GreenSoft

Green Communications' Software
for OEM Licensing

Green PI

Green Communications' software (the GreenSoft) is the key enabler of Green PI, a low carbon footprint Internet with edge cloud and services.
**The GreenSoft allows hardware to:**
i) **connect with nearby Green PI devices to create a dynamic and self-configuring wireless network with quality of service (QoS);**
ii) **access and share a common edge cloud with edge-based services.**

GreenSoft is a set of software components dedicated to wireless networking. It features a wide range of applications, from low-level programs to web applications for end users. GreenSoft's low-level programs are mostly routing software for mesh networks, but also feature an SNMP module and helpers for Zeroconf networking, among others. High-level utilities feature web applications such as a chat, a network setup app, or a live network visualization tool.

Automatic Configuration and 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 table accordingly (thus ensuring that every device forwards data properly, and that any network host can reach any other host).

Live Network Visualization

- 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.
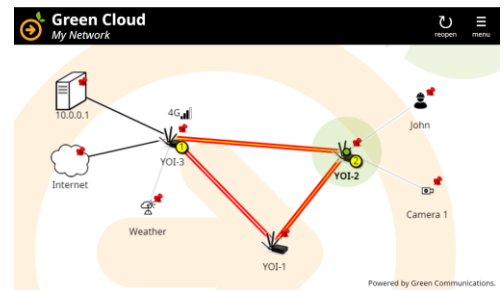
Network Coverage that Features Mobility and Zeroconf

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

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The handoff manager performs the following tasks:
- it either acts as a distributed DHCP server or as a DHCP relay, relaying DHCP requests from users to a designated DHCP server.
- it snoops on DHCP transactions and informs the network accordingly so 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 users.

In addition, GreenSoft features an mDNS helper. This is a userspace daemon that ensures Zeroconf works. In practice, this means that devices that run the GreenSoft may advertise Zeroconf services to other devices and users; and that users may also advertise their own Zeroconf services to the network (including other users).

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 both on the core mesh network and on the access points.

It may also optionally be in charge of discovering group members and forwarding 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 of multicast group member discovery and multicast traffic forwarding, in order to avoid packet duplication.

The mesh routers advertise the information about discovered group members to all the other mesh routers, such that each of them knows how to forward multicast packets efficiently.

The IPv4 (resp. IPv6) header TTL (resp. hoplimit) field of multicast packets is honored and decreased accordingly during forwarding in the mesh network. This means that in order for multicast packets to properly arrive at their destinations, the initial value of this field has to be large enough to traverse all the mesh network.

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.

Nevertheless, to make protocols using such packets 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.

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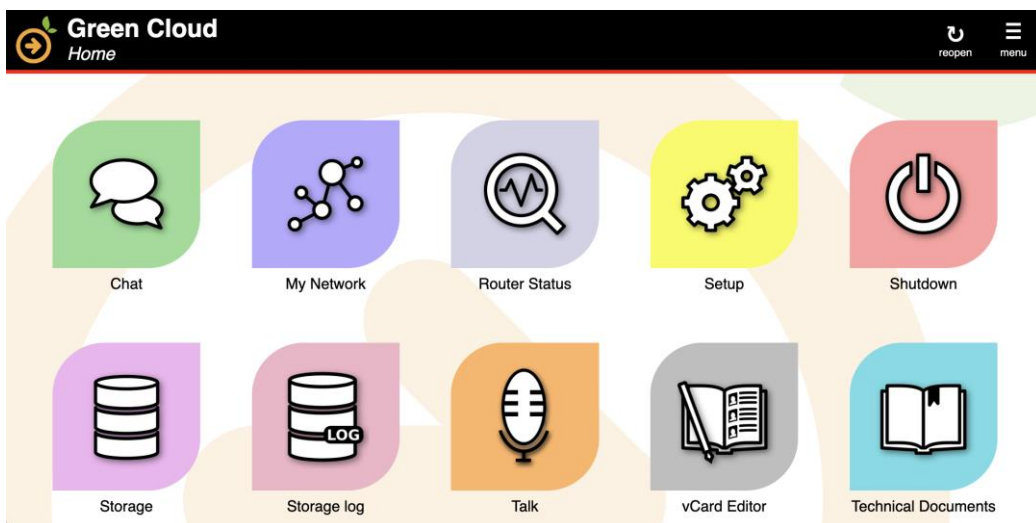Green Communications' Software
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Edge Cloud and Services

GreenSoft features a web framework that provides users with a number
of web applications (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 the
  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) relies on ejabberd for 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). One can easily
use the web server to provide local content to users. One can also easily develop new applications to
integrate to the framework.

GreenSoft's framework

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OEM Requirements

To integrate the GreenSoft to a custom hardware (or system), there are mostly two options:

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

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

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

In both cases, the requirements for GreenSoft are:

OEM Integration Requirements

- ❖ A toolchain with a modern C++ compiler. GCC 9.3.0 and Clang 11 are known to work.

- ❖ A Linux kernel with version 5 or above

- ❖ Wi-Fi interfaces with drivers that support IBSS or mesh mode (i.e., 802.11s), nl80211, RX signal level reporting through nl80211, and `SO_WIFI_STATUS` on packet sockets. (Note: Greensoft assumes the data sent over a Wi-Fi interface is encrypted, so we recommend support for RSN over IBSS or for SAE over mesh mode).

- ❖ libdbus, and a running D-Bus daemon.

- ❖ libcurl.

- ❖ The following Boost libraries: Align, Program Options, Filesystem, System, Regex, Locale.

- ❖ For the SNMP module, Net-SNMP, ifup/ifdown, `hostapd` and `wpa_supplicant`.

- ❖ For the live network visualization tool, a web server that supports SCGI.

- ❖ For the network setup app, a web server that supports CGI and the SNMP module.

- ❖ For the chat web app, an XMPP server that supports BOSH.

- ❖ For the talk wep app, a janus-gateway server.

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Performance

Videoconferencing Over Multiple hops:

Green Communications partnering with the leading energy provider EDF tested the rapid deployment of an instant communication network: a set of YOI (GreenSoft enabled routers) was spread out. Routers connected instantaneously using our advanced Device-to-Device technology, creating a Wi-Fi network without the need of either a preliminary audit or previous infrastructure.

Within minutes, two people located at each end of the network were able to exchange calls and videoconference over multihops (up to 30). GreenSoft's Handoff functionality allowed them to move along the network without interruption.

It is the first time a real-time video is operated over a high number of Wi-Fi hops validating our routing algorithm for large-scale deployment and for mobility.

Green PI
achieves
videoconferencing up to
30 Wi-Fi hops

References

Green PI's software, the GreenSoft, is being used by French Armed Forces.

FORCES AS USED BY FRENCH ARMED FORCES

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