White Paper:

Green PI: Device2Device wearable networks

By Green Communications

Telecommunication technologies in all their forms (2G to 4G, Wi-Fi, Wi-Max…) use a unique model to communicate between two entities. It consists in forwarding the packets to an access point which sends the information back to the destination (Figure 1-a). This happens when source and destination are in the same cell. If source and destination are located in two different cells, then the information uses a hierarchical path based on a tree topology going up and then down to the final destination as shown on Figure 1-b.

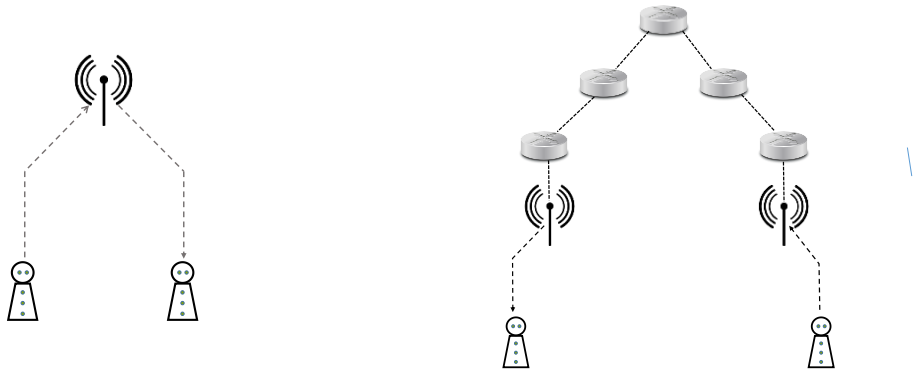

Figure 1. (a) Communication in one cell; (b) in different cells

This model implies many disadvantages in terms of capacity and energy consumption:

1) When many devices want to access to the network in the same cell (Figure 2), they have to send the information to the access point serving the cell. However, the access point can only process one request at the same time. If many requests arrive simultaneously, they generate collisions and interferences. A scheduling mechanism needs to be elaborated at the access point in order to organize the access to the network, request after request. Parallel request cannot be served which limits the capacity of the cell.

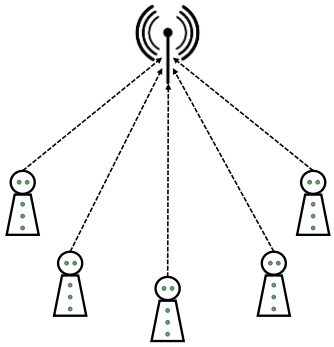

Figure 2. Scheduling at the access point

2) In terms of energy consumption, transferring the information to an intermediate access point instead of direct transfer doubles the number of transmissions/receptions. Also, when using a tree-topology

path to climb up then down on a vertical way will increase the energy per bit comparing to a direct and horizontal path. Figure 3 illustrates the difference between horizontal and vertical communications.

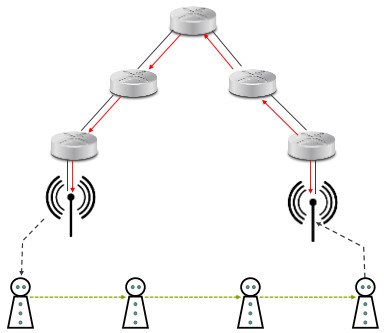

Figure 3. Horizontal versus Vertical communications.

The objectives of the next generation 5G is to increase the network capacity by introducing a Device to Device technology. Using direct communications would increase the capacity of the networks since parallel communications could happen comparing to an access point centralized scheduling. Direct communications do not need to communicate with high power since the destination is very close to the source. The low power reduces the energy consumption and increases the capacity by reducing the interferences.

Observation on the traffic

When scanning the traffic on telecommunication networks, one could observe that an important part of the traffic is local. People during events or in smart cities and smart homes, share pictures and videos, exchange information on their environment. The information in the majority of cases do not need to travel through the infrastructure of the network and the cloud and to consume a huge amount of resources and energy to come back to the neighborhood. Although, the video traffic on mobile devices is doubling every year, damaging seriously the capacity at access points by creating bottlenecks.

Embedded Internet and 5G

The idea to go directly from source to destination is not new. Its implementation was never realized in the past because operators of networks had to control the traffic for accounting and monitoring. Nowadays, the majority of subscriptions include an unlimited usage of the network. Hence, the more the traffic is out of the operator network, the less the infrastructure of the operator is saturated while its income stays the same. Introducing horizontal and direct communications is a win-win policy for operators, customers and also the entire eco-system. Why, should local traffic travel over the entire network and data centers to just reach a close destination?

5G networks include in their requirements the faculty that two devices should communicate directly with no need of any network infrastructure. This implies that the device should contain a minimum of network intelligence to have the capacity to detect destinations and to also transfer the traffic of its peers. In addition, Device2Device communication should continue to work even when the global network is not operating or when damages push the global network offline.

Attempts to make intelligence in the applications of Smart Phones is an option to introduce the Device2Device. Some products are already working on different platforms (IOS, Android…) such as AirDrop or Firechat. In those cases, the Device2Device is managed at the application layer and with a proprietary protocol. It means that Smart Phones should first install the application to run a Device2Device. Furthermore, each new service requires the development and download of a new application. This model cannot scale.

Green PI: Wearable and Embedded Internet

Green Communications introduces the concept of Embedded Internet where devices hold a full TCP/IP environment, an open operating system (Buildroot-based Linux) and a sharing storage. Each device contains two wireless network interfaces. One to establish the network between the devices and the second to offer an access to SmartPhones, PADS and computers. All type of applications will be active immediately because the network is running a TCP/IP locally. It is also possible to provide many applications over http using a local web server and latest web technologies (htmls). This gives the opportunity to anyone to communicate even if they didn't download a native application.

The Green Communications' device is light enough to be held or wearable. It could be distributed on-site or could come directly within the visitors. When turning the devices ON, the network is established in few seconds and then a local Internet is operated. A subset of the devices could be configured as gateways to the global Internet to create a hybrid model where local traffic stay local and global traffic is transferred across the gateways.

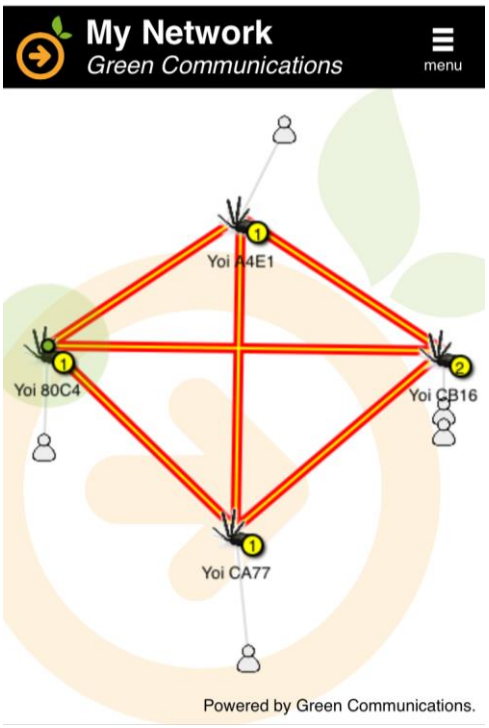

Figure 4. Monitoring interface with open data.

The device also includes storage with security options to offer the possibility to share information and also to install new specific applications related to the area where the network is running. The network provides access to its raw open data to help people in their connections and enables application developers to build more appropriate applications related to on-site usage. Figure 4 shows the different kind data that are open: network topology, number of users per access point, quality of links between access points, location of the Internet Gateways, access point profiles through the vCard Standard…

The idea that people could hold their personal Boxes creates the concept of the Participatory Internet (PI). Any group of persons could simply, by turning ON their own Boxes, create an Internet that could operate on local content or connect to the Global Internet.

Green PI offers advantages to facilitate the communication in many cases:

1) Network densification: dense areas such as stadiums and large arenas need a strong network densification to offer Internet access with acceptable quality. Providing an access point every 30 users

is cash intensive and need heavy civil engineering schemes for cabling. Asking a subset of participants to hold a Green PI access point reduces the cost of the coverage by a factor of seven.

2) Mobile Units: Connecting mobile units (robots, drones, and people on the move) is not possible with an infrastructure-based network (4G, satellite…). A participatory Internet with an embedded TCP/IP and local content is the solution to create an on demand network and allow direct communications.

Distributed TCP/IP

In order for an embedded Internet to work correctly, it is mandatory to distribute all the services over the devices. Services shouldn't depend on one specific machine to avoid any network blackout. When a device enters or leaves the network, services must continue to work correctly. Green Communications provides distributed TCP/IP over the devices by enhancing them with Zeroconf (mDNS, DNS-SD…), anycast addresses, handoff management, distributed DHCP implementation, distributed database…

YOI (Your Own Internet device)

YOI consists on a Hardware containing three network interfaces (two wireless plus Ethernet) and working with a Buildroot-based Linux. It offers embedded TCP/IP providing Wi-Fi access to the local or global Internet. All native TCP/IP applications may be active in private or public connections.

The performance of Green Communications product have approved to provide voice over IP and video conferencing over 30 Wi-Fi hops. This unique performance has never been shown before by any competitor.

Here is a subset of the YOI specifications:

Hardware:

Dimensions	85 × 105 × 35 mm
Weight	324g (enclosure and antennas included)
Power consumption	< 5W
Network interfaces	2 Wi-Fi interfaces (a, b, g, n) 1 Ethernet port (10/100/1000 Mbit/s)
Frequency	2.4 GHz and 5 GHz
CPU	Cortex-A9 800 MHz Dual Core
RAM	512 MB
Operating system	Custom Linux system (based on Buildroot)
Storage	SD Card (by default 32GB)

Software:

Networking	Mesh routing according to the best links
	Wireless link estimation
	Network open data
	Auto-configuration for the backhaul (plug&play)
	Handoff in both access and backhaul
Embedded Services	Embedded TCP/IP, Zeroconf compliant
	Distributed XMPP local server
	Distributed DHCP for the access
	Distributed storage capacity
	Distributed chat services
	VLAN on access and backhaul
	Start and Stop mechanism for unused devices
Security	WPA2 Enterprise on network access and network backhaul