Ad-hoc Computer Network Negotiation

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Ad-hoc computer network negotiation is an emerging technology that holds significant promise for facilitating access to information and communication services in rural areas, during natural disasters, in war zones, and in other situations where traditional centralized Internet connectivity is limited or unavailable. The premise of the technology is to find ways to allow electronic equipment to communicate and establish connections to one another without depending on a central authority or centrally maintained resources such as an Internet service provider, commercially operated cables, or a name authority service.

Research into ad-hoc computer network negotiation is ongoing, and implementing this widely, effectively, and practically is a difficult problem. In an ad-hoc computer network, individuals' privately owned, portable equipment could perform all the necessary routing to establish a connection to any other node of the network.

There are several pieces that must come together to effect such a technology.

Consensus upon a standardized protocol for wirelessly establishing a decentralized network has not yet been fully established. Getting this consensus is largely a social and usage-dependent problem (the "network effect" creates something of a chicken-and-egg problem hindering the establishment of this). On the other hand, communication protocols to enable networking is a solved problem: the protocols which underlie Internet communication, UDP, TCP, and IP, are distributed already, which is what allows intranets and other independent, non-Internet-connected networks to communicate in an Internet-like fashion. The protocols are the same, but the independent networks are not connected to the specific instances of centralized trust systems that are a defining part of the Internet.

Because fully distributed systems are inherently somewhat limited in their capabilities, due to the lack of a common trust system, this is not a technology that would entirely decentralize the Internet.

Rather, it would provide a means for the system to continue operating in the event of losses of centralized service, and it would simplify replacing those few services which by nature must be centralized if an independent, separate network chose to implement them (a distributed centralization, in a sense, as it enables the centralized parts to be forked or replaced and to have their roles filled by equivalent but separate instances).

One missing part of the technology is integrated relays for connectivity: if one piece of equipment can see another, and that one can in turn connect to the public Internet, there is no standardized protocol to enable the latter to route traffic on behalf of the former, and most common equipment does not provide the hardware necessary for such a facility. A protocol with a similar purpose has been implemented by ZigBee-brand communication hardware, which provides communication facilities for Internet of Things equipment, but it has a different purpose; even so it demonstrates the feasibility of the concept.

The ability to locate and establish a connection to a specific network node given only its name and a connection to other nodes in the network, without centralization being needed, is demonstrated by distributed hash trackers (DHT). DHT is a system using which, given a network connection, can return — given the cryptographic hash of desired information — the address of a computer containing the information corresponding to that hash, without any centralized authority. Similarly, an experimental system called Namecoin attempts to implement a decentralized alternative to the Internet's Domain Name System using a similar technique.

As with the Internet, verification of the identity of the connection thereby established can be accomplished using public-key cryptography, given an existing centralized public key infrastructure (PKI). The PKI is one of the aspects of the Internet that cannot be effectively decentralized, due to the challenge of knowing whether a public key belongs to the network node it is purported to without any source of trusted information transfer from which to bootstrap trust of the given node.

These other implementations show that many of the hard problems that obstruct and have historically prevented developing ad-hoc computer network negotiation have already been partially or fully solved by other technologies. This indicates that effective development and adoption of this technology is possible.

The primary challenge remaining is not technical, but socioeconomic: an existing base of electronic equipment using a common protocol for distributed network routing is needed for any one piece of equipment with this capability to show substantial benefit to its owner, and individuals are unlikely to invest in the additional cost of the equipment necessary for this capability without knowing that they will be able to use it. This chicken-and-egg problem can be solved, however, in several means.

The most likely solution is that one or more large equipment manufacturers will see the potential benefit of the technology and implement it in their products despite the additional cost. If it is provided and made available with new equipment when it is purchased, its benefits would be felt at least in part by consumers, driving other manufacturers to adopt it. Another possible solution for this issue is that governments, businesses, nonprofits, or other organizations will develop and produce equipment implementing this technology and use it for their work, and that this would provide the seed needed for its adoption.

In any regard, this technology has huge potential benefits, because of the access to information it can provide: this facilitates, makes more effective, and democratizes access to emergency response and safety, business work in areas without established infrastructure, personal access to education and communication technologies, military operations, and the many other benefits afforded by access to the Internet.

Bibliography:

AlBlue. “Git Tip of the Week: Objects and Packfiles”. http://alblue.bandlem.com/2011/09/git-tip-of-week-objects-and-packfiles.html

Git manual, section 10.4: “Git Internals - Packfiles”

Kahle, Brewster. “Locking the Web Open: A Call for a Distributed Web”. http://brewster.kahle.org/2015/08/11/locking-the-web-open-a-call-for-a-distributed-web-2/

Kahle, Brewster. “Content Addressing is Magic”. http://brewster.kahle.org/2016/12/18/content-addressing-is-magic/

Singh, Simon. *The Code Book*.

Wikipedia. “Mobile ad hoc network”; “Mesh network”; “Network topology”; “Wireless ad hoc network”