Intervals

Formula	Intervals
$1 - (\frac{RES}{2})$	RES < 0
$1 - RES$	0 ≤ RES < 75
$\frac{1}{4\ \times RES + 1}$	RES ≥ 75

III. METHODOLOGY

As previously mentioned by the author, this study will use discrete mathematics concepts—directed weighted graphs and weighted hypergraphs—to model the elemental reaction mechanics of Genshin Impact. Graph theory is used to represent the relationships between elemental types and their resulting reactions. Binary and directional reactions, such as Melt and Vaporize are modeled using directed graphs, while more complex interactions involving multiple elements—such as Hyperbloom or Quicken-based reactions—are modeled using hypergraphs, where hyperedges can connect more than two nodes. To fit the in-game context, the nodes represent elemental types, while edges or hyperedges represent elemental reactions. Each connection is assigned a weight corresponding to the theoretical damage output of said reaction, based on standardized formulas sourced from official game references. It is also important to note that this modeling only covers reactions that produce damage, to maintain consistency with the goal of theoretical damage analysis. Non-damaging reactions are not included.

Due to the differing structural logic and prerequisites of reaction types, the models will be separated into three groups: one for Amplifying reactions (graph-based), one for Transformative reactions (hypergraph-based), and one for Additive reactions (hypergraph-based). This division prevents excessive visual clutter and allows each reaction category to be more accurately represented. While the graphs and hypergraphs will not be programmatically visualized, manually drawn representations will be constructed to illustrate the relationships and complexity of elemental interactions.

Since the author would like to focus solely on the damage analysis, to maintain consistency and simplicity, a fictional character (dummy) with fixed stats will serve as a control profile. These stats more or less reflect an average late-game character build and are applied uniformly throughout the calculations:

- Character Level: 80
- Elemental Mastery (EM): 225
- Base Attack: 1100 (used only for Amplifying reactions)
- Enemy Elemental Resistance: 10% (1.0), as the majority of enemies in-game have 10% Elemental RES. Calculations will also be under the assumption that the enemy has no other bonus RES effects (e.g., Geovishap Hatchlings have +40% Geo RES aside from a 10% Elemental RES)
- No CRIT, artifact, weapon, or talent bonuses applied.

Damage outputs on the other hand, will be computed based on official formulas that are categorized by reaction types:

➢ Amplifying:

$$Damage_{Amplified} = Damage\ \times (Reaction\ Multiplier\ \times (1 + \%EM\ Bonus_{Amplifying}))$$

Where the *%EM Bonus* is

$$2.78\ \times \frac{EM}{EM + 1400} \times 100\%$$

➢ Transformative:

$$Damage_{Transformative} = (\ 1\ + \%EM\ Bonus_{Transformative}) \times\ RES\ Multiplier_{Target} \times\ Level\ Multiplier_{Characterr} \times\ Reaction\ Multiplier$$

Where the *%EM Bonus* is

$$16\ \times \frac{EM}{EM + 2000} \times 100\%$$

➢ Additive:

$$Additive\ Base\ Damage\ Bonus_{Quicken} = Reaction\ Multiplier\ \times Level\ Multiplier_{Player}\ \times (1 +\ \%EM\ Bonus_{Quicken})$$

Where the *%EM Bonus* is

$$\frac{5\ \times EM}{EM + 1200} \times 100\%$$

The Level Multiplier is set at 1077.443668 for more accuracy, as it is what a level 80 character would have based on community-verified resources, and each elemental reaction is matched with its respective reaction multiplier. The *%Reaction Bonus* is not included within this version of the formula, as there will be no artifact bonuses applied.

To assist with the damage analysis and calculation, a custom Python script was developed to simulate the damage output of reactions using the dummy character profile. The calculator prompts users to input key parameters (Level, EM, Base Attack, and Enemy Elemental RES) as well as the type of reaction they want to use in the calculation. The script then applies the appropriate formula automatically and outputs the expected damage, allowing for reproducible and adjustable analysis. For further note, the %EM Bonus formulas will not be multiplied by 100% because it will already be in decimal form, and so multiplying it with 100% would instead give a percentage style number. Although the graphs and hypergraphs are created manually, the computed values are used to assign weights to each reaction, allowing for further comparison and modeling. The link to the repository for this code will be put underneath the appendix section.

IV. RESULTS AND DISCUSSION

This section presents and discusses the findings from the graph- and hypergraph-based modeling of Genshin Impact's elemental reactions, along with the results of the damage simulations. Using the Python calculator built for this study, several example scenarios are simulated to estimate the theoretical damage output of each reaction based on the dummy character profile. The results highlight how Elemental Mastery and enemy resistance influence the effectiveness of each reaction. Afterward, the reaction models are revisited and updated with the corresponding weights from the simulation, allowing for a more complete visual and analytical comparison between different reaction types.

Below are the graphs and hypergraphs for each type of Damaging reaction:

1) Amplifying Graph

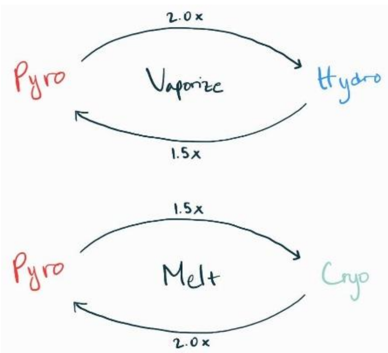

Figure 3. The Amplifying Reactions Graph
Source: Author

The diagram above illustrates the directional interactions involved in Amplifying reactions—specifically Vaporize and Melt. Each arrow shows which element is acting as the trigger, with the weight (1.5× or 2.0×) indicating the damage multiplier based on trigger order (e.g., Pyro → Cryo, meaning that Pyro came first, then Cryo, making it the trigger element). Since Amplifying reactions are order-dependent, they're modeled as directed graphs rather than hypergraphs.

2) Transformative Hypergraph

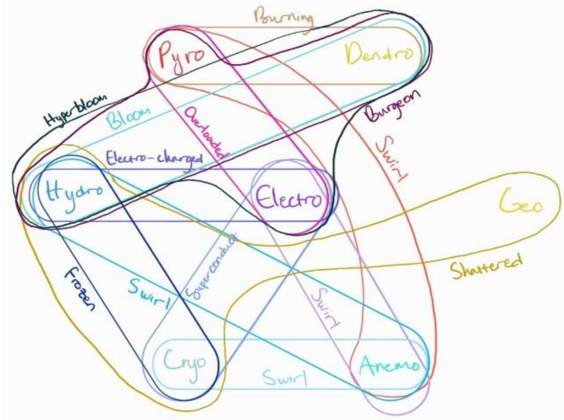

Figure 4. The Transformative Reactions Hypergraph
Source: Author

The diagram above shows the Transformative reactions represented as a hypergraph, where each node corresponds to an element type, and each hyperedge represents a reaction caused by the combination of two or more elements. The structure helps visualize how different elements interact to produce damage-based effects, with each reaction type mapped based on its required elements.

3) Additive Hypergraph

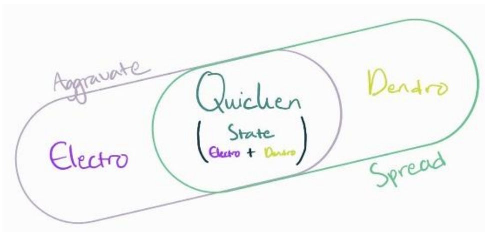

Figure 5. The Additive Reactions Hypergraph
Source: Author

The diagram above represents Additive reactions using a hypergraph. Electro and Dendro are shown as elemental nodes, while the central node represents the Quicken state, which is created when those two elements interact. From this state, Aggravate and Spread can occur depending on which element is applied next, making this structure ideal for modeling reactions that depend on conditional states.

After visualizing the reaction models, the next step is to simulate how much damage each reaction would theoretically deal. For this purpose, a custom Python calculator was built to apply the formulas using the same dummy stats across all cases.

The table below presents the calculated damage outputs for each elemental reaction, grouped horizontally by reaction category (Additive, Transformative, and Amplifying) to allow for easier side-by-side comparison. Here are the results that were acquired with the calculator:

Table 3. Damaging Reactions and Their Elemental Reaction Damage Output Grouped Horizontally by Reaction Category

Amplifying	Damage	Transformative	Damage	Additive	Damage
Strong Vaporize	3046.83	Superconduct	846.22	Spread	2410.07
Weak Vaporize	2285.12	Electro-charged	1128.29	Aggravate	2217.27
Strong Melt	3046.83	Hyperbloom	1692.43	-	-
Weak Melt	2285.12	Bloom	1128.29	-	-
-	-	Shattered	1692.43	-	-
-	-	Burgeon	1692.43	-	-
-	-	Swirl	338.49	-	-
-	-	Overloaded	1551.40	-	-
-	-	Burning	141.04	-	-

From the table above, we can conclude a few things:

- In the Transformative category, the lowest damage output comes from the Burning reaction (141.04), while the highest output—at 1692.43—comes from reactions like Shattered, Burgeon, and Hyperbloom.
- Most reactions that deal the highest damage overall come from Amplifying reactions such as Strong Melt and Vaporize, due to their multiplicative scaling with Base Attack and EM.
- Additive reactions, despite being conditional, yield surprisingly competitive damage (e.g., Spread at 2410.07), suggesting that under certain builds focused on EM and Quicken uptime, they can rival or even outperform Transformative ones.
- Swirl and Burning are notable outliers with the lowest outputs, likely due to their low multipliers and narrow scaling factors.
- Ultimately, each category presents a trade-off in scaling and consistency—Amplifying excels with high base stats, Transformative favors predictable EM-based scaling, and Additive shines when Quicken states are reliably maintained.

Below are the updated graphs that show each edge's/hyperedge's weight according to each reaction:

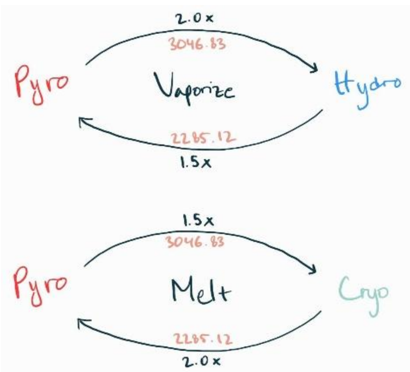

Figure 6. An Update of The Amplifying Reactions Graph with Damage Outputs as Weights
Source: Author

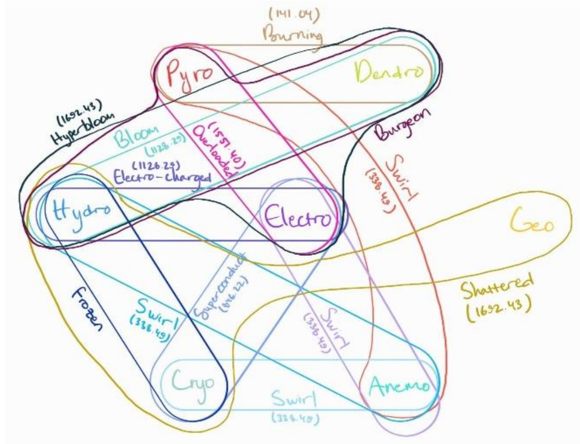

Figure 7. An Update of The Transformative Reactions Hypergraph with Damage Outputs as Weights
Source: Author

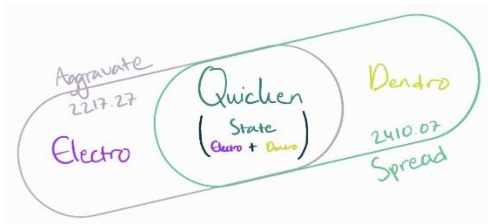

Figure 8. An Update of The Additive Reactions Hypergraph with Damage Outputs as Weights
Source: Author

V. CONCLUSION

The purpose of this study was to use weighted graphs and hypergraphs to simulate and analyze damaging elemental reactions in Genshin Impact. We were able to map out elemental interactions and replicate damage output using a standardized dummy profile by incorporating discrete mathematical structures into the game's combat systems. The findings demonstrated that, depending on elemental mastery and reaction conditions, amplifying reactions typically result in the greatest theoretical damage because of their multiplicative traits, followed by additive and transformative reactions.

Overall, this study shows how graph theory, especially when expanded through hypergraphs, can provide meaningful insight of real-time systems in video games. For more practical accuracy, this model could be expanded in the future by adding additional influencing elements like CRIT scaling, buffs, or in-game testing.

VI. APPENDIX

Github Repository Link: https://github.com/Beeziebloop/Genshin-Elemental-Reaction-Damage-Calculator

Mini Presentation Video Link: https://drive.google.com/file/d/1i-LYtEc8kwD-E2ZjBX2cieHmVok0UHoh/view?usp=drive_link

VII. ACKNOWLEDGMENT

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STATEMENT

With this, I hereby declare that this paper that I have written is my own, not an adaptation or translation of someone else's work, and not plagiarized.

Bandung, 20 June 2025

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