GreenSoft

Software suite to create an Internet of Edge on customer hardware

The **Internet of Edges (IoE)** is a disruptive digital infrastructure created by a network of interconnected edge devices that share resources to deliver high-performing, locally hosted digital services. Autonomous and interoperable, it serves as both an alternative and a complement to centralized global systems. IoE combines cutting-edge technologies in direct communications networking, edge computing, and distributed systems through GreenSoft, designed to integrate custom edge devices. We also offer ready-to-use edge devices called **YOI (Your Own Internet of Edges device)** with GreenSoft integrated.

GreenSoft, developed by Green Communications, is key to enabling the Internet of Edges. It is a set of software components dedicated to wireless mesh networks, edge computing and distributed services with an embedded, low-energy design.

GreenSoft includes a wide range of applications, from low-level programs to web applications for end users. Low-level programs are mostly routing software for mesh networks, but also include an SNMP module and helpers for Zeroconf networking, among others. High-level utilities include web applications such as a chat, a push-to-talk, a file sharing tool, a controller, a system setup, or a live network visualization. The software could be packaged to run in a chroot, allowing it to be integrated in existing specific hardware.

Main Features

Automatic Configuration, Intelligent Routing

GreenSoft features an intelligent routing protocol implemented as a userspace daemon in charge of the following tasks:

- Detection of the other devices that are part of the network.
- Estimation of QoS properties for each link.
- Calculation of (possibly indirect) routes to other devices and setting of the system's routing tables accordingly (thus ensuring that every device forwards data properly and that any network host can reach any other host).
- When some devices forward data from the mesh network to other networks (e.g., the Internet), ensuring that all network hosts may reach these other networks.

Network Coverage that Features Mobility and Zeroconf

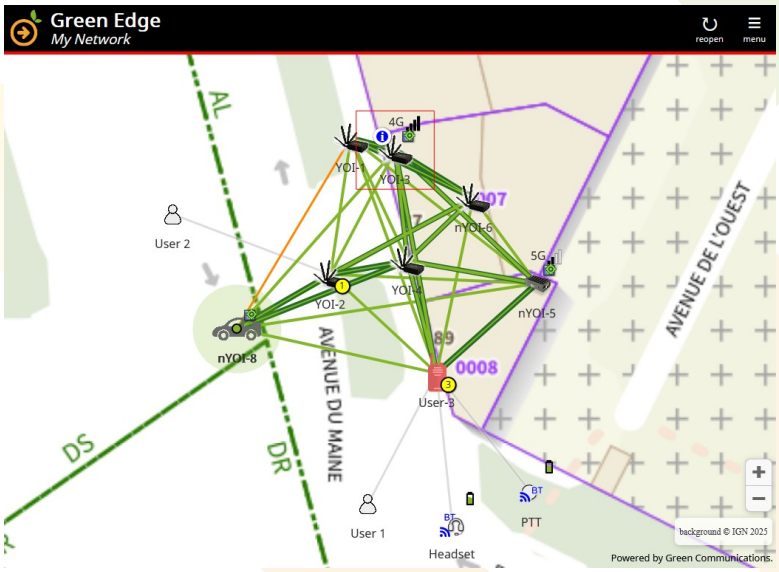
GreenSoft features a handoff manager program. This is a userspace daemon that helps routers provide access points to regular Wi-Fi stations. These stations, though outside the core mesh network, may associate to the access points and get regular network connectivity through the mesh network. The handoff manager ensures users can move from one access point to another without disrupting their connections.

E-mail: contact@green-communications.fr - Web: www.green-communications.fr

Green communications

The handoff manager performs the following tasks:

- It either acts as a distributed DHCP server, or as a DHCP relay that relays requests from stations to a designated central DHCP server.
- It snoops on DHCP transactions and informs the network accordingly so that routers can map MAC addresses to IP addresses.
- It snoops on Wi-Fi association and disassociation events, so routers can detect handoffs.
- It updates the system's routing tables accordingly and configures access point interfaces to act as a gateway to associated stations.



Live Network Visualization

Multicast Routing

Multicast Group Members Discovery and Multicast Traffic Forwarding

GreenSoft supports forwarding of multicast traffic across the mesh network. It automatically discovers multicast group members using IGMP snooping both on the core mesh network and on the access points.

It may also optionally support forwarding of multicast traffic on external network interfaces. Since more than one mesh router may be connected to the same external network, only one of them is automatically chosen to be in charge, in order to avoid packet duplication.

Multicast Diversion

Optionally, the mesh routers can also divert multicast packets destined to non-routable groups, in the `224.0.0.0/24` address block. These packets are not supposed to be forwarded and their initial TTL/hoplimit header field value is supposed to be set to 1.

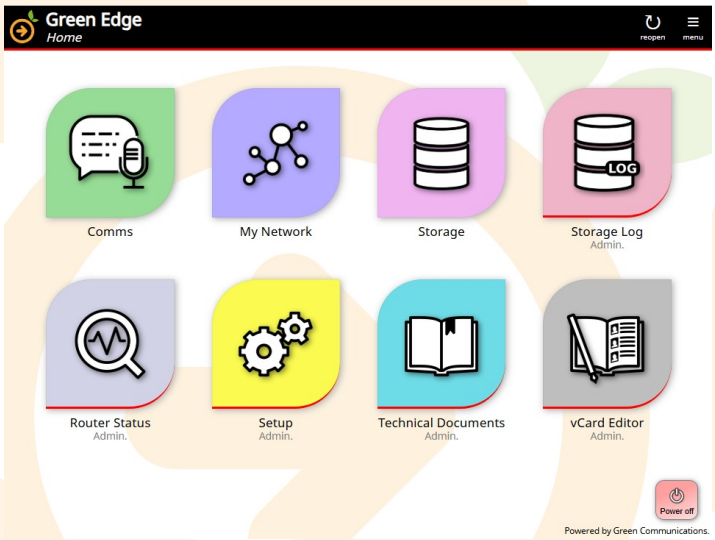
To make protocols such as Zeroconf work across the mesh network, it is possible to specify which of these groups are to be diverted by the mesh routers. A diverted group is thus treated as a routable multicast group for which members are discovered and advertised, and when multicast packets destined to this group are received by a mesh router, their TTL/hoplimit header field is initialized to some configurable initial value that will allow proper forwarding.

Edge Services

GreenSoft features a web framework to offer a number of web applications to users (chat, network setup, live network visualization tool, etc.). This framework uses client-side JavaScript and static HTTP, except for three dynamic HTTP resources:

- A resource that provides a GraphML (XML) representation of the current network. The network visualization tool uses this resource. A custom GreenSoft program provides this resource to the web server using the SCGI protocol.
- A resource that converts GET and POST HTTP requests including JSON data to SNMP GetBulk and Set requests. The network setup app uses this resource. A custom GreenSoft program provides a SNMP/JSON converter to the web server using the CGI protocol. Also note that GreenSoft features a Net-SNMP module that implements the SNMP configuration backend.
- A resource that maps XMPP traffic to HTTP using the BOSH protocol. The chat app uses this resource. Green Communications' routers (YOI) use ejabberd to provide this resource.

GreenSoft web apps therefore need a web server. Any software can provide this server as long as it supports SCGI and CGI (Green Communications' routers uses nginx with fcgiwrap for CGI). The web server can easily be used to provide local content to users. New applications can be easily developed and integrated into the framework.



GreenSoft's framework

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OEM Requirements

To deploy the GreenSoft on custom hardware (or system), there are mostly two options:

- Collaborate with Green Communications to adapt the Green Communications system image to the custom hardware.
- Use the custom system image and add parts of the GreenSoft to it, running in a chroot.

The Green Communications system image is generated using Buildroot. To adapt the Green Communications system image to custom hardware, either Buildroot should support it, or an appropriate toolchain and Linux kernel should be provided to Green Communications (see requirements below). Green Communications does provide the Buildroot sources it uses to generate the images, under a GPLv2 license.

To integrate parts of GreenSoft to a custom system image, the latter must meet the requirements below and an appropriate toolchain must be provided to Green Communications.

In both cases, the requirements for GreenSoft are:

- A toolchain with a modern C++ compiler. GCC 12.3.0 and Clang 16 are known to work.
- A Linux kernel with version 6.1 or above, with support for packet scheduling, IPv4 and IPv6 routing.
- Wi-Fi interfaces with drivers that support mesh mode (i.e., 802.11s), nl80211, RX signal level reporting through nl80211, and SO_WIFI_STATUS on packet sockets. (Note: GreenSoft assumes data sent over a Wi-Fi interface is encrypted, so we recommend support for SAE over mesh mode)

References

GreenSoft, is being used by French Armed Forces.

E-mail: contact@green-communications.fr - Web: www.green-communications.fr