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THE "ACCIDENT NETWORK": A NETWORK THEORY ANALYSIS OF PROXIMATE CAUSATION

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In torts, proximate causation, or legal cause, examines whether harmful negligent conduct is "closely enough related" to the damages that ensue. Torts professors often use the metaphor of a stone being thrown into a pond to explain this rather amorphous legal doctrine. The ripples the stone creates surrounding it are the direct result of the act of it being thrown. The stone tossed into the pond, i.e., a negligent act, created an effect which perpetuated via ripples to a long distance, forever changing the entire pond, i.e., causing close and far damages. Can all of those affected by the negligent act be compensated? Should they? It is up to proximate causation to determine if a ripple is too remote from the thrown stone to be viewed as its "direct" or "foreseeable" result. However, this does not provide the legal system with a lot of guidance. This is where network theory can be helpful.

Network theory holds great value when it comes to analyzing "accident networks" and the proximate nexus between the negligent conduct and the damages ensued. Network theory enables different stakeholders, such as regulators, judges, insurers, and policymakers, to visualize multifaceted legal scenarios in a manner that can assist them to better understand and evaluate the connections (edges) between the different entities (nodes) and their reciprocal relationships. In our case, the existence of a legal nexus between the negligent conduct and the harms that followed.

This Article offers to use network theory to enable the legal system to better justify and explain the results of their proximate causation tests via tangible measurements. Integrating network theory into the evaluation of proximate causation will ensure different stakeholders will better understand and internalize the value and importance of this important doctrine. It will provide a stronger basis for deciding that certain damages cannot be traced back to a negligent act as a matter of policy or fact. The core purpose of the proximate

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causation doctrine is to provide a "normative strainer" to prevent each and every one of us from being constantly liable for actions that perpetuated remotely from us. This Article aims to develop a network theory framework to better evaluate and implement this seminal doctrine.

I. INTRODUCTION

> Cause and effect find their beginning and end in the limitless and unknowable.
>
> **—Judge Arthur G. Powell**[1]

It is said that a butterfly flapping its wings in one place can lead to a tornado half the world away.[2] Whether this "butterfly effect theory" is real or plain myth,[3] it embodies the basic notion that our actions have consequences, even far-reaching ones we did not think of or dare imagine.[4] This relationship

1. Atlantic Coast Line R.R. Co. v. Daniels, 70 S.E. 203, 205 (Ga. Ct. App. 1911).

2. EDWARD N. LORENZ & FLAVIO LORENZELLI, THE ESSENCE OF CHAOS 179 (2003).

3. Timothy Palmer, Andreas Doering & Gregory Seregin, *The Real Butterfly Effect*, 27 NONLINEARITY R123, R123–24 (2014).

4. For a discussion about the butterfly effect in the context of factual cause, rather than legal cause, see John D. Rue, *Returning to the Roots of the Bramble Bush: The "But For" Test Regains Primacy in Causal Analysis in the American Law Institute Institute's Proposed Restatement (Third) of Torts*, 71 FORDHAM L. REV. 2679, 2704 (2003).

between cause and effect is of the utmost importance when dealing with negligence claims in tort law. A long causal chain exists between our actions and their influence upon the world, and some of these influences are bound to be negative and manifested in the form of damages. However, it is undesired from a normative perspective to hold one liable for all of these damages, even if the act that led to them was negligent. Proximate causation, also known as legal cause, acts as a "normative strainer" to prevent this type of scenario. It allows us to pursue social interactions, or even simply leave our house, without the constant fear of being held liable for far-reaching consequences of our actions.[5]

But how will we decide if a specific harm was proximately caused by a negligent act?[6] The crux of proximate causation is well-explained by the seminal *Palsgraf* case.[7] A man hurrying to catch a train jumped upon it as it was already leaving the station.[8] He held a small package covered by a newspaper with no indication to its content.[9] Two guards on the platform helped the man board the train—the first guard on the train reached forward to help him climb in, while the second guard on the platform pushed him from behind.[10] As a result, the small package held by the passenger fell on the rails.[11] This package, which contained fireworks, exploded upon contact with the rails.[12] The shock of the explosion "threw down some scales at the other end of the platform many feet away. The scales struck the plaintiff, causing injuries [for which the suit was brought]."[13] This peculiar situation led to damages,[14] but the question whether we can establish a legal causation between the guards' conduct and the harm that ensued is disputable.

In his majority opinion, Judge Cardozo stated that a negligent act did not happen, and therefore the question of proximate causation was foreign to the

5. *See generally* WILLIAM WIRT HOWE, ON PROXIMATE CAUSE (1895).

6. This Article takes as a given the fact that a duty, a breach of duty, and causation-in-fact have all been established. It only focuses on the question of proximate cause.

7. Palsgraf v. Long Island R.R. Co., 162 N.E. 99 (N.Y. 1928).

8. *Id.* at 99.

9. *Id.*

10. *Id.*

11. *Id.*

12. *Id.*

13. *Id.*

14. Over the years, claims have been made that the factual background was grossly inaccurate. *See, e.g.*, Michael I. Krauss, *Palsgraf: The Rest of the Story*, 9 GREEN BAG 2D 309 (2006); PROSSER, WADE AND SCHWARTZ'S TORTS: CASES AND MATERIALS 336 (13th ed. 2015). This Article refers to the facts as they were described by Judge Cardozo.

case.[15] In contrast,[16] in his dissenting opinion, Judge Andrews narrowed in on the question of proximate cause:

> What we do mean by the word 'proximate' is that, because of convenience, of public policy, of a rough sense of justice, the law arbitrarily declines to trace a series of events beyond a certain point. This is not logic. It is practical politics. . . . There is in truth little to guide us other than common sense.[17]

Judge Andrews stated that proximate causation, at the very least, should be "something without which the event would not happen," and that the court must seek "a natural and continuous sequence between cause and effect."[18] He continued to list several questions one should ask in an effort to evaluate the aforementioned cause and effect correlation:

> Was the one a substantial factor in producing the other? Was there a direct connection between them, without too many intervening causes? Is the effect of cause on result not too attenuated? Is the cause likely, in the usual judgment of mankind, to produce the result? Or, by the exercise of prudent foresight, could the result be foreseen? Is the result too remote from the cause, and here we consider remoteness in time and space.[19]

These questions seem clear and straightforward, but they do not provide objective and understandable guidelines on how to evaluate proximate cause. Later, the Second Restatement provided greater subjectivity to judges by stating that "[t]he actor's conduct may be held not to be a legal cause of harm to another where after the event and looking back from the harm to the actor's negligent conduct, it appears to the court highly extraordinary that it should have brought about the harm."[20]

It is true that "the greater the distance either in time or space, the more surely do other causes intervene to affect the result."[21] It is also true that "an

15. *Palsgraf*, 162 N.E. at 103.

16. For a further discussion comparing the majority and minority opinions in the *Palsgraf* case and its implications in courts and law school years later, see Jonathan Cardi, *The Hidden Legacy of Palsgraf: Modern Duty Law in Microcosm*, 91 B.U. L. REV. 1873 (2011). Cardi concluded that Cardozo's approach to examine foreseeability as part of the duty prong and not the proximate cause prong is the predominant one, though law schools and the Restatement practices contradicts it. *Id.* at 1890.

17. *Palsgraf*, 162 N.E. at 103–04.

18. *Id.* at 104.

19. *Id*. (citation omitted).

20. RESTATEMENT (SECOND) OF TORTS § 435(2) (AM. L. INST. 1965).

21. *Palsgraf*, 162 N.E. at 104.

uncertain and wavering line"[22] must be drawn, but it remains unclear how and what are the rationales guiding us on how to draw this line. Judge Andrews heavily focused on intervening factors that may have severed the link between the act and the damage. But even without intervening factors, a negligent act can still be labeled external or not closely enough related to be the cause that led to the damage. In *Palsgraf*, Judge Andrews concluded that proximate causation was established because there was "a natural and continuous sequence—direct connection"[23] between the explosion and the harm caused to the plaintiff standing on the platform. In Judge Andrews' mind, Palsgraf was a foreseeable plaintiff. But as this Article shows, vague and abstract legal terms such as "natural" and "direct" do not provide a well-grounded foundation for decision-making. The hindsight bias is also significant once a judge or a jury evaluates whether proximate causation exists. If it actually happened, surely a reasonable man should have seen it coming. However, this is not always the case, and using external instruments, such as network theory, can assist in diminishing this prevalent bias in the realm of tort law.[24]

These days, it seems that the common understanding of legal causation is reduced to whether "the injury was a natural and probable result of the negligence," as well as examining if "there was no efficient intervening cause."[25] But this too does not explain what one should be looking for while evaluating proximate cause.[26]

This Article addresses this important question and offers to use network theory to better evaluate the existence of proximate causation once negligence and damages occur. As will be elaborated, network theory studies the relationship (edges) between connected entities (nodes). It offers insights about the nature, foreseeability, and interconnectivity between nodes in a manner that can better establish the existence, or the lack thereof, of proximate causation. This Article presents and demonstrates how the common law system can utilize

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22. *Id.*

23. *Id.* at 105.

24. *See, e.g.*, Overseas Tankship (U.K.) Ltd. v. Miller Steamship Co. [1966] 1 AC 617, 643–44 (appeal taken from Wales) ("If a real risk is one which would occur to the mind of a reasonable man in the position of the defendant's servant and which he would not brush aside as far-fetched, and if the criterion is to be what that reasonable man would have done in the circumstances, then surely he would not neglect such a risk if action to eliminate it presented no difficulty, involved no disadvantage, and required no expense.").

25. *See, e.g.*, Wilke v. Woodhouse Ford Inc., 774 N.W.2d 370, 382 (2009).

26. In the context of statutory proximate cause, Sandra F. Sperino stated that: "Proximate cause is a notoriously flexible and theoretically inconsistent concept." Sandra F. Sperino, *Statutory Proximate Cause*, 88 NOTRE DAME L. REV. 1199, 1200 (2013); *see also* Sandra F. Sperino, *The Emerging Statutory Proximate Cause Doctrine*, 99 NEB. L. REV. 285 (2020); Sandra F. Sperino, *Discrimination Statutes, the Common Law, and Proximate Cause*, 2013 U. ILL. L. REV. 1 (2013).

the features of network theory, focusing on a tortfeasor node's centrality and strength. By focusing on these features within a network, one can deduce that the more central a node is and the more connections it has with its neighboring nodes, the more foreseeable it is that his negligent actions will vibrate throughout the network and lead to damages of near and remote nodes. This will enable decisionmakers to properly envision, understand, and evaluate the normative causal nexuses connecting a tortfeasor node and a victim node. It will provide tools to decide whether that connection fulfills the proximate causation doctrine. In other words, this Article will help translate these features into measurable tools that can better justify decisions concerning the existence of legal causation.

The Article continues as follows. Part II provides a recap about the law of proximate cause, focusing on the tests suggested in the past concerning the evaluation of proximate cause, as well as the doctrine of intervening factors. Part III delves into the study of network theory and details its features as well as its different applications within the legal realm. Part IV combines proximate causation and network theory by discussing the way the latter can be used to better evaluate the former. This Part analyzes prominent examples of case law, as well as new technological scenarios, concerning legal causation questions using network theory features.

II. PROXIMATE CAUSATION: A RECAP

Negligence is comprised of four elements: a duty of care, a breach of said duty, causation, and damages. Causation is divided into two separate tests: actual causation, also known as causation-in-fact, and proximate or legal causation.[27] This Article focuses on the way network theory can better evaluate and determine whether legal causation is established once a duty and a breach have been found. To do so, a brief recap of the doctrine of proximate causation doctrine is warranted.[28]

The Second Restatement of Torts states that one's negligent act will be seen as a "legal cause" of a harm if the tortfeasor's conduct "is a substantial factor in bringing about the harm, and . . . there is no rule of law relieving the actor

27. For a discussion about the difference between the two causation tests, see Snyder v. LTG Lufttechnische GmbH, 955 S.W.2d 252, 256 n.6 (Tenn. 1997).

28. For a detailed discussion of this doctrine across different states in the United States, see MELVILLE PECK, THE DOCTRINE OF PROXIMATE CAUSE AND LAST CLEAR CHANCE (1914). For a discussion about the difference in interpretation of this doctrine between formalists and realists, see Joshua Knobe & Scott J. Shapiro, *Proximate Cause Explained: An Essay in Experimental Jurisprudence*, 88 U. CHI. L. REV. 165, 174 (2021).

from liability."[29] The Third Restatement of Torts took a different approach and stated that "[a]n actor's liability is limited to those [physical] harms that result from the risks that made the actor's conduct tortious."[30]

The Tennessee Supreme Court has explained the essence of the legal causation test as follows:

> Proximate or legal cause is a policy decision made by the legislature or the courts to deny liability for otherwise actionable conduct based on considerations of logic, common sense, policy, precedent and "our more or less inadequately expressed ideas of what justice demands or of what is administratively possible and convenient."[31]

Thus, the main role of this doctrine is to normatively limit the wide-scope liability obligations one might have in a world where only causation-in-fact exists. Factually, a certain negligent act can lead to various, different, and remote damages. The but-for test applied in the first step of causation-in-fact catches a lot of actions in the net of negligence. But as a policy matter, we do not wish to hold a person liable for every possible damage his or her actions may have caused. The common law tort system does not wish to hold a person liable if no appropriate relationship between the negligent act and the damages have been proven. The "appropriateness" of a relationship is usually evaluated through a policy lens held by the court, not through a factual one.[32]

A. Directness, Foreseeability, and What's in Between

In 1927, Professor Leon Green opened his book discussing the rationale of proximate causation by stating that "[i]t is no doubt generally felt that the whole subject of 'proximate causation' is a bogey, the sort of thing found only in

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29. RESTATEMENT (SECOND) OF TORTS § 431 (AM. L. INST. 1965) ("The actor's negligent conduct is a legal cause of harm to another if (a) his conduct is a substantial factor in bringing about the harm, and (b) there is no rule of law relieving the actor from liability because of the manner in which his negligence has resulted in the harm.").

30. RESTATEMENT (THIRD) OF TORTS: LIABILITY FOR PHYSICAL HARM § 29 (AM. L. INST. 2010). Comment d is also relevant as it states:

> [A]n actor should be held liable only for harm that was among the potential harms—the risks—that made the actor's conduct tortious. . . . This limit on liability serves the purpose of avoiding what might be unjustified or enormous liability by confining liability's scope to the reasons for holding the actor liable in the first place.

Id. at § 29 cmt. d.

31. *Snyder*, 955 S.W.2d at 256 n.6.

32. For an interesting explanation on why proximate causation has persisted despite its longstanding criticism, see Jessie Allen, *The Persistence of Proximate Cause: How Legal Doctrine Thrives on Skepticism*, 90 DENV. U. L. REV. 77 (2012).

children's story books—a sort of child's mind creation."[33] Several sentences after, he wholeheartedly declared that "[w]hatever may be said, it is undoubtedly the general opinion that the field of legal liability is greatly cluttered by 'proximate causation' and that it needs to be cleaned up."[34]

Over the years, courts have tried to accomplish this goal. They attempted to provide legal certainty via legal tests and rules to evaluate the existence of proximate causation in negligence cases.[35] In their reasoning, courts have stated that some damages, even if they pass the first hurdle in the form of the but-for test, will be considered too remote or unpredictable from the negligent act to be properly linked to the tortfeasor conduct. In the case of *Ryan v. New York Central Railroad*, from 1866, the New York Court of Appeals stated that the negligent conduct of the defendant was not the proximate causation for the burning of the plaintiff's house, located one hundred thirty feet away from the source of the fire.[36] In this case, the plaintiff's property caught fire after sparks from a train set fire to the defendant's own woodshed and then spread to the plaintiff's property.[37] The question here focused on the remoteness of the damages. The court stated that one is "liable in damages for the proximate results of his own acts, but not for remote damages. It is not easy at all times to determine what are proximate and what are remote damages."[38] It further stated that the damages to the plaintiff in this case were not an *ordinary*, *natural*, and *expected* result of the destruction of the woodshed.[39] It treated the damages the plaintiff incurred as subsequent harms which depend on other factors ("such as the degree of the heat, the state of the atmosphere, the condition and materials of the adjoining structures and the direction of the wind")[40] over which the defendant has little to no control.[41]

33. LEON GREEN, RATIONALE OF PROXIMATE CAUSE, at (v) (1927).

34. *Id.*

35. *See* Patrick J. Kelley, *Proximate Cause in Negligence Law: History, Theory, and the Present Darkness*, 69 WASH. U. L. Q. 49, 50–51 (1991).

36. Ryan v. N.Y. Cent. R.R., 35 N.Y. 210, 210, 213 (1866). For a similar factual case, see Atchison, T. & S.F.R. Co. v. Stanford, 12 Kan. 354 (1874). There, the damages happened "three and one-half or four miles distant from the railroad track." *Id.* at 375. Unlike the *Ryan* case, here the court concluded that "both upon reason and authority, that the damage is not too remote to be recovered." *Id.* at 376.

37. *Ryan*, 35 N.Y. at 210.

38. *Id.* at 210–11.

39. *Id.* at 212.

40. *Id.*

41. *Id.*

The *Ryan* court also specified a slippery slope argument concerning insurance.[42] This argument stated that if liability will not be limited by space and time, insurance companies will be entitled to reimbursement from a given defendant via a subrogation claim.[43] From a policy perspective, this is an undesired result which will probably lead to defendants' bankruptcy and the collapse of the industry market.[44]

The rationales stated in *Ryan* are somewhat scattered and unclear.[45] Different measurement terms are used to try and articulate the distinction between close and remote damages with no clear explanation. These include ordinariness, natural, expectations, and immediacy.[46] It also seems that the court put special emphasis on the institution of insurance in evaluating the remoteness of a harm.[47] Even notions of "directness" and "foreseeability" that have been discussed and added in later cases[48] do not assist in creating a formulated distinction between harmful acts that are proximately related to the damages and those that are not.

With regard to foreseeability, which is considered an important doctrine in evaluating one's negligent acts, John Fabian Witt has stated that whether a thing is foreseeable highly depends on the level of generality on which the analysis is applied,[49] which can be subjective to the person conducting the analysis. It is accepted and agreed-upon that the specifics of the harm that happened need not be reasonably foreseeable. Meaning, "the *exact harm* need not be foreseeable. Rather, the harm need only be *within the class* of reasonably foreseeable hazards that the duty exists to prevent."[50] For example, if one intended only to break another's nose but ended up putting him in a coma, his or her actions are

42. *Id.* at 217. Indeed, courts often consider the availability of insurance to potential defendants as they fashion new liability rules. KENNETH S. ABRAHAM, THE LIABILITY CENTURY: INSURANCE AND TORT LAW FROM THE PROGRESSIVE ERA TO 9/11, at 12 (2008).

43. *Ryan*, 35 N.Y. at 217 (noting, for example, the right an insurance carrier has to legally pursue a third party, such as a defendant, which caused an insured loss).

44. *See id.*, 35 N.Y. at 216–17. For a broader discussion on this, see *infra* Section IV.B.ii.

45. For more criticism on this case, see *infra* Section IV.B.ii.

46. *Ryan*, 35 N.Y. at 211.

47. *Id.* at 217; *see also* Gary J. Valeriano, *What's Tort Got to Do With it: Proximate Cause and the Interpretation of Insurance Contracts*, 24 FIDELITY L.J. 141 (2018). Today, courts draw the line of remoteness more broadly than was stated in *Ryan*. *See* Webb v. Rome, Watertown & Ogdensburgh R.R. Co., 49 N.Y. 420, 427, 429–30 (1872).

48. *In re* Polemis, 3. K.B. 560, 574 (1921); The Wagon Mound Cases (Overseas Tankship (U.K.) Ltd. v. Morts Dock & Eng. Co. [1961] A.C. 404, 408–09, 411–14, 416; Overseas Tankship (U.K.) Ltd. v. Miller Steamship Co. [1966] 1 A.C. 617, 634–36).

49. JOHN FABIAN WITT & KAREN M. TANI, TORTS: CASES, PRINCIPLES, AND INSTITUTIONS 346 (2018).

50. Kirlin v. Halerson, 758 N.W.2d 436, 451 (S.D. 2008).

proximately linked to the damages. Furthermore, the law does not require that the manner which led to the harm be reasonably foreseeable.[51] Meaning, the general character of the event or harm should be foreseeable, but not the precise nature or manner of occurrence.[52] Little has been decided and established by the courts beyond that.[53]

Foreseeability is also a key issue in the context of the "eggshell skull" doctrine, which may be an important part of the proximate causation test. This doctrine states that the defendant takes the plaintiff as she finds him.[54] Even if the plaintiff has specific vulnerabilities which are unforeseeable, the defendant will still be held liable for the damages caused. For example, in *Benn v. Thomas*, a bruised chest and a fractured ankle eventually led to the plaintiff's death due to a heart attack given the specific vulnerabilities the plaintiff suffered from.[55] The Iowa Supreme Court stated that "[t]he eggshell plaintiff rule rejects the limit of foreseeability that courts ordinarily require in the determination of proximate cause."[56] This means that the defendant will be held liable for uncommon outcomes of personal injuries, which may be viewed as wholly unforeseeable.[57]

Another attempt to better establish the meaning and application of proximate causation can be found in the "harm within the risk" test, which many scholars have hoped will assist in determining proximate causation when "directness" and "foreseeability" come too short.[58] This test examines two different tiers, first if the plaintiff was among the class of people who could foreseeably be harmed, and second whether the harm inflicted was foreseeable within the class of risks. The Third Restatement embodies this test by asking "whether there is an intuitive relationship between the act(s) alleged and the damages at issue (that is, whether the conduct was wrongful *because* that type

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51. WITT & TANI, *supra* note 49, at 346. *See, e.g.*, Mussivand v. David, 544 N.E.2d 265, 272 (Ohio 1989); Ballard v. Uribe, 715 P.2d 624, 628 n.6 (Cal. 1986); Laabs v. S. Cal. Edison Co., 97 Cal. Rptr. 3d 241, 251 (Ct. App. 2009).

52. Bigbee v. Pacific Tel. & Tel. Co., 665 P.2d 947, 952 (Cal. 1983).

53. Cardi has discussed the fluctuation in levels of generality in the caselaw involving foreseeability, *supra* note 16, at 1884–86.

54. *See* RESTATEMENT (SECOND) OF TORTS § 461 (AM. L. INST. 1965).

55. Benn v. Thomas, 512 N.W.2d 537, 538 (Iowa 1994).

56. *Id.* at 539.

57. RESTATEMENT (SECOND) OF TORTS § 461 (AM. L. INST. 1965) ("The negligent actor is subject to liability for harm to another although a physical condition of the other . . . makes the injury greater than that which the actor as a reasonable man should have foreseen as a probable result of his conduct.").

58. Peter Zablotsky, *Mixing Oil and Water: Reconciling the Substantial Factor and Result-Within-The-Risk Approaches to Proximate Cause*, 56 CLEV. ST. L. REV. 1003, 1005–06 (2008).

of damage might result)."[59] A common example for this test is that of an unlabeled container of poison placed on the kitchen counter. The harm within the risk test states that if someone eats the poison and is injured, proximate causation exists. However, if the poison explodes as a result of being put in the microwave, the test is not fulfilled and no proximate cause can be established.[60] This test is rather uncommon today and it has been criticized as being focused on culpability, rather than on normative causation.[61]

The definition of proximate causation as it was set in the Third Restatement is termed the "scope-of-the-risk" test, but has been coined the "risk rule."[62] This test is rather similar to the above "harm within the risk" test and essentially focuses on the particular risks that made the conduct negligent. For example, handing a child a loaded gun which causes damages by falling on someone's foot does not pass this test.[63] This is because the injury did not stem from the risk that made the conduct negligent. If an injury would have occurred because the child accidently fired the gun, then the test would have been fulfilled and proximate cause would have been established.

There have been other attempts to formalize and create clear distinctions between remote and non-remote damages. For example, in 1920 Joseph Henry Beale gave the following explanation to when a harm is proximately caused by a negligent act, and when it is too remote:

> If the defendant's active force has come to rest, but in a dangerous position, creating a new or increasing an existing risk of loss, and the foreseen danger comes to pass, operating harmfully on the condition created by defendant and causing the risked loss, we say that the injury thereby created is a proximate consequence of the defendant's act. . . . On the other hand, where defendant's active force has come to rest in a position of apparent safety, the court will follow it no longer; if some new force later combines with this condition to create harm, the result is remote from the defendant's act.[64]

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59. RESTATEMENT (THIRD) OF TORTS: LIAB. FOR PHYSICAL AND EMOTIONAL HARM § 29 (AM. L. INST. 2010) (quoting Owens v. Republic of Sudan, 412 F. Supp. 2d 99, 115 (D.D.C. 2006)).

60. Larrimore v. Am. Nat'l Ins. Co., 89 P.2d 340, 343 (Okla. 1939).

61. Heidi M. Hurd & Michael S. Moore, *Negligence in the Air*, 3 THEORETICAL INQ. L. 334, 381–82 (2002).

62. ROBERT E. KEETON, LEGAL CAUSE IN THE LAW OF TORTS 9–10 (1963).

63. Benjamin C. Zipursky, *Foreseeability in Breach, Duty and Proximate Cause*, 44 WAKE F. L. REV. 1247, 1253 (2009).

64. Joseph H. Beale, *The Proximate Consequences of An Act*, 33 HARV. L. REV. 633, 650–51 (1920). This reasoning was applied in the case of *Henningsen v. Markowitz*, 230 N.Y.S. 313, 316 (N.Y. Sup. Ct. 1928).

Jerome Frank strongly rejected and objected to this abstract and rather vague approach, which he termed "Bealism": "the vagueness of his vocabulary aids him to avoid recognizing contradictions and absurdities which his assertions involve."[65] Responding to Beale, Edgerton called to avoid creating specific rules and stick to a balance of considerations: "[W]hile logic is useful in the premises, it is inadequate; that intuition is necessary and certainty impossible."[66] Eventually, Beale's approach, as well as the general tactic of casting concrete notions of proximate causation in advance, disappeared from legal discourse.[67] Today, as Edgerton suggested, we are left with general rules of thumb, trying to explore the foreseeability of the damages and decide whether their occurrence was "natural," "probable," and "foreseeable."

B. Intervening Factors

Courts have recognized several intervening factors that, as a policy matter, sever the link of causality between the negligent conduct and the damages. When these factors intervene, proximate causation is not established, and the defendant will not be held liable.

The Second Restatement refers to these factors as "superseding causes."[68] It specifically excludes criminal or negligent acts carried by a third party from being viewed as superseding causes if those acts were a foreseeable consequence of the defendant's negligence or if the likelihood of those acts was the reason why the defendant's conduct was negligent.[69] The Third Restatement does not use the term "superseding," but it reaches the same result. According to it, a defendant will be held liable for all damages that "result from the risks that made the [defendant's] conduct tortious."[70]

At common law, it has been held that the following intervening causes are foreseeable, and therefore will rarely break the causality link between the act and the damage. These causes are subsequent medical malpractice, negligence

65. JEROME FRANK, LAW AND THE MODERN MIND 62–63 (1930).

66. Henry W. Edgerton, *Legal Cause*, 72 U. PA. L. REV. 211, 211 (1924).

67. McLaughlin has also tried to enumerate a couple of guiding points in an article from 1925. James Angell McLaughlin, *Proximate Cause*, 39 HARV. L. REV. 149, 197–99 (1925). Another attempt was carried out by Carpenter in an article dived to three pieces aiming at suggesting workable rules for proximate cause. Charles E. Carpenter, *Workable Rules for Determining Proximate Cause—Part I.*, 20 CAL. L. REV. 229 (1932); Charles E. Carpenter, *Workable Rules for Determining Proximate Cause—Part II (Continued)*, 20 CALIF. L. REV 396 (1932); Charles E. Carpenter, *Workable Rules for Determining Proximate Cause—Part III (Concluded)*, 20 CAL. L. REV 471 (1932).

68. RESTATEMENT (SECOND) OF TORTS §§ 448–49 (AM. L. INST. 1965).

69. *Id.* § 448; *see also* WITT & TANI, *supra* note 49, at 356.

70. RESTATEMENT (THIRD) OF TORTS: LIAB. FOR PHYSICAL AND EMOTIONAL HARM § 34 (AM. L. INST. 2010). In other words, the defendant is generally liable for all harmful results that are the normal incidents of and within the increased risk from the defendant's actions.

rescue, reaction forces, and subsequent diseases and accidents.[71] It has been well-established in common law cases that rescue care, even if negligent, will not be considered an intervening factor, as we wish to encourage bystanders to help people in danger.[72] This means that as a matter of policy, according to Cardozo's "rescue rule," as it was set in *Wagner v. International Railway Corporation*,[73] a causal link will not be severed if a rescuer attempts to help the plaintiff call for help. In these cases, a defendant should always foresee harm to a rescuer, and thus, proximate causation will always be established.

On the other hand, the following intervening factors can sever the causality link, depending on the defendant's ability to anticipate them: negligence of a third party, criminal conduct of a third party, and an act of God[74]—all of which will only be considered as intervening causes if they were not foreseeable. For example, a thunderstorm can be viewed as an act of God if it suddenly erupts with no prior forecast. However, if one has a duty of care towards another during a thunderstorm and he fails to warn him or her, he will be held liable. Building on this example, imagine that an employer and an employee are working in an open field together when a storm hits. The employer runs towards lower grounds because he knows he would be safer there. If he failed to alert his employee and, as a result, the latter was struck by lightning and injured, the storm is not viewed as an intervening act of God. Proximate causation will be established, and the employer will be held liable for the damage his employee suffered from.

These intervening factors limit the liability scope while heavily depending on foreseeability and other policy decisions that assert a normative causal link still exists even if a third party intervened. This is not a close list. In general, it has been stated that "[i]f the intervening act is extraordinary under the circumstances, not foreseeable in the normal course of events, or independent of or far removed from the defendant's conduct, it may well be a superseding act which breaks the causal nexus."[75] Courts have also stated that these types

71. *See* JOHN L. DIAMOND, LAWRENCE C. LEVINE & ANITA BERNSTEIN, UNDERSTANDING TORTS 183–84 (6th ed. 2018).

72. Stoleson v. United States, 708 F.2d 1217, 1221 (7th Cir. 1983); Pridham v. Cash & Carry Bldg. Ctr., 359 A.2d 193, 197–98 (N.H. 1976); Anaya v. Superior Ct., 39 Cal. Rptr. 2d 228, 229–30 (Cal. App. 2000).

73. Wagner v. Int'l Ry. Co., 232 N.Y. 176, 181 (N.Y. 1921).

74. UNDERSTANDING TORTS, *supra* note 71, at 184; PECK, *supra* note 28, at 142–46.

75. Derdiarian v. Felix Contracting Corp., 414 N.E.2d 666, 670 (N.Y. 1980); *see also* Watson v. Ky. & Ind. Bridge & R.R. Co., 126 S.W. 146, 151 (Ky. 1910) ("[I]f the intervening agency is something so unexpected or extraordinary as that he could not or ought not to have anticipated it, he will not be liable, and certainly he is not bound to anticipate the criminal acts of others by which damage is inflicted and hence is not liable therefor.").

of questions, inquiring into what is foreseeable or normal, are usually the "subject of varying inferences."[76] Whether it is the task of the fact finder to decide if proximate causation was established, or the task of the court itself,[77] it is wildly unclear how this decision should be made.

As is evident from the above recap, proximate causation is confusing. This doctrine is used by common law systems to somehow arbitrarily limit the scope of liability. In some cases, the judicial system follows specific policy rules, such as the rescue rule and the eggshell skull doctrine, which are more generally applied. But in other cases, it is hard to have certainty whether a certain remote or not-so-foreseeable damage is indeed too remote or unforeseeable to sever liability. This is where network theory can help.

III. NETWORK THEORY

Network theory is the study of symmetric or asymmetric relations between connected items.[78] This study is rooted in graph theory.[79] Some trace back the beginning of network analysis to 1735 when Swiss mathematician, Leonard Euler, solved the "Bridges of Königsberg" question.[80] This question focused on whether one can walk across the seven bridges of the small German town of Königsberg without crossing the same bridge twice.[81] Euler created a graph of the town's bridges and managed to solve this conundrum, leading to the birth of graph theory.[82] This theory was later applied in social contexts,[83] and slowly made its way into different aspects of science and life as an influential field of study.

Network theory focuses on information about the relationships between objects.[84] The theory describes the separate objects as nodes; in the case of tort law, a node can be a tortfeasor, a joint tortfeasor, a victim, an agent, a third-

76. *Derdiarian*, 414 N.E.2d at 670.

77. For more on the question of who should determine whether proximate causation exists, see Cardi, *supra* note 16, at 1898.

78. MARK NEWMAN, NETWORKS: AN INTRODUCTION 1–2, 7 (2010).

79. Vaidehi Joshi, *A Gentle Introduction to Graph Theory*, MEDIUM (Mar. 20, 2017), medium.com/basecs/a-gentle-introduction-to-graph-theory-77969829ead8 [https://perma.cc/2Q3W-3U6J].

80. Vaidehi Joshi, *Königsberg*: *Seven Small Bridges, One Giant Graph Problem*, MEDIUM (Mar. 27, 2017), medium.com/basecs/k%C3%B6nigsberg-seven-small-bridges-one-giant-graph-problem-2275d1670a12 [https://perma.cc/9V37-J87M].

81. *Id.*

82. *Id.*

83. Beginning with the work of Jacob L. Moreno. *See* JACOB L. MORENO, WHO SHALL SURVIVE?: A NEW APPROACH TO THE PROBLEM OF HUMAN INTERRELATIONS 10–11 (1934) (containing the foundation to sociometry, known today as social network analysis).

84. NEWMAN, *supra* note 78, at 1.

party tortfeasor, a bystander, etc.[85] The relationships and activities connecting these nodes are called edges.[86] These two elements present a general view and understanding of the world as an infinite number of edges (i.e., connections) between nodes.[87] Network theory focuses, *inter alia*, on the degree of *connectivity*, overall *structure* (centralized, decentralized, or distributed), and *properties* (robust or critical) of the network in order to analyze it and its features.[88]

Network theory has proven itself to be a valuable instrument in different legal and nonlegal disciplines, and its unique features are also beneficial in the realm of tort law. Utilizing network theory when a tortfeasor inflicts damages can help us to better determine if legal causation is established.

This Part first provides an overview of this field of study and the different ways in which it has already been applied within the realm of the law. Then, it presents the basic features of network theory. The next Part will explore the ways in which network theory could be of assistance in examining the causal link between the negligent actions of a tortfeasor and the damages that ensued.

A. An Introduction to Network Theory and its Legal Applications

The nodes and edges of a given network present a general view of the world, or a specific system within it, as an infinite or finite number of edges connecting nodes. This view allows us to analyze connected systems from a different perspective using different measuring features. An important feature of a network is its defined "boundary,"[89] or the relevant nodes and edges in the network we are focused on. The definition of the network's boundary is usually subjective in essence, and it depends on the perspective of the observer.[90] In our case, the observer would be a judicial or administrative authority observing the tortfeasor's negligent behavior which led to an accident.

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85. *Id.*

86. An interesting question is what amounts to the creation of a link, i.e., edge. Was a link created between two passing cars if no accident happened? This Article assumes that a link was indeed created, but not one that involves questions of proximate cause, because no damage was caused.

87. NEWMAN, *supra* note 78, at 1–2.

88. *Id.* at 8–9, 147.

89. Sue Heath, Alison Fuller & Brenda Johnston, *Chasing Shadows: Defining Network Boundaries in Qualitative Social Network Analysis*, 9 QUALITATIVE RSCH. 645, 650 (2009); Edward O. Laumann, Peter V. Marsden & David Prensky, *The Boundary Specification Problem in Network Analysis*, *in* RESEARCH METHODS IN SOCIAL NETWORK ANALYSIS 62 (Linton C. Freeman, Douglas R. White & Antone Kimball Romney eds., 1992).

90. Paul Cilliers, *Boundaries, Hierarchies and Networks in Complex Systems*, 5 INT'L J. INNOVATION MGMT. 135, 138–39 (2001).

Networks can be characterized as directed or undirected systems.[91] Directed networks have only a one-way connection between two nodes, while undirected networks have connections that move in both directions.[92] The World Wide Web is an example of a directed system because links within web pages can run from page A to page B, but page B is not obligated to insert a link leading back to page A. Most simple networks, however, are undirected networks where the edges move in both ways, such as social networks where the interactions are mutual and bilateral.[93] This is also the case in the vast majority of negligence claims, given that they are a result of physical or social interactions between a tortfeasor node and a victim node which led to damages.

Network theory is used in many disciplines, such as mathematics,[94] biology, sociology, physics, economics, and finance.[95] Some of its most well-known applications include the World Wide Web, the Internet,[96] gene regulatory

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91. NEWMAN, *supra* note 78, at 5.

92. *Id.* at 114.

93. ROBERT A. HANNEMAN & MARK RIDDLE, INTRODUCTION TO SOCIAL NETWORK METHODS Ch. 3 (2005) http://faculty.ucr.edu/~hanneman/nettext/C3_Graphs.html [https://perma.cc/E5UY-DGWT] (ebook). Other examples may include any bidirectional edges between neurons, biological reactions, etc. NEWMAN, *supra* note 78, at 104.

94. It actually originated from this field. Ryan Whalen, *Legal Networks: The Promises and Challenges of Legal Network Analysis*, 2016 MICH. ST. L. REV. 539, 543–44 (2016).

95. *E.g.*, NEWMAN, *supra* note 78, at 6, 78; BURGERT A. SENEKAL, CANONS AND CONNECTIONS: A NETWORK THEORY APPROACH TO THE STUDY OF LITERARY SYSTEMS WITH SPECIFIC REFERENCE TO AFRIKAANS POETRY (2015); HUGH COMPSTON, POLICY NETWORKS AND POLICY CHANGE: PUTTING POLICY NETWORK THEORY TO THE TEST, 9–17 (2009); DEBORAH E. DE LANGE, CLIQUES AND CAPITALISM: A MODERN NETWORKED THEORY OF THE FIRM 38 (2012); DEREK L. HANSEN, BEN SHNEIDERMAN & MARC A. SMITH, ANALYZING SOCIAL MEDIA NETWORKS WITH NODEXL: INSIGHTS FROM A CONNECTED WORLD 3–4 (2017); DUNCAN J. WATTS, SIX DEGREES: THE SCIENCE OF A CONNECTED AGE 28 (2003); THEORIES OF DEMOCRATIC NETWORK GOVERNANCE 8–9 (Eva Sørensen & Jacob Torfing eds., 2007); FABRIZIO DE VICO FALLANI & FABIO BABILONI, THE GRAPH THEORETICAL APPROACH IN BRAIN FUNCTIONAL NETWORKS: THEORY AND APPLICATIONS 13–14 (2010); EXPONENTIAL RANDOM GRAPH MODELS FOR SOCIAL NETWORKS: THEORY, METHODS, AND APPLICATIONS 18–19 (Dean Lusher, Johan Koskinen & Garry Robbins eds., 2013).

96. YOCHAI BENKLER, THE WEALTH OF NETWORKS: HOW SOCIAL PRODUCTION TRANSFORMS MARKETS AND FREEDOM 242–43 (2006). For a discussion about the difference between the World Wide Web and the Internet in the network context, see NEWMAN, *supra* note 78, at 5.

networks,[97] and social networks.[98] Network theory offers a wide set of tools in these disciplines and applications for analysis and scrutiny of a given network in an attempt to expand current research and develop future ones. This allows a better understanding of the ecosystems surrounding us.[99]

In the legal field, legal scholars have researched and applied network theory in several legal analyses, and its appearance in the legal academic discourse has increased in recent years. For example, network theory has been used as part of a proposed model to tackle internet jurisdiction issues;[100] to better understand corporations and their inner structure;[101] to better regulate the intersection of intellectual property and antitrust laws;[102] to study the structure created by case law citations;[103] to better understand when one's right to privacy has been violated because the information spread about an individual, which flows within the network, is considered to be public or private;[104] as a tool to better determine secondary liability of a content supplier;[105] as a method of regulating

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97. Abhiskhek Garg, Kartik Mohanram, Giovanni De Micheli & Ioannis Xenarios, *Implicit Methods for Qualitative Modeling of Gene Regulatory Networks*, *in* GENE REGULATORY NETWORKS: METHODS AND PROTOCOLS 397 (Bart Deplancke & Nele Gheldof eds., 2012); Kerstin Kaufmann & Dijun Chen, *From Genes to Networks: Characterizing Gene-Regulatory Interactions in Plants*, *in* PLANT GENE REGULATORY NETWORKS: METHODS AND PROTOCOLS 1–2 (Kerstin Kaufmann & Bernd Mueller-Roeber eds., 2017).

98. *See* MARCO MASSAROTTO, SOCIAL NETWORK (2011); Corey Jay Liberman, *The Application of Traditional Social Network Theory to Socially Interactive Technologies: A Reconceptualization of Communication Principles*, *in* SOCIAL NETWORKING: REDEFINING COMMUNICATION IN THE DIGITAL AGE 25 (Anastacia Kurylo & Tatyana Dumova eds., 2016); Whalen, *supra* note 94, at 544–46; Lior Jacob Strahilevitz, *A Social Networks Theory of Privacy*, 72 U. CHI. L. REV. 919, 946–73 (2005).

99. For more examples of network theory applications, see NEWMAN, *supra* note 78, at 8.

100. Andrea M. Matwyshyn, *Of Nodes and Power Laws: A Network Theory Approach to Internet Jurisdiction through Data Privacy*, 98 NW. U. L. REV. 493, 527–29 (2004).

101. Claire Moore Dickerson, *Corporations as Cities: Targeting the Nodes in Overlapping Networks*, 29 J. CORP. L. 533, 549 (2004).

102. David McGowan, *Networks and Intention in Antitrust and Intellectual Property*, 24 J. CORP. L. 485, 487, 491 (1999).

103. Whalen, *supra* note 94, at 548; James H. Fowler, Timothy R. Johnson, James F. Spriggs II, Sangick Jeon & Paul J. Wahlbeck, *Network Analysis and the Law: Measuring the Legal Importance of Precedents at the U.S. Supreme Court*, 15 POL. ANALYSIS 324, 325–26 (2007); James H. Fowler & Sangick Jeon, *The Authority of Supreme Court Precedent*, 30 SOC. NETWORKS 16, 17–18 (2008); Thomas A. Smith, *The Web of Law*, 44 SAN DIEGO L. REV. 309, 310–11 (2007).

104. Strahilevitz, *supra* note 98, at 988. The author attributes high importance to the future utilization of network theory in the discipline of law. "Understanding the relevant social networks helps us evaluate the need for legal regulation of private actors. Social network theory, in short, may lay the foundation for a second generation of interesting social norms scholarship." *Id.* at 987.

105. Michal Lavi, *Content Providers' Secondary Liability: A Social Network Perspective*, 26 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 855, 890, 892, 933 (2016).

the financial sector;[106] in the field of contract law;[107] in making regulation decisions about networked economies;[108] in deciding whether patents fulfill the non-obvious requirement;[109] in imposing liability on technological companies;[110] and in modeling a tool for studying enforcement networks of governmental agencies.[111]

Given its vast success in non-legal fields and across multiple disciplines, there seems to be a need for the further implementation of legal network studies.[112] As I have written elsewhere, network theory holds great value in the tort context.[113] Tort law is concerned with civil wrongs which do not arise from a contract and are derived from relationships, connections, and interactions transpiring between a tortfeasor node on the one hand, and a victim node on the other. In some cases, these nodes are complete strangers forced to get acquainted due to an event (e.g., a random car accident). In other cases, the nodes know each other to a certain degree, and the nature of their relationship stands at the heart of the damage which was caused (e.g., medical malpractice and duties of care enforced on owners and occupiers of land).

Many of the fundamental principles of the tort system can benefit from an analysis of the networks in which accidents occur. In addition to determining proximate causation and predictability, it can also help us decide whether the tortfeasor had a duty to act in a certain way toward the injured party given their relationship, which parties should be held jointly and severally liable, and even establish insurance schemes based on the connections and structure of the network in which an accident occurred. Our ability to visualize the connections between the relevant parties can enable us to determine the existence, or the lack thereof, of a legal nexus in a more accurate and nuanced manner.

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106. Luca Enriques & Alessandro Romano, *Institutional Investor Voting Behavior: A Network Theory Perspective*, 11 U. ILL. L. REV. 223, 225 (2019); Luca Enriques, Alessandro Romano & Thom Wetzer, *Network-Sensitive Financial Regulation*, J. CORP. L. 351, 354 (2020).

107. Matthew Jennejohn, *The Architecture of Contract Innovation*, 59 B.C. L. REV. 71, 104 (2018); Lisa Bernstein, *Contract Governance in Small-World Networks: The Case of the Maghribi Traders*, 113 NW. U. L. REV. 1009, 1014–15 (2019); Alan Schwartz & Scott E. Robert, *Third-Party Beneficiaries and Contractual Networks*, 7 J. LEGAL ANALYSIS 325, 326 (2015).

108. Kevin Werbach, *Higher Standards Regulation in the Network Age*, 23 HARV. J. L. & TECH. 179, 181 (2009).

109. Laura G. Pedraza-Farina & Ryan Whalen, *A Network Theory of Patentability*, 87 U. CHI. L. REV. 63, 66 (2019).

110. Rory Van Loo, *The Revival of Respondeat Superior and Evolution of Gatekeeper Liability*, 109 GEO. L.J. 141, 184–85 (2020).

111. Verity Winship, *Enforcement Networks*, 37 YALE J. ON REG. 274, 319–20 (2020).

112. Whalen, *supra* note 94, at 539–40.

113. Anat Lior, *The AI Accident Network: Artificial Intelligence Liability Meets Network Theory*, 95 TUL. L. REV. 1103, 1104–06 (2021).

Before turning to discuss how network theory can help the evaluation of proximate cause, we must first understand what the features are that make network theory, as well as the pattern of a specific system, a beneficial tool when accidents transpire.

B. Network Theory Features

To measure and evaluate if proximate causation is established, it will be useful to consider three main characteristics of the network: *connectivity*, *structure* (centralized, decentralized or distributed), and *properties* (robust or critical). This subsection reviews these features and establishes links between them and our methodological proposal, with regard to the evaluation of a legal nexus between a tortfeasor and damages in a given accident network.

Connectivity of a node is the minimum number of nodes or edges that can be eliminated from a graph in order to isolate the remaining nodes.[114] Put more technically, it "is the minimum number of node-disjoint (link-disjoint) paths between any pair of nodes."[115] Much can be learned from evaluating the connectivity level of a given node.[116] For example, the position of an edge and its type (i.e., friendship, trading partners, authority, physical cables, etc.) can indirectly tell us about the strength of the connection, its centrality, and more.[117] The feature of connectivity can tell us, *inter alia*, how quickly a new event (e.g., in the form of information) can spread or propagate throughout the system.[118] The connectivity of a node is directly related to our next character of a system—the structure and the centrality of nodes.[119]

114. ISRAEL KOREN & C. MANI KRISHNA, FAULT-TOLERANT SYSTEMS 110 (2007). For example, in a star graph, every node is only two links away from a fellow node, thus transmitting information is easier than in a circle, whereas the removal of one node can disconnect the graph. Thus, a star graph is considered to be more "connected."

115. *Id.* at 142.

116. Mark Granovetter, *The Strength of Weak Ties*, 78 AM. J. SOC. 1360, 1361 (1973); Mark Granovetter, *The Strength of Weak Ties: A Network Theory Revisited*, 1 SOCIO. THEORY 201, 203–09 (1983).

117. Stephen P. Bogratti & Daniel S. Halgin, *On Network Theory*, 22 NEW PERSP. ORG. SCI. 1168, 1169 (2011).

118. This will be answered by calculating the average degree of connectivity—the total number of edges divided by the total number of nodes in the system. *See* Systems Innovation, *Network Theory Overview*, YOUTUBE (May 2, 2014), www.youtube.com/watch?v=-ckaLBsCoxo [https://perma.cc/L2K4-PLEE].

119. Connectivity is viewed as a measurement of centrality. NEWMAN, *supra* note 78, at 168–69.

The *structure* (or topology) of a network is the combination of nodes and edges in a given system.[120] The structure depends on the way the relationships between the nodes were formed. The structure of a network quantifies the importance of a node, which assists us in identifying the centrality of specific nodes within the network. An example of the way we can use this feature is directly linked to the connectivity of a node by measuring its "degree" of connectivity, which stands for the number of edges attached to a single node. The most basic measure of centrality is the "standardized degree centrality," which is the number of connections a node has divided by the total number of possible connections.[121] Another important feature which accompanies the former measurement is the "eigenvector centrality," which takes into account the connectedness of the neighboring nodes to determine its centrality.[122] In applying network theory to the structure of the internet, for example, these two measurements would represent the "number of data connections a computer, router, or other device has"[123] (standardized degree centrality), as well as the number of edges these connections have (eigenvector centrality).[124] Nodes with the highest degrees within a network usually have important roles in the functioning of the system as a whole—and with great power comes great ability to inflict harm. Therefore, a node's degree of connectivity can be a useful indicator to identify the system's crucial elements. In many networks, there is a small, but significant, number of "hubs"—a node with an unusually high degree of connectivity.[125] Another quantifiable feature is the "geodesic distance," which measures the minimum number of edges one would have to travel to get from one node to another.[126] This trait provides insights about the

120. *Id.* at 2; GUIDO CALDARELLI, SCALE-FREE NETWORKS: COMPLEX WEBS IN NATURE AND TECHNOLOGY 34–35 (2007).

121. SANJEEV GOYAL, CONNECTIONS: AN INTRODUCTION TO THE ECONOMICS OF NETWORKS 16 (2007).

122. This method is highly utilized in search engines via the Eigenvector centrality method, which measures both how many edges a node has, and how connected the nodes it connects to are. This method ranks webpages based on the number of links that leads into a webpage, and the total degree of connectivity of other pages that link into them. This can give a general understanding of the importance of a specific webpage website. *See* Phillip Bonacich, *Some Unique Properties of Eigenvector Centrality*, 29 SOC. NETWORKS 555, 555 (2007); Luis Solá, Miguel Romance, Regino Criado, Julio Flores, Alejandro García del Amo & Stefano Boccaletti, *Eigenvector Centrality of Nodes in Multiplex Networks*, CHAOS: INTERDISC. J. NONLINEAR SCI., Sept. 2013, at 1–2, 8; NEWMAN, *supra* note 78, at 169; Vasco M. Carvalho, *From Micro to Macro Via Production Networks*, 28 J. ECON. PERSP. 23, 36–37 (2014).

123. NEWMAN, *supra* note 78, at 9.

124. *Id.* at 169.

125. *Id.* at 9.

126. This is also known as the small-world effect, and in popular culture it is referred to as "six degrees of separation." *See id.* at 9–10; WATTS, *supra* note 95, at 39.

nature of the edges' relationships between nodes and their mutual or non-mutual obligations and commitments.

Other structures of networks can be decentralized or distributed. A distributed system refers to a network in which the connections between the nodes were generated randomly, leading to a relatively even distribution of edges.[127] In this system, the relative importance of any node is distributed across the system, and the existence of "hubs" is rarer than that of a centralized network. Similar to a distributed network, a decentralized network (also known as a small-world network) is also composed of randomized distant connections. It is generated by connected local clusters.[128]

Different structures of a network lead to different "properties."[129] The key feature in this context is how robust or fragile a specific system is. Understanding the properties of a system can help us in designing and managing a system *ex ante*. A decentralized system will usually be seen as more robust,[130] given the fact that, even if we remove a node with a small to medium connectivity level, the system will still be able to function due to the disperse nature of the system. In contrast, while a centralized system may be more efficient, it is also considered more fragile.[131] If we remove or affect even a single primary node (i.e., a node with a high degree of connectivity), this will likely have a large, systemic effect in a way that will severely limit the network's ability to function.[132] Whether a system is robust or fragile seems less critical in the context of this Article, given that accident networks in a negligence context happen at random and usually cannot be stopped, or planned, in advance. Also, our focus here is on the foreseeability or remoteness of damages that ensued in light of a negligent act carried out by a tortfeasor node. The properties of the network may assist us in evaluating the centrality and connectivity of the tortfeasor node on a micro-level, but given the inherent *ex post* nature of the tort system, it cannot do much more.

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127. Some nuances exist between a distributed network and a random one, which exceed the scope of this Article. *See Random & Distributed Graphs*, SYSTEMS INNOVATION, www.systemsinnovation.io/random-distributed-graphs/ [https://perma.cc/8TZ5-P3XJ].

128. Systems Innovation, *supra* note 118.

129. NEWMAN, *supra* note 78, at 9.

130. This is not always true and depends on the nature of the shocks within the system. For instance, in financial markets, decentralized systems are less capable of absorbing smaller shocks. *See* Enriques, Romano, & Wetzer, *supra* note 106, at 365, 380.

131. Systems Innovation, *supra* note 118.

132. *Id.*; *see also* R. V. Solé & J. M. Montoya, *Complexity and Fragility in Ecological Networks*, 268 PROC. R. SOC. LOND. B. 2039, 2039 (2001); REUVEN COHEN & SHLOMO HAVLIN, COMPLEX NETWORKS: STRUCTURE, ROBUSTNESS AND FUNCTION 101–05 (2010); Jianxi Gao, Sergey V. Buldyrev, Schlomo Havlin & H. Eugene Stanley, *Robustness of a Network of Networks*, 107 PHYS. REV. LETT. 195,701, 195,701 (2011).

Another relevant feature of a network relates to the weight of the edges, in what is known as a "weighted network."[133] In these networks, a specific weight is assigned to the edges among the nodes.[134] This weight indicates the strength of the node and can represent its intensity or capacity.[135] This enables us to further evaluate a node's strength, on top of its centrality, by evaluating its edges and their assigned weight.[136] In this context, a node's strength will be the sum of weights assigned to edges which are connected to that node.[137] This is based on the fact that not all edges have the same capacity, and that an edge's weight provides a differentiation measure for its strength, intensity, or capacity.[138] For example, in a social context, the strength of relationships in a social network can be viewed as a function of their duration, emotional intensity, or intimacy.[139] These features will help assign an edge's weight. In a non-social context, the assigned weight refers to the function or behavior performed by a specific edge, for example, the amount of traffic flowing in a transportation network.[140] Given that negligence claims are based on social situations and interactions gone wrong, a node's strength is an important feature to consider when we evaluate a specific node's ability to foresee damages based on the intensity of the edges belonging to it.

Once an accident has occurred, we can analyze the features described above in a specific accident network to better understand the connections between the relevant players (i.e., nodes), the nature and strength of the connections between them (i.e., edges), and the importance and significance of each in the system and as part of the whole network. The visualization and analysis of an accident network is made possible by using these instruments and pre-defined traits as part of our effort to better understand the system, so that we can better evaluate the existence of legal causation, or lack thereof. Considering these different characteristics of a network is imperative to the creation of efficient, well-thought-out policies and a more accurate and just application of our existing

133. *See, e.g.*, A. Barrat, M. Barthélemy, R. Pastor-Satorras & A. Vespignani, *The Architecture of Complex Weighted Networks*, 101 PROC. NATL. ACAD. SCI. U.S.A. 3747, 3747 (2004); STEVE HORVATH, WEIGHTED NETWORK ANALYSIS: APPLICATIONS IN GENOMICS AND SYSTEMS BIOLOGY 1 (2011); S. H. Yook, H. Jeong & A.-L. Barabási, *Weighted Evolving Networks*, 86 PHYS. REV. LETT. 5835, 5836 (2001).

134. NEWMAN, *supra* note 78, at 112–13.

135. Barrat, Barthélemy, Pastor-Satorras & Vespignani, *supra* note 133, at 3747–48.

136. *Id.* at 3748.

137. *Id.*

138. *See* NEWMAN, *supra* note 78, at 112–13.

139. Granovetter, *supra* note 116, at 1361.

140. Tore Opsahl, Vittoria Colizza, Pietro Panzarasa & José J. Ramasco, *Prominence and Control: The Weighted Rich-Club Effect*, 101 PHYS. REV. LETT. 168702, 168702–03 (2008).

legal doctrines. The next Part will draw the relationship between utilizing network theory analysis, the features we presented, and the application of proximate causation doctrine.

IV. Applying Network Theory to Proximate Cause

Given the uncertainty stemming from the different approaches and tests the common law system has developed over the years in an attempt to examine the existence of proximate causation, a more concrete, yet flexible, tool is needed. This Article proposes such a tool: network theory. It does so by examining the "Accident Network" created in each case with a plaintiff node (victim) on the one hand, and defendant node (tortfeasor) on the other. The visualization of the nodes and edges involved in an accident, as well as their features, will provide a strong basis to decide whether proximate causation is established in a given negligence case. This will also consider policy decisions with regard to intervening factors and the eggshell skull doctrine. This Part will first set the stage for evaluating an Accident Network; then, it will demonstrate the value of this Article's proposal by analyzing seminal common law cases, as well as new technological scenarios, using network theory.

A. Setting the Accident Network Stage

First, it is important to note that network theory does not offer a completely objective tool to examine an accident. Subjectivity still plays an important part as it does in other aspects of the common law system. Assigning weight to edges and evaluating a node's centrality are still rather subjective tasks. It is also not desirable to strictly evaluate proximate causation using solely objective measurements, since there is great value in the flexibility of the proximate causation analysis, as its evaluation is bound to change with time. Damages that were once unforeseeable or too remote can be viewed differently with time given today's network economy, or as Castells calls it, "network society."[141] Because we are much more connected, our ability to inflect damages upon each other is greater,[142] and thus damages that were once too remote or unforeseeable are not necessarily viewed as such today.[143] The great value network theory has to offer in the context of the proximate causation doctrine lies in the fact that it

141. MANUEL CASTELLS, THE RISE OF THE NETWORK SOCIETY 469–78 (1996); Werbach, *supra* note 108, at 183; *see* ANNE-MARIE SLAUGHTER, THE CHESSBOARD AND THE WEB: STRATEGIES OF CONNECTION IN A NETWORKED WORLD 8 (2017).

142. This is especially true in the context of automated devices. *See, e.g.*, Leon E. Wein, *The Responsibility of Intelligent Artifacts: Toward an Automation Jurisprudence*, 6 HARV. J. L. & TECH. 103, 107 (1992) ("[A]utomated devices generate liability of a different order or degree than humans performing an equivalent task . . . .").

143. For more on this, see Lior, *supra* note 113, at 1122–23.

provides well-founded and agreed-upon measurable features, which should be examined in a given scenario to determine the remoteness and foreseeability of a damage ensued vis-à-vis a negligent conduct.

Second, it is important to discuss the boundary of a given Accident Network. In addition to the tortfeasor node(s) (defendant(s)) and parallel victim node(s) (plaintiff(s)), other relevant nodes might also be a part of the Accident Network, having connections with the above nodes. These nodes are also most likely connected among themselves in various degrees and for various purposes. Since the Accident Network cannot be infinite, the tortfeasor and victim nodes will define the boundary of the Accident Network depending on the relevance of their neighboring nodes and the nature of their edges.[144] Not setting such a boundary would undermine network theory's ability to serve as a valuable instrument to help establish or disprove the existence of proximate causation. Boundaries can also be too strict, however, by using a pre-defined and rigid number of edges or nodes. Each Accident Network must be evaluated and delineated in a way that ensures only relevant nodes and edges are considered as part of it.[145] This is the network theory embodiment of the level of generalization applied on a given accident Witt discussed.[146] This Article chooses not to limit the boundary of a given Accident Network in order to ensure that whenever damages occur, network theory can assist. However, this Article argues that visualizing the network itself will restrict the entity making the decision from applying too wide a level of generalization.

Finally, some may view the usage of network theory as just a more elaborate and fanciful way to apply the "zone of danger" rule.[147] This rule is applied when a negligent infliction of emotional distress tort is brought to court.[148] Similar to proximate causation, this rule aims to limit the liability of the defendant only to those who were "placed in immediate risk of physical harm" by the defendant's negligence and "frightened by the risk of harm."[149] In a way, the usage of network theory essentially analyzes the zone of danger in a given Accident Network. However, unlike the strict "zone of danger" rule, network theory does not only observe the physical location of the plaintiff to

144. *See supra* notes 78–88 and accompanying text. As mentioned above, this will probably be determined by the judicial or administrative authority examining the accident.

145. The boundaries can also be defined to specific relevant events.

146. *See* WITT & TANI, *supra* note 49, at 346–47 and accompanying text.

147. For this test in the context of *Palsgraf*, see John Pothier, *Palsgraf v. Long Island Railroad Edimation*, YOUTUBE (Sept. 30, 2013), www.youtube.com/watch?v=yl93BePFrs4&ab_channel=JohnPothier/ [https://perma.cc/5XQ6-YNB8].

148. *See* John J. Kircher, *The Four Faces of Tort Law: Liability for Emotional Harm*, 90 MARQ. L. REV. 789, 815 (2007).

149. *Id.* at 816; *see also Zone-of-Danger Rule*, BLACK'S LAW DICTIONARY (7th ed. 1999).

see if one was "placed in immediate risk of physical harm."[150] Rather, it reviews other important elements and features of the network, including various policy considerations, to help determine whether liability should be limited.

B. Applying Network Theory Features

The features discussed above, focusing on connectivity and structure, move upon a wide spectrum. Deciding where in that spectrum a given Accident Network lies will enable different stakeholders, such as judges and juries who operate in a common law system, to make more justifiable and grounded decisions while evaluating proximate causation. The higher *connectivity* level a node has, the more it is able to inflict harm upon its surroundings and, therefore, the more it is foreseeable that its negligent conduct will lead to damages. This also helps in evaluating the remoteness of the damages; the more connected a node is, the more the damages it causes can vibrate throughout the system. This means a tortfeasor node may not evade legal liability for damages caused to remote nodes. On the other hand, if a node has a low connectivity level, its actual ability to cause damages to remote nodes is low and therefore unforeseeable, or at the very least less foreseeable. Thus, the proximate causation test will most likely not be fulfilled.

Furthermore, while examining the *structure* of an Accident Network, it can be seen that the more it is centralized around the tortfeasor node, the more likely it is that the damages it inflicts are foreseeable. This is due to its strength, and thus its ability to inflict harm to its neighboring nodes. The more central a node, the more connected it is. Thus, directly evaluating a centralized Accident Network relates to our previous analysis concerning the tortfeasor's level of connectivity. However, if the network is a distributed one, it is less likely that any specific node, including the tortfeasor node, has the necessary characteristics to inflict damages that can vibrate through the network and foreseeably cause remote harms. The same can be said with regard to a decentralized system. In this system, the existence of small clusters leads to the fact that a given damage is less likely to be foreseeable if it is inflicted upon a node that lies beyond the small cluster itself.

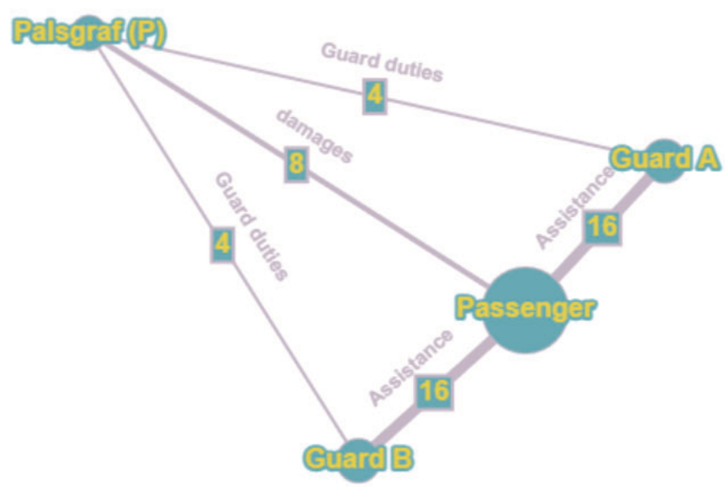
The strength of the nodes within the Accident Network is a good indicator of their centrality and connectivity levels. It is important to evaluate the strength of both the tortfeasor and victim nodes to help establish predictability of the damages. As stated above, the weight assigned to an edge connecting two nodes is inherently subjective based on the viewers' (i.e., decisionmakers) perceived relationship taking into consideration its intensity, and in the context of

150. *See* Pothier, *supra* note 147.

proximate causation, its ability to foresee the harm that was negligently inflicted. Given that a node's strength is the sum of weights assigned to edges connected to it, the "heavier" a node is, the more potential and ability it has to inflict damages upon far nodes, which is foreseeable due to its relative strength compared to other nodes within the network. The "lighter" a node is, the less likely we can hold it liable for a remote damage given its low level of connectivity and centrality within the Accident Network. To more clearly illustrate this analysis, the following subsections present the Accident Networks of the seminal cases of *Palsgraf* and *Ryan*.

i. *Palsgraf*

The Accident Network of the *Palsgraf* case should include at least the two guards who were sued in the original case (Guard A and Guard B), as well as Palsgraf (P), and the Passenger carrying the package of fireworks (Passenger). These four nodes were chosen to constitute this network given their substantial roles in the factual background, as described in the case, leading to the damages. Other nodes can also be added, such as the Railroad Company, other passengers that were on the platform at the time of the accident, and so on. However, it seems these nodes are unlikely to contribute to the analysis as the main edges we are interested in are the ones relating to the creation of the damage between these four main nodes. Therefore, the Accident Network should look like this:[151]



Palsgraf (P) is physically positioned in a distance from where the negligent act took place, on the rail while the Passenger was trying to board the train. The

151. This network was created using GRAPH ONLINE, graphonline.ru/en/ [https://perma.cc/2ZG5-9Q9F].

edges connecting both guards to the passenger, as well as to the plaintiff, are characterized by their duties as guards hired by the Long Island Railroad Company, the defendant in this case. The edges connecting them to the Passenger are assigned the weight sixteen, and are therefore four times heavier than the weight assigned to the edges between Palsgraf and the guards (4). This is because the guards' physical location, as well as the fact that they were offering assistance to the Passenger at the moment the damage occurred, indicate that the nature of the relationship between the passenger and the guards are more significant than that between them and Palsgraf. The guards' ability to cause damages to the Passenger is greater and more expected than that of Palsgraf. Given the fact that the guards were unaware of the content of the passenger's package, their reasonable foreseeability of causing harm, other than the harm that might have been caused to the Passenger himself, is low.

This is also true from the perspective of the Passenger. The weight assigned to the edges connecting him to the guards (16) is double the weight which was assigned to the edge connecting him to Palsgraf (8). This is because it is more foreseeable that the passenger, well aware of being in possession of explosives, will cause damages to the guards positioned near him, rather than Palsgraf standing on a different platform. Nonetheless, the fact that it is less foreseeable does not mean the passenger cannot be held liable for Palsgraf's damages. It only means that, relative to the damage that may have happened to the guards, the chances of Palsgraf being hurt are less expected. The actions of the Passenger running to board a train with a package of fireworks wrapped in an unmarked manner are highly likely to inflict damage upon the passenger's surroundings. In the above network, this is indicated by the thickness of the passenger's node vis-à-vis his neighboring nodes. This represents its heavy weight, and as a result, its centrality and significant ability to inflict damages upon connected nodes.

It is true that the above weights assigned to the edges connecting all four nodes in the system are rather arbitrary, but it is important that they will still be relative to each other. In other words, the potential damages the Passenger might have inflicted on the guards would have been foreseen as more significant than that inflicted on Palsgraf. For this reason, the weight assigned to the edges connecting the Passenger to the guards is double that connecting the Passenger to Palsgraf. Though the relative weights of these two edges ultimately involve some subjective reasoning on the part of judges and other decisionmakers, still the initial assignment of a specific number as the weight of an edge should be based on an analytical factual analysis. This is routinely carried out by judges and juries and is an inherent part of their role.

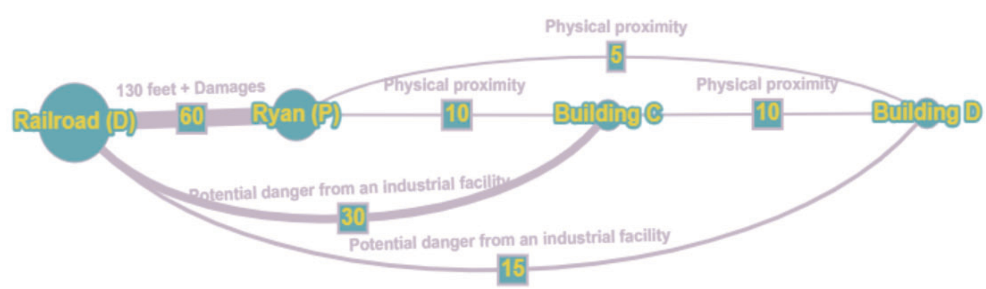
In this case, the physical location of the nodes on the train platform in relation to each other plays a vital role in the assignment of their edges' weight.

This is because it is inherently connected to a node's ability to pinpoint foreseeable victims of their negligent actions and proactively eliminate or minimize the possibility of causing damages. If a node is not in possession of dangerous instrumentalities that can inflict damages on nodes situated far from it, such as the Passenger's fireworks, public policy, as well as common sense, does not compel it to foresee that his actions may perpetuate to a long distance. Thus, location is a key feature in the factual analysis and weight assignment of the *Palsgraf* Accident Network.

The *Palsgraf* Accident Network above shows that proximate causation may have been established with regard to the Passenger itself, but less so with regard to the guards, and as a result, the Railroad Company. This does not necessarily mean, however, that the Passenger is the only liable party. It could have been established that the Passenger and the guards were jointly or severally liable for the damages Palsgraf suffered and were assigned a relative attribution of liability to each node based on its features within the network. Either way, the above network has enabled us to see more clearly the foreseeability level of each node that their actions will lead to Palsgraf's injury.

ii. *Ryan*

The Accident Network of the *Ryan* case should at least include the source of the fire (the Railroad Company (D)) and the node who suffered damages (Ryan (P)). However, given the unique circumstances of the case, focusing on the physical proximity between the source of the damages and the damages that eventually ensued, it seems vital to add additional nodes. Two other nodes in the form of adjacent buildings (Building C and Building D) were added to the network to help evaluate the remoteness element of proximate cause. Thus, the Accident Network should look like this:



The Railroad company (D) is located one hundred thirty feet away from Ryan's (P) building which was damaged as a result of a fire caused by the negligent conduct of the railroad company. This Accident Network assumes that the further a building is located from the railroad, the less foreseeable it is that the building will be damaged by the negligent act (i.e., catch fire and disintegrate). In the above Accident Network, this diminished foreseeability is embedded via the weight of the edges assigned, which decrease by half the further the building is located from the source of the negligent conduct.[152] For example, given the close proximity of Ryan's property to the Railroad's woodshed, the edge connecting them was assigned the weight of 60. The weight assigned to the edge between the woodshed and Building C was reduced by half to 30, and the edge to Building D was reduced by another half to 15. Furthermore, the weight assigned to the edges between Ryan and Building C, as well as Building C to Building D, is only 10, embodying the low foreseeability of damages inflicted between those nodes given their noncommercial business nature. Because Ryan is located remotely from Building D in comparison to Building C, the assigned weight to that edge is half of that (5). As was elaborated in the above *Palsgraf* analysis, the numbers behind these weights are arbitrary, but they are relative to each other, thus embodying the different foreseeability levels each of them represents with regard to inflicting potential damages upon neighboring nodes.

The weight of the edges, as well as the strength of the nodes,[153] can embody policy considerations such as the existence of insurance. Insurance has been mentioned by the *Ryan* court as a relevant component to be evaluated as part of the proximate causation test.[154] If the owner of Building D, or even the Plaintiff himself, has a property insurance policy, this can be taken into account to determine if we wish to hold them liable for a specific harm.[155] This is because insurance is a significant risk hedging mechanism of important value in today's society. Making decisions that might hurt the role of this tool as a risk hedging institution should be considered as a policy matter when evaluating liability.[156] However, it is important to note that in 1866 when the case was decided, third-party liability insurance was not offered by insurance companies as it was considered to be against public policy.[157] The court stated that holding the railroad company liable would "create a liability which would be the

152. Similar to the *Palsgraf* Accident network, the physical location of the nodes plays an important role in this network as well. This is because the location of the nodes is indicative of the possibility of them catching fire from each other.

153. Indicated in the above graph via the size of the node.

154. Ryan v. N.Y. Cent. R.R., 35 N.Y. 210, 216–17 (1866).

155. Decisionmakers might opt to find a defendant not negligent (i.e., "less liable") so her insurer will be responsible for paying the damages, and not the defendant herself. Otherwise, defendants will be held responsible to pay for damages they cause, and insurance may become irrelevant.

156. For more on insurance, see Anat Lior, *Insuring AI: The Role of Insurance in Artificial Intelligence Regulation*, 35 HARV. J.L. & TECH. 467 (2022).

157. ABRAHAM, *supra* note 42, at 19.

destruction of all civilized society."[158] It is unclear, however, whether the availability of liability insurance would have changed the "one-building" rule adopted in *Ryan* and its analysis of "remoteness."

Analyzing the *Ryan* Accident Network from a factual perspective, its visualization helps us account for the different nodes in place and evaluate the centrality and strength of the tortfeasor node, the Railroad, and therefore the foreseeability of it inflicting harms on connected nodes, near and far. It seems as though the Railroad's activities and operation of business within its woodshed were foreseeable to cause harm to adjacent property given their nature—engines operations for commerce purposes. This is the main criterion in assigning the highest weights to edges connecting the Railroad to neighboring nodes. Thus, its ability to inflict damages was substantial and expected, and the court's decision that the damage was too "remote" was a misconception in nature. This can be seen by the thickness of the Railroad (D) node and, as a result, its centrality in the network. Hence, the court erred in deciding the damage was too remote or not the "natural and expected" result of the destruction of the woodshed. The Railroad company should have been held liable for the plaintiff's damage.

This case has been heavily criticized throughout the years. Abraham described it as the "poster child for a long-running dispute over the extent to which tort law in the nineteenth century largely served economically powerful interests, subsidizing industrial and commercial growth at the expense of the individuals who suffered accidental physical harm."[159] The Accident Network above aligns with this common critique by showing that an analysis focusing on the features of the nodes within the network leads to the conclusion that proximate cause did exist between the defendant's negligent act and the damages. It seems as though the policy considerations the court injected into the proximate cause test are disputable in nature.

The network theory analysis of the *Palsgraf* and *Ryan* cases enables decisionmakers to reason their evaluation of proximate causation in an accessible way. Network theory is not aimed at preventing subjectivity on the part of the decisionmakers. It adds a much-needed layer of reasoning to the process of decision-making. It also acts as an accountability instrument to ensure the reasoning aligns with a holistic analysis of the Accident Network,

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158. *Ryan*, 35 N.Y. at 217; ABRAHAM, *supra* note 42, at 19.

159. ABRAHAM, *supra* note 42, at 18; *see also* MORTON J. HORWITZ, THE TRANSFORMATION OF AMERICAN LAW, 1780–1860 (1977); LAWRENCE M. FRIEDMAN, A HISTORY OF AMERICAN LAW 351 (3d ed. 2005) (claiming that the *Ryan* case exemplified how courts limited damages because "capital had to be spared for its necessary work"). For a different view, claiming that the *Ryan* case is only a minority, see PETER KARSTEN, HEART VERSUS HEAD: JUDGE-MADE LAW IN THE NINETEENTH CENTURY 101–06 (1997).

and if it does not, it compels an elaborated policy explanation as to why we should diverge from it. This explanation is bluntly missing in the *Ryan* case. The process of evaluating a proximate causation question via the lens of network theory will essentially provide a safeguard mechanism, ensuring subjectivity is preserved, but is also audited. In *Palsgraf* and *Ryan*, network theory provides an important tool that diverges from the outcome that was reached in these seminal cases. That is not necessarily to say that they are "bad law," but rather that they require an additional layer of explanation and justification in their discussion of proximate cause.

iii. Other Considerations

Network theory can also help accommodate different policy decisions with regard to intervening factors as well as the eggshell skull doctrine. The Accident Network, via the features of the edges, can account for intervening factors that have been adjudicated as such and do not sever the link of legal causation. In the rescue rule, for example, the nature of the edge connecting the rescue and the rescuer can be classified as one that does not sever the causality link as a policy decision, even if in fact the Accident Network suggests otherwise. The same is true with regard to the eggshell skull doctrine. If a plaintiff node possesses vulnerabilities that are unknown to a defendant node, these traits can be integrated into the Accident Network via the assigned weight of the edge connecting them and the strength of the nodes itself. This should be implemented even if no foreseeability was established due to a court's policy decisions that the plaintiff takes his victim "as he finds" him or her.[160]

As mentioned above in the *Ryan* case, another policy decision that may be considered by courts is the existence of an insurance policy. For example, Judge Friendly has stated that "[i]f there were any way in which the doctrine could be manipulated so as to correspond with probable insurance that would be fine."[161] This element is external to questions of foreseeability and directiveness, but it does embody a policy consideration the court may view as relevant when trying to establish proximate causation. The implementation of network theory into their analysis ensures these policy considerations are properly fleshed out while examining proximate cause, especially when a purely factual examination leads to a different conclusion.

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160. *See* Section II.A.

161. DAVID M. DORSEN, HENRY FRIENDLY: GREATEST JUDGE OF HIS ERA 309 (2012). See also Judge Friendly's opinion in *In re Kinsman Transit Co.*, 338 F.2d 708, 725–26 (2d Cir. 1964).

iv. Technological Implications

More modern examples of the application of network theory to evaluate proximate causation seem apt given the technological and social changes since *Ryan* and *Palsgraf* were adjudicated almost a century ago. There have been many technological developments since the era of *Palsgraf* and *Ryan*, and cyberattacks are a particularly useful example. Cyberattacks are common in today's digital age.[162] These can be carried out from afar and can involve multiple malicious entities located across the world.[163] Network theory can be a great asset to mitigate the complexity and inherent remoteness of these situations and can provide us with a tangible tool to analyze a specific Accident Network. It is important to note that, in these situations, the hacker is acting with malice, and therefore a negligence theory is inapplicable with regard to the edge connecting them to the victim. However, a negligence claim can be brought against other nodes within the network acting as a gateway between the hacker and the victim. There are many methods to carry out a cyberattack.[164] The below Accident Network describes a Man-in-the-Middle (MitM) attack. In this scenario, "a hacker inserts itself between the communications of a client and a server,"[165] i.e., between two connected devices, such as a laptop and a Wi-Fi router. The hacker gains access to a victim's sensitive information, such

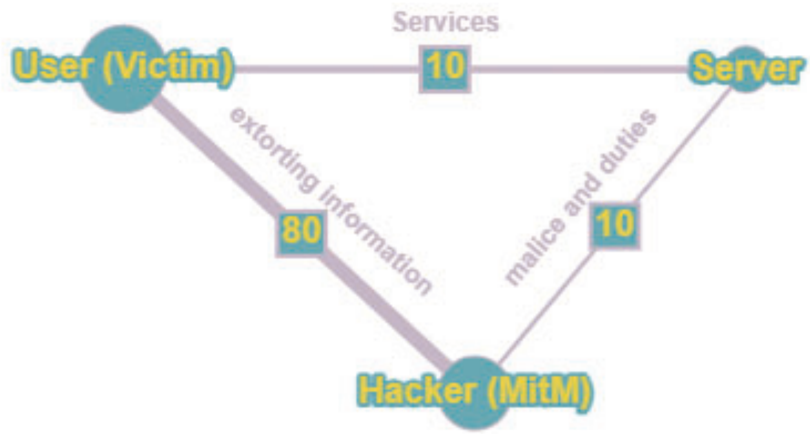
162. *See generally Significant Cyber Incidents Since 2006*, CTR. FOR STRATEGIC & INT'L STUD., www.csis.org/programs/strategic-technologies-program/significant-cyber-incidents [https://perma.cc/F22D-BSEV].

163. Thomas Rid & Ben Buchanan, *Attributing Cyber Attacks*, 38 J. STRATEGIC STUD., Dec. 2015, at 4, 19. *See generally* Kristen Eichensehr, *Cyberattack Attribution and International Law*, JUST SECURITY (Jul. 24, 2020), www.justsecurity.org/71640/cyberattack-attribution-and-international-law/ [https://perma.cc/9EML-WQSJ].

164. Jeff Melnick, *Top 10 Most Common Types of Cyber Attacks*, NETWRIX BLOG (May 15, 2018), blog.netwrix.com/2018/05/15/top-10-most-common-types-of-cyber-attacks/ [https://perma.cc/GMY9-P9X2].

165. *Id.*

as bank account and credit card information, which may lead to financial damages to the victim:



We have three nodes in this scenario—the Hacker (MitM), the User (Victim), and the Server which the victim is using. Usually, the server is provided by a commercial company. Unlike the *Palsgraf* and *Ryan* networks, here the physical location of these nodes is irrelevant and is of no value in assigning the weight of the edges. The nodes can be located anywhere in the world, so long as they have a connected device. Therefore, the weight assigned in this network is based on the nodes' intention to cause harm to each other, as well as the nature of the relationships between them. This can include the legal and non-legal obligations and rights they owe each other, the intensity of their relationship (e.g., frequency of contact), and any prior interactions they might have had in the past.

The node between the User and the Hacker is assigned the weight of 80, given the malicious intent of the Hacker to inflict damages to the User (Victim). As stated, a negligence action cannot be brought based on this edge against the Hacker, but this Accident Network can help us decide whether such a claim could and should be brought against a third-party, in our case, the Server. The weight assigned to the edges connecting the Server to the Hacker and to the User highly depends on the unique circumstances of each case. If the Server is provided by a private company and it is paid for, the weight of the edge connecting it to the Hacker and the User should be high, given the expectations of the User to be protected by the Server, and the latter's duty to provide a safe connection. Alternatively, if the Server is public, such as a free Wi-Fi router at a café, the weight assigned to the connecting edge should be low, as there are no expectations from the User, nor obligations from the Server, to actively prevent hacking. This also affects the weight assigned to the edge connecting the Server and the Hacker. The more a Server guarantees protection to the User, the more it is obligated to offer protection against the MitM. The Accident

Network above assumes that the User was hacked while using a public free Server. Thus, the weight assigned to both edges connected to the Server is extremely low, given the lack of protection this type of server offers to the User against the Hacker. Thus, in this Accident Network, it is unlikely that proximate causation could be established against the Server for the damages the User endured.

Another important technological development is the emerging technology of artificial intelligence (AI). This technology presents a salient challenge to the doctrine of proximate causation, as it is difficult to draw a legal nexus between the damages ensued by the AI entity and a human entity that can be held liable.[166] It is often unclear what part the AI entity had in causing a harm.[167] In cases where the AI entity caused the damages as a stand-alone actor, proximate cause and causal ambiguity are not usually an issue, as the scope of liability is mostly clear.[168] These “stand-alone” cases refer to situations where there is no cooperation between an AI entity and a human in performing the former’s assigned tasks. Examples of such stand-alone cases include a fully automated vehicle operation,[169] a fully autonomous security guard robot, and a hiring algorithm basing its decision on pre-defined proxies.

However, proximate causation might be difficult to prove given a causal uncertainty. This stems from the difficulty, in some cases, of distinguishing between damages with sufficient proximate cause between the injury and the AI entity, and those caused by others. These instances usually refer to damages caused by an AI entity which worked in cooperation with a human entity, including doctors aided by medical AI technology to set a harmful course of treatment or make a mistaken diagnoses,[170] lawyers aided by AI software to

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166. For more on this issue, see Anat Lior, *AI Entities as AI Agents: Artificial Intelligence Liability and the AI Respondeat Superior Analogy*, 46 MITCHELL HAMLINE L. REV. 1043, 1057 (2020); Lior, *supra* note 113, at 1111.

167. Lior, *supra* note 156, at 521.

168. *See* RESTATEMENT (THIRD) OF TORTS: LIABILITY FOR PHYSICAL AND EMOTIONAL HARM § 29 (AM. L. INST. 2010).

169. *SAE International Releases Updated Visual Chart for Its “Levels of Driving Automation” Standard for Self-Driving Vehicles*, SAE INT’L (Nov. 12, 2018), www.sae.org/news/press-room/2018/12/sae-international-releases-updated-visual-chart-for-its-%E2%80%9Clevels-of-driving-automation%E2%80%9D-standard-for-self-driving-vehicles [https://perma.cc/A6KS-K5ZK].

170. *See, e.g.*, Rob Matheson, *Automating Artificial Intelligence for Medical Decision-Making*, MIT NEWS (Aug. 5, 2019), news.mit.edu/2019/automating-ai-medical-decisions-0806 [https://perma.cc/9JAL-RZHA]; Cade Metz, *A.I. Shows Promise Assisting Physicians*, N.Y. TIMES (Feb. 11, 2019), www.nytimes.com/2019/02/11/health/artificial-intelligence-medical-diagnosis.html [https://perma.cc/D7HD-P3CU].

decide upon a wrongful cause of action,[171] or investment consultants aided by algorithms in recommending a harmful route to invest their clients' money.[172] These cooperation scenarios should be a common feature in the years to come as AI technology continues to embed itself into commercial and social aspects of our lives.[173] Network theory can be of value in these "joint causation" scenarios.

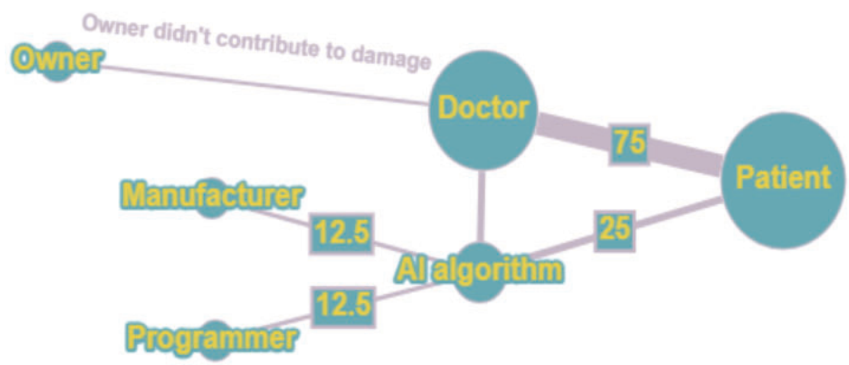
The below Accident Network describes a situation in which Doctor has made a mistaken diagnosis while being aided by an AI algorithm. As a result, Patient suffered damages. In addition to these three nodes, other nodes may be relevant to our analysis, such as the Programmer, Manufacturer, and Owner of the AI algorithm. Similar to the above cyberattack scenario, the weight assigned to the edges connecting all of these nodes highly depends on the unique circumstances of each case. These weights are determined by many factors, such as the scope of reliance Doctor had on the AI algorithm while making her decision; whether Patient was aware and consented to the usage of an AI algorithm; what is the applicable medical standard of care under the circumstances and whether Doctor deviated from said standard; was the mistaken diagnosis derived in part or in whole from an error made by Programmer or Manufacturer of the AI algorithm; were there protocols dictated by Owner of the AI algorithm (e.g., a hospital) on how to use it; etc. The conclusion of a proximate causation analysis will pivot on these important considerations.

171. *See, e.g.*, Neil Sahota, *Will A.I. Put Lawyers Out Of Business?*, FORBES (Feb. 9, 2019), www.forbes.com/sites/cognitiveworld/2019/02/09/will-a-i-put-lawyers-out-of-business/#26525c3031f0 [https://perma.cc/L9EV-Z47D]; Steve Lohr, *A.I. Is Doing Legal Work. But It Won't Replace Lawyers, Yet.*, N.Y. TIMES (Mar. 19, 2017), www.nytimes.com/2017/03/19/technology/lawyers-artificial-intelligence.html [https://perma.cc/Y5M3-M2GG].

172. *See, e.g.*, Ellen Chang, *How Artificial Intelligence Will Help Financial Advisors Provide Better Guidance*, THESTREET (Nov. 19, 2017), www.thestreet.com/story/14159924/1/how-artificial-intelligence-will-help-financial-advisors-provide-more-guidance.html [https://perma.cc/UPK7-CND4]; Lorie Konish, *Firms Like Morgan Stanley are Using Artificial Intelligence to Manage Clients' Money*, CNBC (Oct. 20, 2018), www.cnbc.com/2018/10/19/-artificial-intelligence-is-changing-how-investors-money-is-managed.html [https://perma.cc/SU36-NGH5].

173. *See, e.g.*, Miranda Katz, *Welcome to the Era of the AI Coworker*, WIRED (Nov. 15, 2017), www.wired.com/story/welcome-to-the-era-of-the-ai-coworker/ [https://perma.cc/K65E-7P6M].

The below network assumes that Doctor followed common practice in its decision-making process, but that he heavily relied on the output of the AI algorithm in making his mistaken diagnosis. Furthermore, it assumes that Doctor did not adhere to the protocols dictated by Owner of the AI algorithm, and that Programmer and Manufacturer made an error that contributed to the mistaken diagnosis carried out by the AI algorithm by 25%. The weight assigned to the edges in this scenario represent the percentage of contribution each node had to the final damage that occurred to the Patient. Therefore, the Accident Network should look like this:



Manufacturer and Programmer share a 25% portion of Patient's damage in light of their error in programming and manufacturing the AI algorithm. Doctor contributed the remaining 75% portion in light of his heavy reliance on the AI algorithm and the fact he failed to adhere to the protocols dictated by Owner. Thus, no weight was assigned to the edge connecting Owner and Doctor. Had Doctor adhered to Owner's protocols, we might have assigned it a portion of the blame given the fact its protocols failed to prevent Patient's damage. Other edges in the Accident Network, such as the one between Doctor and the AI algorithm, are also weightless given the fact this Accident Network assigns weight based on one's share of the damages. A different decisionmaker using this tool can decide to assign weight using a different criterion, such as the cooperation level connecting these nodes or their capability to inflict damage upon each other. Given a similar scenario, the network analysis would reach a similar result with regard to the nodes that should be held liable, and their share in the damages that ensued.

C. More than Juridical Contribution

The simple scenarios presented above illustrate the advantages of network theory to proximate causation evaluation. Although the damages may seem distant or not direct at first, given their remoteness and existence of other factors, the graphs enable decisionmakers to better understand the underlying connections between the nodes in the Accident Network. Thus, the inherent features of network theory can aid decisionmakers to better evaluate the node's ability and foreseeability to inflict damages upon their neighboring nodes. Focusing on the judicial branch, in comparison to traditional tests that common law courts use to evaluate proximate causation, network theory offers an additional layer of definitive measurements for evaluation. In this sense, its incorporation to the proximate causation doctrine will create a more nuanced, understandable, and accessible proximate causation evaluation process.

That is not to say the current traditional tests developed and used by the court system should be cast aside.[174] Network theory should be used as a complementary instrument to court's discretion, whether it is the judge or the latter's instructions to the jury, in evaluating the existence of proximate cause.[175] It enables these decisionmakers to more accurately assess and comprehend ambiguous subjective legal terms, such as foreseeability,[176] predictability, and intervening factors, in a manner that allows them to reach a justifiable decision with regard to the existence of proximate cause. Furthermore, providing this tool to juries may enable them to understand more clearly the concept of proximate causation in light of their ability to visualize complex causation situations, and thus rationalize their decision in a more coherent way.[177]

Besides the juridical contribution in applying a network theory analysis on proximate cause, other relevant decisionmakers can also benefit. These may include regulators and insurers. For example, regulators, and other policymakers, may choose to use network theory analysis to legislate new

174. For a review of the traditional tests, see *infra* Section II.A.

175. For more on the vast topic of judicial discretion, see AHARON BARAK, JUDICIAL DISCRETION (1989) and Richard S. Higgens & Paul H. Rubin, *Judicial Discretion*, 9 J. LEGAL. STUD. 129 (1980).

176. For more on the difficulty in the interpretation of foreseeability, see Victor P. Goldberg, *The Achilleas: Forsaking Foreseeability*, 66 CURRENT LEGAL PROBS. 107 (2013), Jocelyn Downie & Kate Scallion, *Foreseeably Unclear: The Meaning of the 'Reasonably Foreseeable' Criterion for Access to Medical Assistance in Dying in Canada*, 41 DALHOUSIE L.J. 23 (2018), Reynolds C. Seitz, *Duty and Foreseeability Factors in Fright Cases*, 23 MARQ. L. REV. 103 (1939), and Melvin Mark, Renee Reiter Boburka, Kristen Eyssell, Laurie Cohen & Steven Mellor, *"I Couldn't have Seen it Coming": The Impact of Negative Self-Relevant Outcomes on Retrospections about Foreseeability*, 11 MEMORY 443 (2003).

177. For more on juries in this context, see Reid Hastie & W. Kip Viscusi, *What Juries Can't Do Well: The Jury's Performance as a Risk Manager*, 40 ARIZ. L. REV. 901 (1998), Neil Vidmar, *The Performance of the American Civil Jury: An Empirical Perspective*, 40 ARIZ. L. REV. 849 (1998), Brian H. Bornstein & Edie Greene, *Jury Decision Making: Implications for and from Psychology*, 20 CURRENT DIRECTIONS IN PSYCH. SCI. 63 (2011), and Dennis J. Devine, Laura D. Clayton, Benjamin B. Dunford, Rasmy Seying & Jennifer Pryce, *Jury Decision Making: 45 Years of Empirical Research On Deliberating Groups*, 7 PSYCH. PUB. POL'Y & L. 622 (2001).

intervening factors based upon policy considerations embedded in network theory analysis. Regulators can decide that certain entities, such as massive factories or tech monopolies,[178] possess a greater ability to inflict damages upon their surroundings and thus render their negligent actions as foreseeable, even if they are physically remote from the damages that ensued. It seems unlikely that regulators will legislate these types of elements *ex ante*, given the way our tort system currently works, and the vast discretion courts have in making these types of decisions.[179] Nevertheless, regulators may choose to do so if a network theory analysis of a given Accident Network will show that creating such a rule is beneficial to society as well as the court system.[180]

Insurers present an interesting beneficiary of network theory when offering first and third-party policies covering negligent behavior. Liability insurance policies, primarily Commercial General Liability (CGL), Directors & Officers insurance, Professional Liability insurance, and automobile insurance, indemnify their holders "against amounts owed due to legal judgments and settlements"[181] that qualify under these types of policies. Liability insurance covers negligent acts of its holder that caused damages to first or third parties. Insurance companies can incorporate the study of network theory and its contribution to the evaluation of proximate causation into their policies. For example, given their expertise and economies of scales,[182] insurers can analyze a vast variety of potential Accident Networks during their underwriting process with regard to a potential insured entity.[183] This will enable them to more accurately calculate adequate premiums that reflect the scope and magnitude of

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178. *See, e.g.*, Van Loo, *supra* note 110, at 181.

179. E.g., this can be seen in the role Restatements have as secondary sources of law. These are published by the American Law Institute to clarify the law and help the courts interpretate it, but not in lieu of their interpretation. *See, e.g.*, Stephen D. Sugarman, *Rethinking Tort Doctrine: Visions of a Restatement (Fourth) of Torts*, 50 UCLA L. REV. 585, 586 (2002); Fred B. Helms, *The Restatements: Existing Law or Prophecy*, 56 A.B.A. J. 152, 152 (1970).

180. Many goals and subgoals of the tort system could be taken into consideration, such as risk distribution, deterrence, justice, judicial efficiency, etc. *See, e.g.*, GUIDO CALABRESI, THE COSTS OF ACCIDENTS: A LEGAL AND ECONOMIC ANALYSIS (1970).

181. KENNETH S. ABRAHAM & DANIEL SCHWARCZ, INSURANCE LAW AND REGULATION: CASES AND MATERIALS 463 (7th ed. 2020).

182. Neil A. Doherty & Clifford W. Smith, Jr., *Corporate Insurance Strategy: The Case of British Petroleum*, 6 J. APPLIED CORP. FIN., no. 3, 1993, at 3, 8. Insurance companies hold vast amounts of data regarding different Accident Networks which they have already dealt with in the past. This expertise, as well as their dominance in certain fields, such as the automobile industry, renders them a good candidate to use network theory in a nuanced way.

183. Insurance underwriting "is the process of evaluating which risks to insure and at what price." Tom Baker & Rick Swedloff, *Regulation by Liability Insurance: From Auto to Lawyers Professional Liability*, 60 UCLA L. REV. 1412, 1420 (2013).

a potential harm that a specific entity can inflict on its surroundings, as well as the possibility that these damages will actually occur.[184]

Implementing this analysis into the underwriting process, as well as the claim management process after an accident occurs,[185] can provide a more accurate and fair coverage to the policy holder. This will lead to charging higher premiums from entities who possess greater potential to inflict harms on their neighboring nodes, and therefore be held proximately liable for their actions. In contrast, less central and connected nodes should pay a lower premium because their ability to inflict widespread harms is lower, and thus are less likely to be held the proximate cause of a harm.[186] Similar to the judicial context, network theory should not replace the existing methods used by insurers and actuaries to calculate their premiums, rather, it should be used as a complementary instrument. Network theory analysis can help validate the accuracy of an offered premium considering all the relevant features of an insured entity in different plausible Accident Networks.[187]

V. CONCLUSION

All the past is a part of the cause of every present effect.
–Judge Arthur G. Powell[188]

The doctrine of proximate causation is a difficult one to master and apply. Its interpretation has been purposely left flexible by the courts, but too much flexibility may render it moot due to its embedded uncertainty. If we cannot

184. Lior, *supra* note 156, at 474.

185. Baker & Swedloff, *supra* note 183, at 1421.

186. It is important to note that different cultures have extreme differences in their connectivity levels. This leads to biases that would be exacerbated by the usage of network theory. This is not foreign to the field of actuarial science and is already an issue with current premiums calculation. *See, e.g.*, Ronen Avraham, Kyle D. Logue & Daniel Schwarcz, *Understanding Insurance Antidiscrimination Laws*, 87 S. CAL. L. REV. 195, 198, 203 (2014). Network theory can offer an opportunity to deepen the discourse regarding these biases in an attempt to leverage this study to combat theme.

187. Insurers are profit driven organizations who have an inherent incentive to reduce their insureds' losses and damages. *See, e.g.*, Daniel Schwarcz, *Regulating Consumer Demand in Insurance Markets*, 3 ERASMUS L. REV. 23, 32, 43 (2010); Omri Ben-Shahar & Kyle D. Logue, *Outsourcing Regulation: How Insurance Reduces Moral Hazard*, 111 MICH. L. REV. 197, 203–05 (2012). They are methodical and consistent in their operation, and thus have a lot to gain from implementing the study of network theory in their evaluation process. It should be noted that insurers, as a quasi-regulator entity, are not perfect and still require supervision. However, they do possess the tools to provide an important risk hedging instrument to society at large. *See* Lior, *supra* note 156, at 512, 518.

188. Atlantic Coast Line R.R. Co. v. Daniels, 70 S.E. 203, 205 (Ga. Ct. App. 1911).

know the scope of legal causation, how can we better adjust ourselves to be cautious in our everyday activities?

In *Derdiarian*, the New York Court of Appeals stated that the concept of proximate causation "has proven to be an elusive one, incapable of being precisely defined to cover all situations . . . . This is, in part, because the concept stems from policy considerations that serve to place manageable limits upon the liability that flows from negligent conduct."[189] In this case, the court also stated that "[d]epending upon the nature of the case, a variety of factors may be relevant in assessing legal cause. Given the unique nature of the inquiry in each case, it is for the finder of fact to determine legal cause . . . ."[190] But as we saw, that is no easy task.

Network theory can play a significant role in bringing new life to this olden doctrine. This is especially true given its recent resurrection in the form of statutory proximate causation, where federal courts have applied the common law idea of proximate causation to several federal statutes.[191] Proximate causation is heavily entrenched in our legal system and, in some ways, it is even expanding. But times have certainly changed since it was created well over a century ago. We now have available different fields of study outside of the realm of law which can enable us to carry legal analysis with more ease and accuracy. Utilizing these non-legal measurements is essential for the growth of law studies and its progress, along with the advance of technology and globalization. The damages of the past are not the damages of today, and they will undoubtedly not be the damages of tomorrow.

Furthermore, unlike the damages of the past, current and future damages transpire in a new digital world where we are all connected.[192] Given this enhanced interconnectivity, it is far more complex to successfully attribute liability to a specific entity, as we saw from the above cyberattack and AI Accident Networks examples.

Adopting the features offered by the study of network theory will equip stakeholders, such as judges and juries, to better identify, justify, and validate when the doctrine of proximate causation has been met. This is also true in other areas of tort law and in other legal disciplines as a whole.[193] Legal scholars, as

189. Derdiarian v. Felix Contracting Corp., 414 N.E.2d 666, 670 (N.Y. 1980).

190. *Id.*

191. *See, e.g.*, Bank of Am. Corp. v. City of Miami, 137 S. Ct. 1296, 1299, 1306 (2017); *see also* Nicole Summers, *Setting the Standard for Proximate Cause in the Wake of* Bank of America Corp. v. City of Miami, 97 N.C. L. REV. 529, 532, 547 (2019); Sperino, *supra* note 26, at 1216.

192. *See, e.g.*, BENKLER, *supra* note 96, at 1–2.

193. For example, in a pure comparative negligence case, network theory can assist the trier of fact in deciding the contribution of the plaintiff to the injury and the adequate reduction to their award.

well as practitioners and judges, should strive to incorporate non-legal fields into their legal analysis, including, but not limited to, network theory. It will ensure a clearer and just legal process and will enable our existing judicial system to tackle new and complex legal challenges as they arise. This Article has attempted to take the first step to accomplish this important goal.

In a modified comparative negligence, network theory can better-equip the trier of fact in deciding whether the 50% threshold has been crossed leaving the plaintiff with no compensation. *See, e.g.*, David C. Sobelsohn, *Pure vs. Modified Comparative Fault: Notes on the Debate*, 34 EMORY L. J. 65, 67–68 (1985).