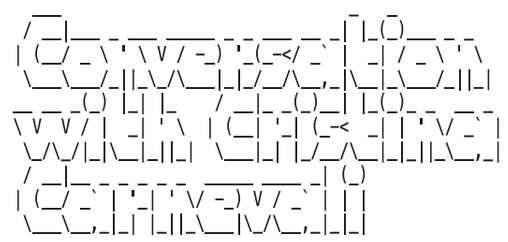


Conversation with Cristina Carnevali

The Mutable Net



8 October 2025 *Translated form Italian by the Author*

In the case of the autonomous network of the Appennino Bolognese, near Bologna, the relationship between a malleable and distributed topology of an infrastructure and the outcoming social organisation that emerges from it is very evident.
Founded in 2017 with the practical goal of connecting the Bolognese Apennines to the Internet, the network is a particularly significant example. Presented by Ignifugo and by residents of the municipality of Valsamoggia, it proposes new ways of understanding connection. Therefore, in the following section, a conversation with one of the technical developers of the network that took place on October 8th, 2025, Cristina Carnevali.

LM:
Could you tell me how the community network project in Valsamoggia began?

CC:
We started building the network in 2017 in Valsamoggia, although I now live in Val di Croara, which is a nearby valley. That's where I'm speaking from right now. And we're having this conversation through a community network: my connection actually goes through antennas installed on rooftops, which I mounted together with other people from the valley.

As for my background: I studied literature, then I ended up doing something different... I've always been interested in Hackmeeting, the annual Italian gathering dedicated to new technologies. And I've been a Linux[01] user more or less since I first had a computer.

Regarding the network: already in 2016 I had attended a Ninux Day[02] in Florence, and I already knew that techniques existed for building point-to-point and mesh networks — networks that account for the instability of nodes and use protocols capable of autonomously recalculating routing paths. These two aspects are, in themselves, technically fascinating.

In practice, I work as an IT technician for Campi Aperti, an association of farmers in Bologna. Many of them live in the surrounding areas, and in Valsamoggia — where I moved — there were about forty farms scattered across the valley. I lived near one of these farms and, while talking with neighbours, we found out that we were in one of the many "dark zones" of connectivity: with very poor GSM coverage and almost no wired telephone service.

LM:
How far does the network extend today? And what technical and organisational choices have you made?

CC:
At the moment, we have four "little islands", meaning four separate networks, two of which are in the same valley. So there is a self-built network in Valsamoggia, in Val di Venola, in Val di Marano, and in Val di Croara. Each valley manages both the devices and the economic aspects autonomously. Some parts are a bit harder to explain to people without technical training, so a few of us handle them: there are three of us, and we coordinate via a mailing list.

We chose to use exclusively free software — Ninux[03] also moves in this direction. In particular, we adopted LibreMesh[04], a Linux distribution for routers based on OpenWrt. The difference is that OpenWrt[05] is multipurpose, whereas LibreMesh already provides a ready-made configuration for mesh networks.

This technical choice led another person involved in the project to start actively contributing to software development and to the community that maintains it. It also shaped how we coordinate internationally to follow its evolution.

In total, there are 9 antennas in Croara; about 6 in Valsamoggia; 3 in Val di Marano; and 6–7 in Val di Venola.

The antennae are basically routers roughly the size of a pencil case: small, low-power devices (12 watts, 24 volts, half an amp) that operate at 5 GHz with low transmission power, around 12 dBm. Over the years, we've changed various models: we mostly use Ubiquiti, TP-Link and Mikrotik; three manufacturers that allow relatively easy replacement of the original firmware with Linux by installing OpenWrt with the special LibreMesh configuration. It's not always simple. On some models, you can just access the web interface and upload the firmware, but on many others, you have to use TFTP — a low-level transfer protocol that moves bits without interpreting data. In those cases, you need to put the antenna into a specific mode: each device has its own reset and power-on combination for entering recovery, then TFTP mode, and from there you upload the firmware from your PC through a Linux terminal. If you make a mistake, you risk bricking the device.

LM:
How does your network compare to other alternative community infrastructures?

CC:
We're a fairly typical network in the sense that many similar communities exist around the world. For instance, in Germany, there's Freifunk, which is huge, and there's Guifi.net as well. Some of these networks were created to provide internal services to cities where there is no digital divide at all: fibre already reaches homes, but people still choose to access a second, bottom-up network.

In France, instead, there's the FFDN, the federation of alternative French networks: a network of associative ISPs — Internet service providers run by associations and citizens, explicitly aiming to protect the right to connectivity.

In our case, in the Apennines, the digital divide was clearly a driving force: the fact of not being connected, of genuinely needing an internet connection. Another favourable element was the presence of an already consolidated community linked to organic and agroecological farming: people who knew each other, were used to organising collectively, and helped new members join thanks to word-of-mouth.

01 » *Linux* is an open-source operating system kernel that forms the basis of numerous operating systems, often referred to as Linux distributions. Since its inception in 1991 by Linus Torvalds, Linux has grown to become a cornerstone in the world of computing, powering everything from supercomputers and servers to smartphones and embedded systems.
02 » *Ninux day* is an italian-based event for Wireless Networks and it is orgainzed around the facilitation of exchanges between communities' memebers. These occasion are known ti the mesh netwotk scene to foster a sense of collectivity between the node's creators, advancing the idea of an infrastructural collective good. Association for Progressive Communications (APC), *Global Information Society Watch 2018: Community Networks* (Johannesburg: APC, 2018) 162-165

03 » Ninux.org is an Italian wireless community network: a free, open and experimental computer network. The basic idea is that users build their own network without centralized control or single ownership, as opposed to traditional ISPs where a single entity owns and manages everything.
04 » LibreMesh is a modular framework for creating OpenWrt-based firmwares for wireless mesh nodes. Think of it as a layer built on top of OpenWrt, specifically designed for the needs of community networks rather than individual home routers. The firmware allows simple deployment of auto-configurable, yet versatile, multi-radio mesh networks.
05 » OpenWrt is a Linux-based customizable operating system for embedded devices. Instead of being a static firmware, it's a flexible Linux distribution that allows applications to be added or removed through a package management system without having to rebuild the entire firmware.

LM:
In my research, I've read about the Ninux project. Why do you think it's less active now? And what makes the Apennine network more long-lasting?

CC:
There are many active people in the Ninux mailing lists— those who organised Ninux Day and so on. These are people who work in networking or who deal with it as a hobby, academically, or professionally. There's a lot of expertise there, but it's still a community of technicians. To have a presence on the territory, you need different types of intersections with communities interested in the services you can offer. That's the case, for example, with Freifunk in Germany, which has grown a lot thanks to service-sharing.

For us, what worked was primarily the concrete need for internet: sharing a connection. Even if there's a political message behind all this, it's hard for people to grasp the technical aspect of free software. What they easily understand, however, is the political value of having an infrastructure that belongs to the people.

LM:
What are the most meaningful aspects of building and maintaining a commu-

CC:
The most beautiful moments, the ones that really cheer you up, are when you go to people's houses, agree on how to install the antenna on their roof, and so on. As the network grows, the fun also lies in doing maintenance and keeping in touch with the people involved. Because a network means interdependence, and sometimes it's not that simple to accept that you are interdependent on your neighbour.

LM:
Does your network provide local services?

CC:
We have some internal services, although it's always difficult to explain them to less technical people. For example, it's hard to make people understand that within the network, the speed is much higher than towards the outside. Our antennas have symmetrical 150 Mb bandwidth, while the connection to the internet reaches about 30 Mb download and 10 Mb upload. Internal services, therefore, are much faster.

Over time, we tried various things: the four services that really work are listed on antennine.org, though some are only accessible from inside.

The first is Nextcloud: we have a shared cloud, a drive, not used very much, but still important because we technicians — distributed across multiple islands — can access (via VPN) a server, which is basically just a computer left on, located in one of the islands. There, we keep firmware and documentation on how the network is built.

The second is the VPN: we pay annually for a small server to have a fixed IP, and then we install WireGuard. The routers, the antennas route some internal addresses through this network.

The third internal functionality is PeerTube. Initially, we kept some videos on Nextcloud, but it was inconvenient; some files weren't viewable directly from the browser. Since video-sharing is important for us, we installed PeerTube. One of our long-term "dreams" is to have real streaming. PeerTube also performs peercasting, meaning peer-to-peer video distribution: in theory, you wouldn't need to fetch the content from the server, but from the nearest node. For now, we use it only as a video repository. It's a good example of software that becomes particularly interesting when run on a mesh network, because it enables peering.

LM:
Concerning the choice of software: how did you figure out which tools were compatible with your network's needs?

CC:
We had to do some studying. We gathered information online on which devices supported OpenWrt, keeping in mind that we would then need to install LibreMesh on top of it. On the OpenWrt forum and wiki, there are pages where users describe which models they have "liberated" by installing free software; thanks to this documentation, you can understand which antennas are usable. The other person working on the technical side of the network has a real passion for second-hand routers, which you can often find at flea markets, but you often end up having to perform complicated operations to install OpenWrt on them.

The suggestion for someone starting today would be to choose models that the OpenWrt wiki clearly labels as easy to install—so you can do everything directly from the browser. You take the device, connect to it, and its configuration page opens, and from there you can upgrade the firmware.

LM:
I'm very interested in the reuse of "old" technologies. You mentioned reusing discarded routers: what role do they play in the network?

CC:
The rooftop antennas create the point-to-point links, so they form the main infrastructure. From the roof antenna, a cable goes to the power injector, next to which there's an Ethernet socket: that's where you connect a router that acts as a signal repeater. In some cases, we manage to flash these routers as well with OpenWrt and thus with LibreMesh, so they extend the mesh network via Wi-Fi.

In practice, on the roof, you have the antenna "looking at" another antenna from which you receive the internet connection. The cable arrives inside the house, plugs into the power injector, and from there, you connect your router via LAN. If that router has LibreMesh, it will repeat the signal via Wi-Fi. At that point, you can add a second LibreMesh-enabled router anywhere in the house, as long as it can see the first one via Wi-Fi. The second one will also repeat the signal and provide connectivity. Naturally, the indoor network extends only if all routers are flashed with LibreMesh.

In some cases, we manage to install LibreMesh on older routers, but not always. When it's not possible, we configure them as what's known online as "dumb APs": devices that simply pass traffic without assigning IP addresses. IPs are assigned by the last LibreMesh device to which the dumb AP is connected, while the dumb AP simply acts as a wireless access point for the antenna or LibreMesh router.

The point is: if the routers have LibreMesh, you can keep extending the mesh even indoors — not only with kilometre-long links, but also within houses. When you insert an access point configured to "do nothing", it no longer repeats the mesh.

To make terminology clearer, we started giving insect names to LibreMesh devices and plant names to those acting only as dumb APs. At one point, it had become complicated for people to describe problems; naming devices helps people remember which object they're talking about.

LM:
How long did it take to create the first functional network?

CC:
One afternoon, we built the first connection, and it worked immediately. A network always begins with two points: you need two endpoints. So we created this 7-kilometre link, and by the end of the afternoon, it was operational. Initially, on one side, the antenna was fixed to a gutter, and on the other, it was positioned in a way that allowed communication with the first point. Later, we had to do some maintenance, repositioning the first antenna on a chimney and building a dedicated support, because the chimney's shape caused the antenna to tilt slightly, and the alignment wasn't optimal.

Over time, we also learned some technical notions, like the Fresnel zone: when you make a point-to-point link, you shouldn't imagine it as a laser beam but as a "cigar", with a thicker central portion. This is why it's important to mount the antennas as high as possible: the longer the distance, the wider the Fresnel zone becomes in the middle, and if there are trees or houses in between, they can cause interference. Installing the first two points was easy; then we gradually added more.

LM:
From a legal standpoint, what does it mean to create an autonomous network? Have you ever encountered opposition? How does it work with ISPs?

CC:
Legal issues depend heavily on your ambitions, and for the most part, we've discussed them internally. Some gateways, meaning points from which internet connection is distributed, have contracts with ISPs that technically don't allow redistributing the line. But this doesn't mean committing a crime; it simply means violating a commercial contract with the provider. That's why we inform each other when choosing ISPs, or accept the risk that a company might contest it and terminate the contract.

For example, the ISP chosen in Molinella had no clause against sharing the connection. Regarding the radio aspect, the 5 GHz band is open at low power and can be used by hobbyists or for civilian purposes. Electromagnetic regulation is quite precise: some activities require an amateur radio licence, others are free. Think of how common 5 GHz connections are for surveillance cameras.

Then it all depends on how ambitious you want to be. Some of the more challenging legal issues concern the fact that we already provide connections to around fifty people, with four gateways: we pay for four different internet subscriptions that we redistribute. It would be interesting to become an actual Internet Service Provider—register our infrastructure with AGCOM, become an Autonomous System, and get our own assigned IP addresses. It's not unusual: even a company with an in-house server can do it.

The problem comes in the next step: to be an ISP, you need a legal status, a registration in the national registry, whose costs we don't fully know; then you need an access point to the backbone, an Internet Exchange (IX). Given the way the Italian network is politically and commercially structured, this is not simple: the main IXs are in Milan, Rome, Turin, andNaples. In France, the experience is different: there are about twenty associative ISPs that benefit from the fact that the state allows renting infrastructure up to the user's delivery point, not just up to the IX. This makes things much easier.

If we decided to become an ISP, we could theoretically rent space inside an Internet Exchange in Bologna, connect our router to an Ethernet port, and even have access to a rooftop where we could install an antenna. The problem is then bringing our infrastructure all the way to users. This naturally favours companies that dig trenches and lay fibre—that's their job. A group of organised citizens cannot easily afford to lay cables.

We're thinking about it, though: if we reached around a hundred users, we might be able to afford the costs for this next piece of infrastructure and make everything economically sustainable. The minimum threshold is around a hundred people—that's not small. In France, instead, the FFDN indicates about 25 users as the minimum, which changes the feasibility entirely.

LM:
Regarding the management of the islands, is it absolutely impossible to connect even just two of them?

CC:
Surprisingly, we identified a point that could connect four out of five islands. The issue is that no one lives there. Maybe one day we'll have the motivation, the need or the collective desire to do it: if we decided to take the connection from a single point, linking all the islands would be very advantageous. In that case, we could make an extra effort to install an antenna in a place without residents, or ask someone outside the network for permission to install one on their roof. It's something that requires study: technically, it's exciting, but unless the community sees it as meaningful, we won't do it. For now, we've only checked on the map that it's possible—and even that was not obvious.

LM:
And what's special about this point? Why could it connect all the valleys?

CC:
It's a ridge from which all four valleys branch out—you can see them all from there.

LM:
Are people in the community able to reach some level of technical autonomy, or do they always depend on the more experienced members?

CC:
Ideally, people will install the antennas by themselves: in many cases, they've learned to do it autonomously. In others, it's understandable that they're afraid to climb onto their roofs, so the technical team steps in.

LM:
How do you determine the best points to create a connection?

CC:
We're always constrained by private property, by people's homes. The ideal situation is when a resident says: "Of course I can see that neighbour's house..."—the classic thing in mountain or countryside areas, where people know exactly which neighbours' houses are visible. People generally have a good sense of which buildings they can see. In some cases, we also used a proprietary online tool, Ubiquiti's AirLink: a map that simulates antenna placement and, by combining elevation data, shows where mountains or obstacles might block the signal.

LM:
Concerning the technical team: no one had prior experience in networking, right?

CC:
For the first node, some people from Bologna, from Ninux, came to help... So yes, at the beginning there were some IT specialists. I actually work as a software developer now: I've been doing this for about 13–15 years. But IT has many specialisations, and networking is a very specific field; being an IT person doesn't automatically mean knowing how to manage a network.

LM:
Have you maintained contact with the Ninux network? Or does the Apennine network remain more separate from other initiatives?

CC:
The technical people are still in touch with Ninux: we're on the mailing lists, and the technical community remains active. There are international connections too, particularly with the Battlemesh community (battlemesh.org), which organises an annual meeting dedicated to testing mesh protocols. So now and then we meet again.