INTERNET POLICY REVIEW
Journal on internet regulation

**Volume** 11 **Issue** 2

GLOSSARY ENTRY

OPEN ACCESS

PEER REVIEWED

# Ad hoc network

**Kelsie Nabben** *RMIT University* kelsie.nabben@rmit.edu.au
**Ellie Rennie** *RMIT University*

**DOI:** https://doi.org/10.14763/2022.2.1666

**Published:** 26 April 2022
**Received:** 15 September 2021 **Accepted:** 6 March 2022

**Competing Interests:** The author has declared that no competing interests exist that have influenced the text.


**Citation:** Nabben, K. & Rennie, E. (2022). Ad hoc network. *Internet Policy Review*, *11*(2). https://doi.org/10.14763/2022.2.1666

**Keywords:** Network design, Wifi, Blockchain, Decentralized Autonomous Organization (DAO), Ad hoc

**Abstract:** There is no one set definition for the phrase “ad hoc networks”. The term refers to the ability for members of a network to establish a network connection between devices. Ad hoc networks are relevant both in technical terms of certain network infrastructures, as well as in terms of the social, political and economic modes of self-organisation they enable. This requires people to combine software and hardware tools to set up peer-to-peer infrastructure that provides access to temporary information networks, as well as networking standards and policy frameworks. When long-standing, these can adapt to become local area networks. An example of an ad hoc network is a temporary cryptocurrency economy, such as a Decentralised Autonomous Organisation, which can connect people, information, and resources online and in person for a specific purpose.

This article belongs to the **Glossary of decentralised technosocial systems**, a special section of *Internet Policy Review*.

## Definition of the term

"Ad hoc" is Latin for "to this" meaning "for this" or "for this purpose". The term "ad hoc network" refers to the ability for members of a network to establish a network connection between devices. Yet, ad hoc networks are relevant both in technical terms, as well as in terms of the social, political and economic modes of self-organisation they enable. They also depend on technical standards, as well as regulatory and policy frameworks in most settings.

A network can be described as ad hoc when it is self-provided and not reliant on an installed base of pre-existing infrastructure, except where it connects to external services (such as internet gateways). Thus, the attribute of "ad hoc" in a network often pertains to decentralised networks that do not rely on a central point of control. Instead, the network is comprised of "peers" in a network and each peer operates as a "node" to forward packets of data to other nodes.

Ad hoc networks require people to combine software and hardware tools to set up peer-to-peer infrastructure to provide access to temporary communication networks. Today, smartphone applications can create ad hoc networks through native Bluetooth or WiFi capabilities. This enables new network architectures for access and coordination through digital infrastructure. When long-standing, these can adapt to become local area networks.

The combination of "ad hoc" networks with other technologies, such as blockchain, enables new social, economic, and political possibilities for self-organising. An example of an ad hoc network are temporary cryptocurrency economies which have proven adaptive and responsive for connecting people, information, and resources online, and in person, for time limited and specific purposes before disseminating. For example "Decentralised Autonomous Organisations" (DAOs), such as ConstitutionDAO, which collectively raised millions of dollars in an attempt to buy an original version of the U.S. Constitution, and UkraineDAO, which responded to raise millions of dollars in support of Ukrainian fighters in the conflict with Russia in a matter of days.

## Origin

Ad hoc networks would not have come about if it was not for a number of preceding developments in distributed communications networking research and development, unlicensed spectrum regulations, and open standards.

Distributed computing emerged in the 1960s as a potential solution for more resilient networks against the threat of military attack. While working for military research organisation RAND Corporation in the 1960s and 1970s, Paul Baran authored 13 seminal papers "On Distributed Communications" (RAND Corporation, n.d.). Baran is credited for inventing the idea of "distributed networks", that went on to inform some of the attributes of the internet and ad hoc networking (Yoo, 2018). Distributed networks require that all nodes be connected in a network by multiple links to make a system robust against physical attack. Through these ideas, "it is thus possible to visualise a new set of systems based upon a distributed organisation" (Baran, 1967, 21). The concepts of "packet switching" and "store and forward" data transfer were pioneered to make distributed networking possible. Baran proposed that data could be divided into individual packets termed "message blocks" that would travel independently through a network and be reassembled once they reach their destination (which later became known as "packet switching", as termed by other independent, simultaneous inventors) (Yoo, 2018). The other fundamental innovation for distributed networking that applies to ad hoc networks is that network data traffic operates on a store and forward routing algorithm to eliminate the vulnerability of a single centralised point of control being targeted by a foreign attack and causing a communications failure across an entire network (Baran, 1967; 1965).

From these origins, ad hoc architecture matters as both a technical architecture and political means for resilience and self-governance, rather than relying on existing infrastructure or third-party provision of infrastructure, as per the example of DAOs.

## Evolution

Ad hoc networks have evolved in terms of usability, security, availability, complexity, and purpose.

Baran's propositions were fundamental for the architecture of the modern-day internet, which was originally an internal network or "intranet" that only authorised parties could access to share information called the Advanced Research Projects

Agency Network (ARPANET) (Abbate, 1999). The concepts of "message blocks" and "store -and -forward" concepts laid the foundation for distributed networks to automatically select routes for multi-hop communication between any two nodes on the network. However, the principle of non-hierarchical distributed networking was not adopted in ARPANET, as the attribute of survivability of the network was not a priority (Abbate, 1999). This emission had consequences in the central points of control that manifested in modern day internet architecture, which peer-to-peer decentralised technologies such as public blockchain networks seek to address.

From the late 1960s, researchers at the University of Hawaii developed wireless networking innovations to allow them to send information across islands and to link to ARPANET. The ALOHAnet's random access techniques formed the basis of Wi-Fi and mobile networking (Abramson, 2009). By the 1970s, the packet radio network (PRNET) project was also underway under the sponsorship of the Defense Advanced Research Projects Agency (DARPA), which is a digital radio communications method that can be used in mobile communications.

The regulatory foundations for legal ad hoc networks was laid by the decision by the US Federal Communications Commission in 1985 to allow unlicensed use of radiofrequency spectrum. This meant that people could access radio frequencies within specific frequency bands, as opposed to co-opting the radiofrequency of others (known as "spectrum piracy"). The wording of the ruling to allow "spread spectrum and other wideband emissions" (FCC, 1984) enabled free market and amateur innovation, resulting in the development of Wi-Fi and other wireless technologies. Without this decision - later replicated in other parts of the world - people would not be legally allowed to establish self-provided wireless networks. Open standards for hardware and software were also an important factor behind the research and development that led to ad hoc networks (Lemstra et al., 2011). For instance, open standards for Wi-Fi technologies enables Wi-Fi router electronics manufacturers to support wireless spectrum networking.

The emergence of personal computing devices such as laptops, local area network (LAN) routers, and smartphones routers have given rise to what is often referred to as "mobile ad hoc networks" (MANETS), which may use Wi-Fi, cellular, Bluetooth or other radio frequency technologies to establish connections between devices. "Ad hoc", in this context, means instances of temporal, networked infrastructure where a central router is not required. In distributed computing, the phrase "ad hoc digital infrastructure" is sometimes used to describe some mobile communication network protocols (Murthy, et. al., 2004; Legendre, et al., 2011).

These dynamic and adaptive networks enable a number of applications where existing infrastructure or a central node is not available, cannot be relied upon, or where scalability is an issue. They may also be used to alleviate digital exclusion by enabling users to share connectivity.

## Applications for ad hoc networks

There are a wide variety of applications of ad hoc networks, some of which are described in the section that follows.

### Military

Military or tactical MANETs are used by military units with emphasis on data rate, real-time requirement, fast rerouting during mobility, data security, radio range, and integration with existing systems (Toh, 2002). Military ad hoc networks offer rapid deployment, infrastructureless, no contact with fixed radio towers, robustness, security, and instant operation. Tactical networks can be formed during a mission and then disappear when the mission is over via mobile, Air Force Unmanned Aerial Vehicle (UAV), Navy ship, or robot.

### Humanitarian

Wireless, ad hoc networks provide communications connectivity in disaster scenarios in circumstances whereby existing infrastructure ceases to function effectively (such as earthquake, flood, storm, or fire), or in remote areas (Leiser et al., 2017). For example, a network run by the Red Hook Initiative, a public housing youth organisation in Brooklyn NY, continued to serve as a communications platform for residents during Hurricane Sandy when mobile telephony and internet services were down (Finlay, 2018).

### Community wireless mesh networks

A mesh network topology refers to a rich interconnection between nodes or devices, whereby each node in the network relays data to other nodes, forming a non-hierarchical network. The resilience of the network increases as more nodes are added, thus reducing dependency on any one connection. In some locales, communities have established community owned wireless mesh networks for internet connectivity, including NYC mesh, Toronto mesh, Freifunk, and GUIFI (NYC Mesh, n.d.; Toronto Mesh, n.d; Freifunk, n.d.; APCNews, 2018). Only one node needs to be connected to the internet for all to be able to access the internet as each node is able to relay data to any other node in the network. Mesh networks organi-

cally adapt as people join or leave, and are dynamic, meaning they automatically reconfigure to guarantee connectivity (Navarro et al., 2018). These networks can be considered "ad hoc" insofar as people can come and go from the network, in definitional terms could transition from being an ad hoc network to a local area network, as hardware and network connection become more fixed, rather than dynamic.

### Blockchain-based ad hoc networks

Blockchains and cryptocurrencies are being used as ad hoc information networks for social coordination. These economic infrastructures are a means for people to transact (transfer value) in a "peer-to-peer" fashion without requiring a third-party service or central intermediary, such as a bank (Nakamoto, 2008, 1). Some scholars have proposed that temporary blockchain networks are a type of "pop up economy" (Rennie, 2019). The organisational framework of "Decentralised Autonomous Organisations" (DAOs) also demonstrates ad hoc, blockchain-based coordination.

One such instance of a "pop-up economy" was the not-for-profit Oxfam's use of the cryptocurrency stablecoin Dai for emergency cash transfers in Vanuatu (Rust, 2019). Oxfam's goal was to trial cash-based aid that could support local economies during disaster relief efforts. Oxfam and their technology partners worked with local vendors to received payments via "Near Field Communication" (NFC) cards that had been distributed to local residents.

Decentralised Autonomous Organisations (DAO), are also a kind of community that can form around a specific objective via network technologies to form an ad hoc network. For example, "Friends with Benefits" is an international social interest DAO that communicates online in a group chat but also holds pop up "in real life" parties and events (Ryce, 2021). "ConstitutionDAO" was a group of people that collectively pooled funds in a failed attempt to purchase an original copy of the United States Constitution (Brown, 2021). A number of funding DAOs have also formed as temporary funding organisations to pool resources and support a common cause, such as in response to the crisis in Ukraine and to subsidise the legal fees to free internet activist Julian Assange (Gottsengen, 2022). DAOs have enabled the rapid, ad hoc mobilisation and direction of resources in a decentralised manner, without relying on a central authority for response coordination.

## Coexisting uses and meanings

Within the discipline of computer science, ad hoc refers to "the capability that

members of a network have to build routing information and forward data units from one location to another in the network" (Barbeau and Kranakis, 2007, 63).

In computer networking, an ad hoc network is a self-configured wireless network that allows each wireless node to dynamically forward and receive data. Devices can connect "on the fly" to create a network and share data without certain pre-existing infrastructure, such as a network router. The devices themselves act as the network equipment, creating a network between them.

Ad hoc networks are often referred to as "on the fly", temporary networks (Feeney et al., 2001). Yet, this is not entirely accurate as establishing and maintaining a network can require significant planning and expertise. The maintenance requirements of ad hoc networks demonstrates what Susan Leigh Star referred to as the mundane nature of infrastructure (1999).

Ad hoc infrastructure and ad hoc networks matter because they create opportunities for civic self-organisation. Modular, ad hoc, distributed, cryptographically secure networks are being erected, maintained and dismantled by groups to serve specific ideological purposes and needs, such as censorship resistance (although it should not be assumed that all ad hoc networks are censorship resistant, temporality and encryption can be some avenues for groups to pursue this attribute against perceived threats). . These adaptive, temporary, technology-enabled economies politically and socially challenge the ideological underpinnings of existing institutions through independence, obfuscation, and subversion (Poblet, 2018). An example of the repurposing of ad hoc networking infrastructure for political purposes is the use of the music festival connectivity mobile application "Bridgefy" in Myanmar, when the internet was throttled to censor information during protests (Potkin and Pang, 2021).

## Issues currently associated with the term

There are some issues associated with the concept of "ad hoc" networking. This includes the dependencies between hardware, software, and policy and standards frameworks, network maintenance, and digital inclusion which are addressed below.

The use of ad hoc networks for tethering devices is now commonplace. While this on the fly user practice seems straightforward, ad hoc technologies are better conceived as a suite of nested infrastructures, including specific hardware and software requirements combined with policy frameworks and standards. When some

of these components are missing or broken, ad hoc networks may be rendered untenable or unsafe in particular contexts.

Mesh networks in particular have been championed as an alternative to commercially provided internet and telephony services in areas where affordability is a barrier to connectivity. Yet, ad hoc networks can be cumbersome to establish and maintain in terms of expertise and resources,as well as broader context expectations and limitations of ad hoc networks as a technical or socio-political solution. Such networks require a significant amount of skills and labour to establish and maintain - resources that are more likely to be present in affluent areas (Powell, 2008). Where mesh networks are used to provide internet services they are also dependent on backhaul service providers, which typically require a contract or agreement with a commercial company or municipal government. Regulatory conditions may impede ad hoc networks by making users liable for the activities of others on the network or requiring the retention of metadata for policing (Giovanella, 2016). Some ad hoc networks can also not be fit-for-purpose for the applications that people adopt. For example, during the Occupy Wall st protests, spontaneous ad hoc networks were not sufficient to provide continuous service (Baccelli, 2012). In disaster scenarios, resilience is largely attributed to community capacity to prepare, respond, and recover, as well as the capabilities afforded by communications infrastructure (Norris et al., 2008).

In some respects, ad hoc networks can create opportunities for digital inclusion. For example, ad hoc networks can allow multiple people to share one internet connection in remote or rural areas, provide free or cheaper access, or extend connectivity to areas previously beyond range, depending on the devices and geography of the network. On the other hand, ad hoc networks also possess elements of digital exclusion. For example, establishing and maintaining a network can require access to specific hardware or a pre-existing infrastructure, such as a mobile network, satellite, or router. Participation can also require a certain level of digital literacy. In some cases, such as the political examples mentioned above, exclusion of unwanted participants could be considered a feature, not an issue.

## Conclusion

At its most basic definition, the term “ad hoc network” refers to the ability for members of a network to establish a network connection between devices. Yet, this capability is representative of a broader socio technical phenomenon, as ad hoc networks are enablers of social organisation and innovation. Ad hoc networks require communities of people to combine software and hardware tools, as well as

standards, and regulatory and policy frameworks.

In this piece, we have explored the origins and history of developments in "ad hoc networks", demonstrated the co-existing uses and meaning of the term "ad hoc" across the disciplines of computer science and the social sciences, and then related this to examples of current technological developments and applications. We then explored co-existing meanings and uses, as well as issues and limitations of access, maintenance, and inclusion and exclusion. Finally, we demonstrated some ways in which the combination of "ad hoc" networks with other technologies enable new social, economic, and political possibilities for self-organising, such as communications during protests, pop-up economies, and DAOs.

This brief history and context of ad hoc networks has outlined the technical requirements, as well as the communities, standards, and socio-political needs and purposes of ad hoc networks. This shows how the development of technology networks are embedded in socio-political dynamics in the ways that people use technology and media for technological innovation.

---

## References

Abbate, J. (1999). *Inventing the Internet*. MIT Press.

Abramson, N. (2009). The AlohaNet: Surfing the wireless data. *IEEE Communications Magazine*, *47*(12), 21–25. https://doi.org/10.1109/MCOM.2009.5350363

APCNews. (2018, March 12). *Guifi.net: Accessible and affordable 5G network architecture*. Association for Progressive Communications. https://www.apc.org/en/news/guifinet-accessible-and-affordable-5g-network-architecture.

Baccelli, E. (2012). *IP-disruptive wireless networking: Integration in the Internet*. Université Pierre et Marie Curie. https://tel.archives-ouvertes.fr/tel-00770791

Baran, P. (1965). *A briefing on the distributed adaptive message-block network*. RAND Corporation. https://www.rand.org/pubs/papers/P3127.html

Baran, P. (1967). *Some remarks on digital distributed communications networks*. RAND Corporation. https://www.rand.org/pubs/papers/P3536.html

Baraniuk, C. (2014, June 14). FireChat warns Iraqis that messaging app won't protect privacy. *WIRED*. https://web.archive.org/web/20150917061844/http://www.wired.co.uk/news/archive/2014-06/25/firechat

Barbeau, M., & Kranakis, E. (2007). *Principles of ad-hoc networking*. John Wiley & Sons.

Brown, A. (2021). *Crypto investors lose out in $43.2 million sale of rare copy of U.S.* Forbes. https://www.forbes.com/sites/abrambrown/2021/11/18/constitution-dao-crypto-ether-constitutional-sotheby

s-sale-auction/?sh=54efaeb66ad4.

FCC. (1984). Further Notice of Inquiry and Notice of Proposed Rule Making adopted regarding authorization of spread spectrum and other wideband emissions not presently provided for in FCC Rules and Regulations Notice of Proposed Rulemaking. General Docket #: FCC-81–413. In *Federal Communications Commission Reports: Advance Reports* (pp. 380–401). Federal Communications Commission.

Fenney, L. M., Ahlgren, B., & Westerlund, A. (2001). Spontaneous networking: An application oriented approach to ad-hoc networking. *IEEE Communications*. https://doi.org/10.1109/35.925687

Finlay, A. (2018). Cutting a line of sight for community connectivity. In A.P.C.-I.D.R.C. (Ed.), *Global Information Society Watch 2018: Community Networks* (pp. 59–63). https://www.apc.org/sites/default/files/2018_community_networks.pdf

Freifunk. (XXXX). *What is Freifunk about? How to join us?* Freifunk. https://freifunk.net/en/

Giovanella, F. (2016). Community networks: Legal issues, possible solutions and a way forward in the European Context. In L. Belli (Ed.), *Community connectivity: Building the Internet from scratch: Annual report of the UN IGF Dynamic Coalition on Community Connectivity* (pp. 111–122). FGV Direito Rio. http://hdl.handle.net/10438/17528

Gottsengen, W. (2022). *New DAO Raises $3M in ETH for Ukrainian Army*. CoinDesk. https://www.coindesk.com/tech/2022/02/27/new-dao-raises-3-million-in-eth-for-ukrainian-army/.

Legendre, F., Hossmann, T., Sutton, F., & Plattner, B. (2011). 30 years of wireless Ad Hoc networking research: What about humanitarian and disaster relief solutions? What are we still missing? *Proceedings of the 1st International Conference on Wireless Technologies for Humanitarian Relief (ACWR'11*, 217–217. https://doi.org/10.1145/2185216.2185279

Lemstra, W., Hayes, V., & Groenewegen, J. (Eds.). (2011). *The innovation journey of Wi-Fi: The road to global success*. Cambridge University Press.

Lieser, P., Alvarez, F., Gardner-Stephen, P., Hollick, M., & Boehnstedt, D. (2017). Architecture for responsive emergency communications networks. *2017 IEEE Global Humanitarian Technology Conference (GHTC)*, 1–9. https://doi.org/10.1109/GHTC.2017.8239239

Murthy, C. S. R., & Manoj, B. S. (2004). *Ad Hoc Wireless Networks: Architectures and Protocols*. Prentice Hall/PTR.

Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System*. https://bitcoin.org/bitcoin.pdf.

Navarro, L., Maccari, L., & Lo Cigno, R. (2018). At the limits of the network: Technology options for community. In A.P.C.-I.D.R.C. (Ed.), *Global Information Society Watch 2018: Community Networks* (pp. 13–20). https://www.apc.org/sites/default/files/2018_community_networks.pdf

Norris, F. H., Stevens, S. P., Pfefferbaum, B., Wyche, K. F., & Pfefferbaum, R. L. (2008). Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. *American Journal of Community Psychology*, *41*(1–2), 127–150. https://doi.org/10.1007/s10464-007-9156-6

NYC Mesh. (XXXX). *Join our community network!* https://www.nycmesh.net/

Poblet, M. (2018). Distributed, privacy-enhancing technologies in the 2017 Catalan referendum on independence: New tactics and models of participatory democracy. *First Monday*. https://doi.org/1583508256

Potkin, F., & Pang, J. (2021). *Offline message app downloaded over million times after Myanmar coup*. Reuters. https://www.reuters.com/article/us-myanmar-politics-bridgefy-idUSKBN2A22H0.

Powell, A. (2008). WiFi publics: Producing community and technology. *Information, Communication & Society*, *11*(8), 1068–1088. https://doi.org/10.1080/13691180802258746

RAND Corporation. (XXXX). *Paul Baran* [RAND Corporation]. https://www.rand.org/pubs/authors/b/baran_paul.html

Rennie, E. (2019). One night in the blockchain economy [Medium]. *Altcoin Magazine*. https://medium.com/the-capital/one-night-in-the-blockchain-economy-d6eeea1d2cdf.

Rust, B. (2019). *Unblocked cash: Piloting accelerated cash transfers in Vanuatu* [Report]. Oxfam Australia. https://policy-practice.oxfam.org/resources/unblocked-cash-piloting-accelerated-cash-transfer-delivery-in-vanuatu-620926/.

Ryce, A. (2021). Decentralized autonomous organizations and the promise of utopia. *RA Magazine*. https://ra.co/features/3914.

Star, S. L. (1999). The ethnography of infrastructure. *American Behavioral Scientist*, *43*(3), 377–391. https://doi.org/10.1177/00027649921955326

Toh, C. K., Lee, E. C., & Ramos, N. A. (2004). Next-generation tactical ad hoc mobile wireless networks. *Technology Review Journal*, *125*($B).

Toronto Mesh. (XXXX). *Toronto Mesh*. https://tomesh.net/

Yoo, C. S. (2018). Paul Baran, network theory, and the past, present, and future of the Internet. *Colorado Technology Law Journal*, *17*(1), 161–186.

Published by

Alexander von Humboldt Institute for Internet and Society

in cooperation with

CREATe

cnrs centre internet et societe

R&I IN3 Internet interdisciplinary Institute Universitat Oberta de Catalunya

University of Tartu Johan Skytte Institute of Political Studies