The Simulator Was Perfect: The Rise and Decline of Ad Hoc Routing Research

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***Abstract*—This paper presents a quantified insight into a shared feeling in the community: getting a sense of the slowdown in academic studies of ad hoc networks. We analyze publication activity across 17 conferences over two decades as a proxy for research momentum.**

***Index Terms*—Routing Algorithms, Routing Protocols, MANET, Ad Hoc Networks, Bibliometric Analysis, Research Trends, Real-World Deployments**

I. Introduction

Research in MANET routing have been a very active community. Surveys of the field catalog approximately sixty architecturally distinct routing algorithms across proactive, reactive, hybrid, geographic, and opportunistic paradigms [1], [2]. This figure, however, understates the true volume of the literature considerably, because each base algorithm has attracted its own lineage of derivatives.

The case of AODV is illustrative. From the single protocol standardised as RFC 3561 [3], the literature has produced, among others: MAODV [4]; AOMDV [5]; SAODV [6]; and AODV6 [7]. Each of these derivatives has itself generated further variants: a dedicated review of the AODV family alone identifies hundreds of named extensions, classified by objective, quality of service, energy efficiency, security, reliability, and routing strategy [8]. When this derivative mechanism is applied across all base protocols in the taxonomy, the total count of named routing schemes in the published literature reaches into the hundreds.

This paper traces the trajectory of academic activity in ad hoc routing and discusses possible reasons to explain the dynamics observed.

II. Publication trends in ad hoc routing

This section quantifies academic research momentum in ad hoc routing through a bibliometric meta-analysis of publication activity across 17 venues over more than two decades.

A. Bibliometric Methodology

Our bibliometric analysis was conducted in two stages: corpus assembly and keyword filtering, both implemented as custom Python scripts operating against the Elsevier Scopus API.

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1) Corpus Assembly: Publication records were retrieved via the Scopus Search API using an institutional key under Elsevier's academic access terms. Venues were stratified into three tiers following the CORE 2023 ranking scheme [15]:

- **Tier 1** (CORE A*): INFOCOM, MOBICOM, MobiHoc, SIGCOMM.
- **Tier 2** (CORE A/B): SECON, MASS, WoWMoM, MSWIM, WCNC, PIMRC, IWCMC.
- **Tier 3** (CORE B + domain journal): LCN, NCA, ICNP, IEEE CCNC, IFIP Networking, and *Ad Hoc Networks* (ISSN 1570-8705) [16].

Each venue was queried by source title via `SRCTITLE()` expressions covering all known Scopus title variants over 1980–2025, retrieving title, authors, venue, date, DOI, citation count, author keywords, and abstract. The `SUBJAREA(COMP)` filter was excluded after diagnostics showed it suppressed 89% of WCNC records and 99.7% of PIMRC records, both indexed under Electrical Engineering in Scopus; out-of-domain noise is controlled at the keyword filtering stage. Co-located workshop proceedings were excluded from MOBICOM and SIGCOMM queries via `NOT SRCTITLE("Workshop")`.

Four coverage limitations apply: IFIP Networking is unindexed before 2013; NCA coverage is reliable only for 2012–2022; and two isolated indexing gaps (MSWIM 2005, ICNP 2015) are treated as missing data rather than zero-activity years.

2) Keyword Filtering: Post-retrieval, a keyword filter was applied via case-insensitive substring matching against the concatenated title, abstract, and author keyword fields. The primary filter targets the core MANET routing literature across three term categories : Domain, Protocols and Topology. The full keyword list used for filtering is provided in the paper repository.

3) Normalisation and Output Metrics: For each venue and each year, two quantities are computed. The *absolute hit count* is the number of keyword-matched papers. The *normalised hit rate* is defined as

$$r(v, y) = \frac{n_{\text{hits}}(v, y)}{n_{\text{total}}(v, y)} \tag{1}$$

where v denotes the venue, y the year, n_{hits} the number of matched papers, and n_{total} the total number of papers retrieved

from that venue in that year. Normalisation is necessary because venue size varies substantially: INFOCOM publishes approximately 500 papers per year while MobiHoc publishes approximately 30. Without normalisation, volume differences between venues confound the activity signal.

4) Reproducibility: All scripts, keyword lists, venue definitions with `SRCTITLE` expressions, and documented coverage gaps are made available as supplementary material. The analysis is fully reproducible from a Scopus API key and the provided scripts without manual curation steps.

B. Publication Trends: Volume, Peak, and Decline

Figures 1a–1c show, for each venue tier, the annual keyword-hit percentage (top panel) and the absolute number of keyword-matching publications (bottom panel) over the period 1980–2024. Figure 2 overlays all venues on a single axis and annotates the timeline with landmark protocol and community events discussed in Section II-C.

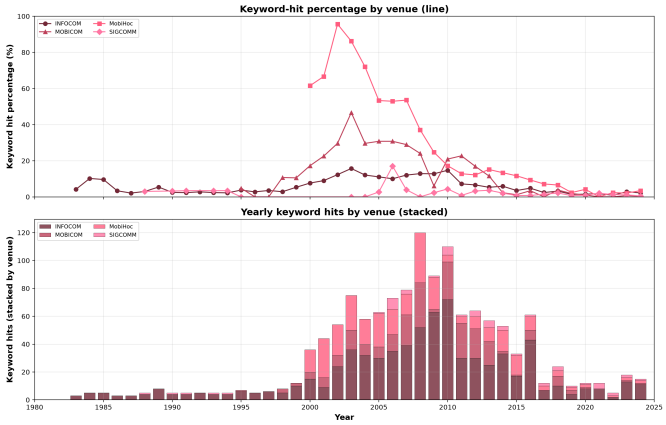
1) Global Trajectory: Across all tiers, the data reveal a canonical rise-and-fall trajectory: negligible activity before 1995, a rapid accumulation phase from roughly 1998 to 2005, a broad peak spanning approximately 2003–2010, and a sustained decline thereafter that levels off at residual but non-zero activity from 2015 onward.

This pattern is consistent across both metrics. The keyword-hit *percentage* captures the relative salience of mesh networking within each venue's annual output, while the absolute count reflects the community's aggregate publication capacity. The two metrics do not always co-vary: venues with growing total output can show a declining percentage even while absolute counts remain stable, and this dissociation is observable at several Tier 2 and Tier 3 venues after 2010.

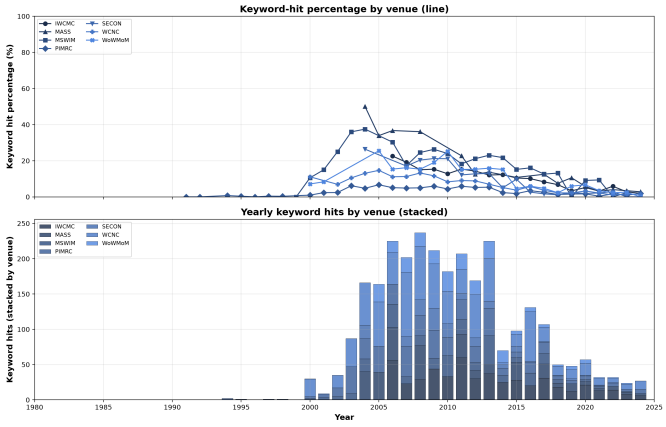
2) Tier 1: Flagship Conferences: Among flagship venues (Figure 1a), MobiHoc exhibits the sharpest and most distinctive peak, reaching approximately 95% keyword-hit rate in 2002 before declining steeply over the following five years. This reflects the venue's founding mandate oriented explicitly toward ad hoc and mobile networking, which naturally positioned it as the primary publication outlet during the field's formative years. MOBICOM shows a secondary peak around 2003–2004 at roughly 35–40%, while INFOCOM sustains a lower but longer plateau, peaking near 10–12% and maintaining measurable activity into the 2010s. SIGCOMM, consistent with its broader systems and architecture remit, never exceeds 2% throughout the entire period, indicating that mesh networking was only a peripheral topic for that community.

In absolute terms, INFOCOM contributes the largest raw counts among Tier 1 venues from approximately 2008 onward, a consequence of its larger annual programme rather than a higher topical concentration. By 2020, all Tier 1 venues converge toward near-zero absolute counts, with only intermittent single-paper appearances.

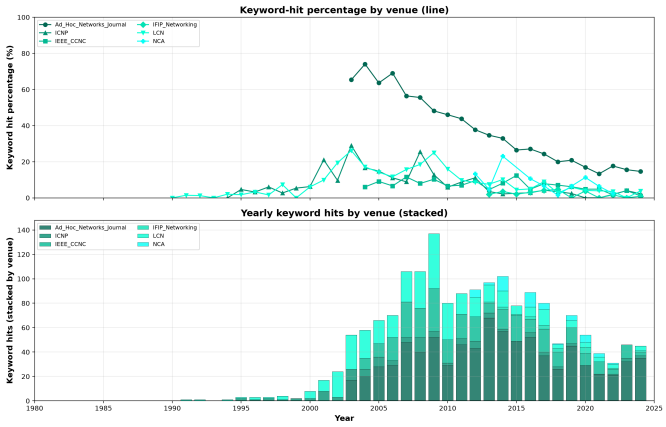
3) Tier 2: Specialist Wireless Conferences: Tier 2 venues (Figure 1b) collectively amplify the global peak while exhibiting greater inter-venue variance. SECON records the highest



(a) Tier 1 (INFOCOM, MOBICOM, MobiHoc, SIGCOMM).



(b) Tier 2 (IWCMC, MASS, MSWIM, PIMRC, SECON, WCNC, WoWMoM).



(c) Tier 3 and *Ad Hoc Networks* journal (Ad Hoc Networks Journal, ICNP, IEEE CCNC, IFIP Networking, LCN, NCA).

Fig. 1: MANET routing keyword-hit percentage and absolute publication count by venue tier, 1980–2024.

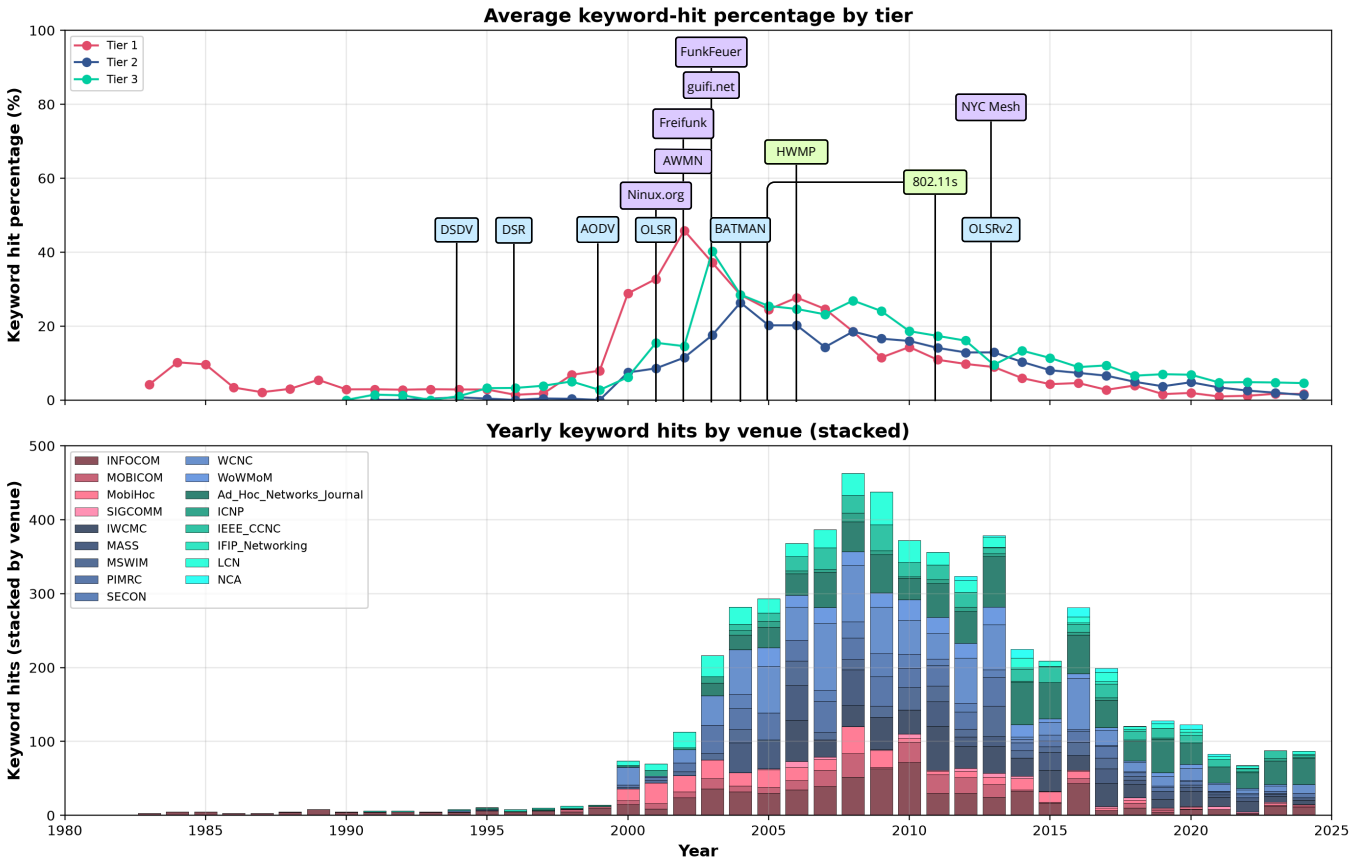


Fig. 2: Composite view of keyword-hit percentage (top) and absolute counts (bottom) across all venues and tiers, with protocol and community milestone annotations.

single-year percentage in this tier, reaching approximately 49% around 2004, consistent with its launch in that year as a venue explicitly targeting sensor and ad hoc network research. MSWIM and MASS also peak prominently in the 2003–2006 window, each exceeding 35%. WCNC and PIMRC, being higher-volume venues with broader wireless scope, show lower percentages but contribute substantially in absolute terms, with WCNC reaching over 70 keyword-matching papers around 2007–2008.

The decline from peak is steeper in percentage terms than in absolute terms for most Tier 2 venues, reflecting growth in overall submission volume that partially masks topical retreat. By 2014–2015, most Tier 2 venues have fallen below 5% keyword-hit rate, and absolute counts are in single digits or zero.

4) Tier 3 and the Domain Journal: The Tier 3 group (Figure 1c) is dominated by the *Ad Hoc Networks* journal, which alone sustains elevated keyword-hit percentages well beyond the conference peak: the journal reaches approximately 70% around 2005 and maintains rates above 20% until roughly 2015, with a gradual decline to approximately 12–14% by 2023. This prolonged tail is structurally expected for a journal bearing the domain name in its title; the persistence of non-trivial rates into the 2020s may reflect ongoing publication of survey articles, retrospective analyses, or niche follow-on work rather than active primary research on new mesh architectures.

Among Tier 3 conferences, IEEE CCNC and LCN show comparable but lower trajectories, both peaking below 30% and declining to near zero by 2015–2018. ICNP, IFIP Networking, and NCA contribute marginal signal throughout.

5) Cross-Tier Synthesis: The annotated composite (Figure 2) contextualises the publication trajectory against key external events. We marked in blue the academic papers on routing algorithm, in purple the network community deployed in real life and in yellow the event linked with standardisation. The initial surge beginning around 1998–2000 coincides with the standardisation and widespread citation of early routing protocols (DSDV, DSR, AODV, OLSR), whose publication dates are marked in the lower panel. The secondary surge and broad peak around 2004–2008 aligns with the emergence of community mesh network deployments (Freifunk, AWMN, guifi.net, FunkFeuer, Ninux.org) [17]–[20] and the ratification of related standards. The subsequent decline precedes the maturation of BATMAN and the 802.11s amendment (ratified 2011) and the adoption of OLSRv2, suggesting that standardization and deployment consolidation redirected community attention rather than directly causing publication decline.

C. Academic activity vs. Deployed Implementations

The annotated composite in Figure 2 places the publication trajectory in relation to key external events, revealing a pattern of partial but imperfect coupling between academic output and deployment activity.

During the early time of ad hoc routing research, activity was primarily protocol-driven: theoretical and simulation work followed the availability of canonical protocol designs, creating a self-reinforcing citation economy around a small number of reference implementations.

The secondary surge and broad peak extending from approximately 2004 to 2008 coincides with the emergence of mesh community deployments, namely Freifunk, AWMN, guifi.net, FunkFeuer, and Ninux.org among them. This alignment is meaningful but should not be over-interpreted. The direction of causation is not established by the timeline alone: academic publication may have preceded and enabled deployment, or deployment may have generated empirical problems that drove academic attention, or both processes may have responded independently to common enabling factors.

The decline in publication activity after 2008–2010 is more difficult to reconcile with the deployment record. The BATMAN protocol gained significant community adoption from approximately 2006 onward; the IEEE 802.11s mesh amendment was ratified in 2011; OLSRv2 was standardised in 2014; and community networks such as guifi.net continued to expand well into the 2010s [21]. Academic output thus declined at precisely the point when deployed infrastructure reached its greatest maturity and operational complexity.

III. Conclusion

Publication activity in MANET routing research peaked in the early 2010s and has declined steadily since, a trend visible across the 17 conferences surveyed.

It is difficult, if not impossible, for practitioners to identify, from the current literature, clear trends and bounds associated with the use case of each routing algorithm. While the literature is rich in valuable proposals and often anticipates the requirements of future networks, comparing existing solutions remains challenging. In the absence of a common benchmarking framework, it is difficult to assess the relative merits of different routing algorithms and to identify the most promising approaches for a given deployment scenario.

Although the shared "feeling" among the community is widely identified, an in-depth retro-study on the reasons ad hoc networks failed to translate into real-world applications is yet to be pursued.

IV. Artifacts

All content necessary to reproduce the figures is made openly available [22]. Open source is the way.

References

[1] O. S. Oubbati, M. Atiquzzaman, P. Lorenz, M. H. Tareque, and M. S. Hossain, "Routing in flying ad hoc networks: Survey, constraints, and future challenge perspectives," *IEEE Access*, vol. 7, pp. 81 057–81 105, 2019.

[2] M. Abolhasan, T. Wysocki, and E. Dutkiewicz, "A review of routing protocols for mobile ad hoc networks," *Ad Hoc Networks*, vol. 2, no. 1, pp. 1–22, 2004.

[3] C. E. Perkins, E. M. Belding-Royer, and S. R. Das, "Ad hoc on-demand distance vector (AODV) routing," IETF, RFC 3561, Jul. 2003.

[4] E. M. Royer and C. E. Perkins, "Multicast operation of the ad-hoc on-demand distance vector routing protocol," in *Proceedings of the 5th Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom '99)*. Seattle, WA, USA: ACM, Aug. 1999, pp. 207–218.

[5] M. K. Marina and S. R. Das, "On-demand multipath distance vector routing in ad hoc networks," in *Proceedings of the Ninth International Conference on Network Protocols (ICNP 2001)*. IEEE, Nov. 2001, pp. 14–23.

[6] M. Guerrero-Zapata, "Secure ad hoc on-demand distance vector routing," *ACM SIGMOBILE Mobile Computing and Communications Review*, vol. 6, no. 3, pp. 106–107, Jul. 2002.

[7] C. E. Perkins, E. M. Belding-Royer, and S. R. Das, "Ad hoc on-demand distance vector (AODV6) routing for IPv6," IETF, Internet-Draft draft-perkins-manet-aodv6-01, Jan. 2003.

[8] T. K. Saini and S. C. Sharma, "Recent advancements, review analysis, and extensions of the AODV with the illustration of the applied concept," *Ad Hoc Networks*, vol. 103, p. 102148, Jun. 2020.

[9] S. Kurkowski, T. Camp, and M. Colagrosso, "MANET simulation studies: The incredibles," in *ACM SIGMOBILE Mobile Computing and Communications Review*, vol. 9, no. 4, 2005, pp. 50–61.

[10] K.-W. Chin, J. Judge, A. Williams, and R. Kermode, "Implementation experience with MANET routing protocols," in *ACM SIGCOMM Computer Communication Review*, vol. 32, no. 5, 2002, pp. 49–59.

[11] T. Clausen and P. Jacquet, "Optimized link state routing protocol (OLSR)," IETF, RFC 3626, Oct. 2003.

[12] A. Neumann, C. Aichele, M. Lindner, and S. Wunderlich, "Better approach to mobile adhoc networking (B.A.T.M.A.N.): An overview," in *Proceedings of the IETF 68 Meeting, MANET Working Group*, 2007.

[13] J. Chroboczek and D. Schinazi, "The babel routing protocol," IETF, RFC 8966, Jan. 2021.

[14] IEEE, "IEEE standard for information technology—telecommunications and information exchange between systems— local and metropolitan area networks— specific requirements—Part 11: Wireless LAN medium access control (MAC) and physical layer (PHY) specifications, amendment 10: Mesh networking," IEEE, IEEE Standard 802.11s-2011, 2011.

[15] Computing Research and Education Association of Australasia, "CORE 2023 conference ranking," https://portal.core.edu.au/conf-ranks/, 2023, accessed: 2025.

[16] "Ad Hoc networks," *Ad Hoc Networks*, elsevier journal, https://www.sciencedirect.com/journal/ad-hoc-networks.

[17] M. D. de Rosnay, F. Tréguer, P. Antoniadis, V. Aubrée, A. Burns, M. Michalis, J. Neumann, and R. R. I. Tió, "Telecommunications reclaimed: A hands-on guide to networking communities."

[18] L. Maccari, "On the technical and social structure of community networks," in *2016 IFIP Networking Conference (IFIP Networking) and Workshops*. Vienna, Austria: IEEE, 2016, p. 518–523. [Online]. Available: http://ieeexplore.ieee.org/document/7497253/

[19] B. Braem, J. Bergs, C. Blondia, L. Navarro, and S. Wittevrongel, "Analysis of end-user qoe in community networks," in *Proceedings of the 2015 Annual Symposium on Computing for Development*. London United Kingdom: ACM, 2015, p. 159–166. [Online]. Available: https://dl.acm.org/doi/10.1145/2830629.2830639

[20] L. Navarro, R. B. Vinas, C. Barz, J. Bonicioli, B. Braem, F. Freitag, and I. Vilata-i Balaguer, "Advances in wireless community networks with the community-lab testbed," *IEEE Communications Magazine*, vol. 54, no. 7, p. 20–27, 2016.

[21] R. Baig, R. Roca, F. Freitag, and L. Navarro, "guifi.net, a crowdsourced network infrastructure held in common," *Computer Networks*, vol. 90, pp. 150–165, 2015.

[22] H. A. Le Dirach, "Artefacts for "the simulator was perfect"," https://github.com/Petitnuagedk/artefacts-for$_{T}he-Simulator-was-perfect$, 2026.