Communications Options for Wireless Sensor Networks

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WSN communications options

When considering communications options, parameters to be taken into account are:

1. Range
2. Multihop capabilities
3. Battery consumption
4. Security
5. Cost (device)

   Cost (service)

   Availability

   Regulation

WSN communications options

There are the following options for WSN communications:

1. 802.15.4
   Zigbee
   Low Power WiFi
   GSM
   Satellite
   TV White Spaces

802.15.4

802.11 – Wireless Local Area Networks (WiFi)

- 802.11a, 802.11b, 80211g, 802.11n

802.15 – Wireless Personal Access Networks (WPAN)

- Task Group 1 – Bluetooth (802.15.1)
- Task Group 2 – Co-existence (802.15.2)
- Task Group 3 – High Rate WPAN (802.15.3)
- Task Group 4 – Low Rate WPAN (802.15.4 or 802.15 TG4)
- Task Group 5 – Mesh Networking (802.15.5)

802.16 – Wireless Metropolitan Area Networks (WiMax)

802.20 – Mobile Broadband Wireless Access (Mobile-Fi) - Defunct

802.22 – Wireless Regional Access Network (WRAN)

- Utilise free space in the allocated TV spectrum

802.15.4

This standard defines a communication layer at **level 2** in the OSI (Open System Interconnection) model. Its main purpose is to let the communication between two devices.

It was created by the Institute of Electrical and Electronics Engineers (IEEE), entity which main task is to set standards so that technological developments can count with a common platform of rules to be set over.

802.15.4 - physical layer

Channels:

868.0 - 868.6MHz	-> 1 channel	(Europe)
902.0-928.0MHz	-> 10 channels	(EEUU)
2.40-2.48GHz	-> 16 channels	(Worldwide)

Bit Rates:

868.0 - 868.6MHz	-> 20/100/250 Kb/s
902.0-928.0MHz	-> 40/250 Kb/s
2.40-2.48GHz	-> 250 Kb/s

802.15.4 - node types

Full-function device (FFD).

It can serve as the coordinator of a personal area network just as it may function as a common node. It implements a general model of communication which allows it to talk to any other device: it may also relay messages, in which case it is dubbed a coordinator.

Reduced-function devices (RFD).

These are meant to be extremely simple devices with very modest resource and communication requirements; due to this, they can only communicate with FFDs and can never act as coordinators.

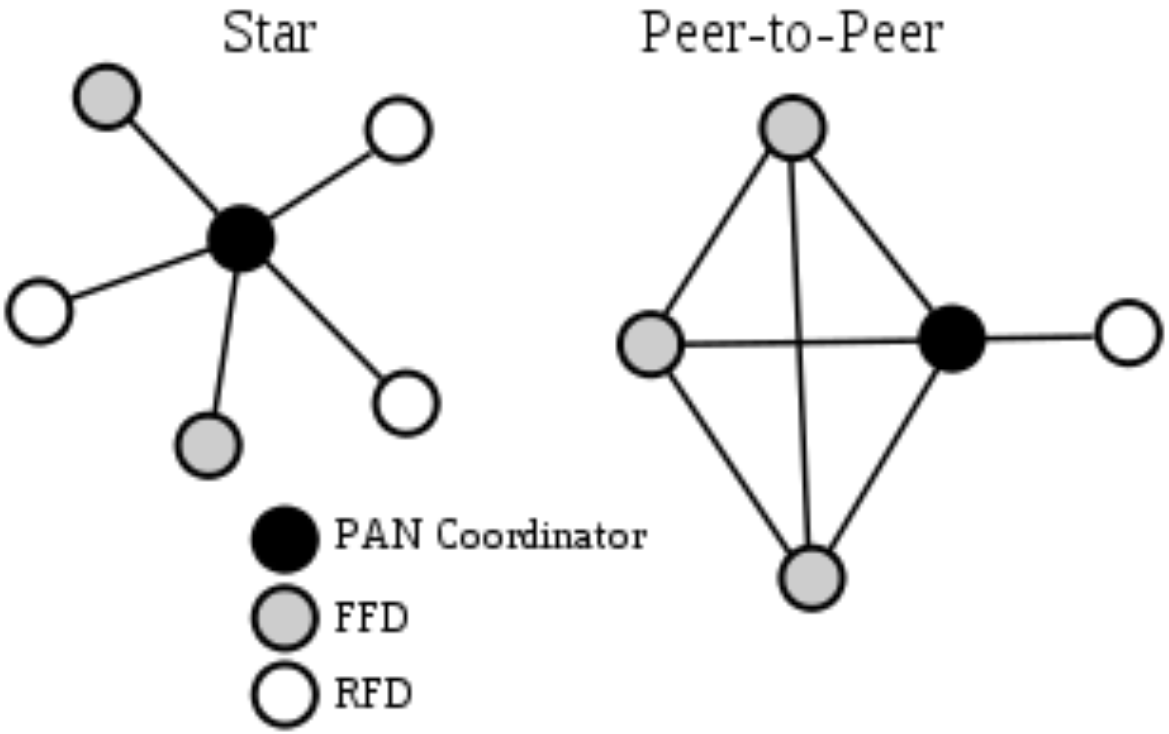
802.15.4 - topologies

Networks can be built as either **peer-to-peer** or **star** networks.

However, every network needs **at least one FFD to work as the coordinator of the network**.

Each device has a unique 64-bit identifier, and if some conditions are met short 16-bit identifiers can be used within a restricted environment. Namely, within each PAN domain, communications will probably use short identifiers.

802.15.4 - topologies



Max number of devices is 65535.

802.15.4 - characteristics

1.	Range		10m
2.	Multihop capabilities	no	
3.	Battery consumption	low	
4.	Security		no
5.	Cost (device)	low	
	Cost (service)	free	
	Availability		good
	Regulation		good

Zigbee

This standard defines a communication layer at **level 3** and upper in the OSI model. Its main purpose is to create a network topology (hierarchy) to let a number of devices communicate among them and to set extra communication features such as authentication, encryption, association and in the upper layer application services.

It was created by a set of companies which form the ZigBee Alliance.

Zigbee

ZigBee offers basically four kinds of different services:

Encryption services (application and network keys implement extra 128b AES encryption)

Association and authentication (only valid nodes can join to the network).

Zigbee

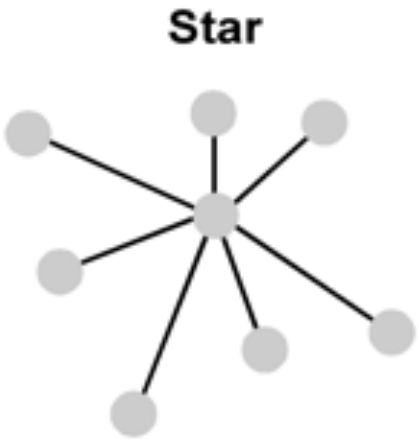
Routing protocol: AODV (Ad hoc On-Demand Distance Vector Routing), a reactive ad hoc protocol has been implemented to perform the data routing and forwarding process to any node in the network.

Application Services: An abstract concept called "cluster" is introduced. Each node belongs to a predefined cluster and can take a predefined number of actions. Eg: the "house light system cluster" can perform two actions: "turn the lights on", and "turn the lights off".

Zigbee - topology

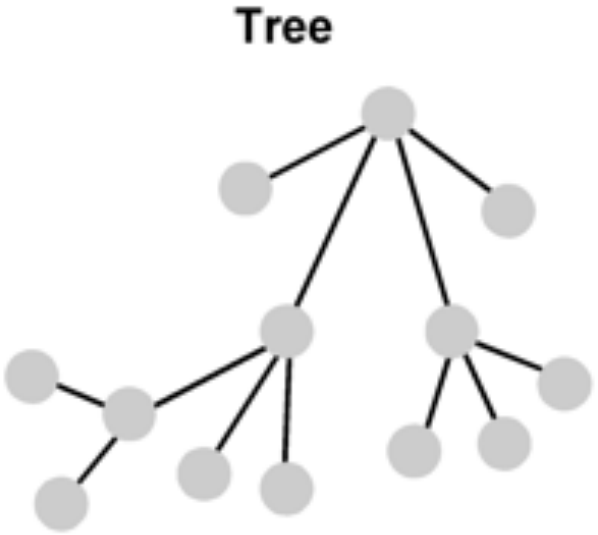
A ZigBee network can adopt one of the three topologies: Star, Tree, Mesh.

Star Topology: a Star network has a central node, which is linked to all other nodes in the network. All messages travel via the central node.



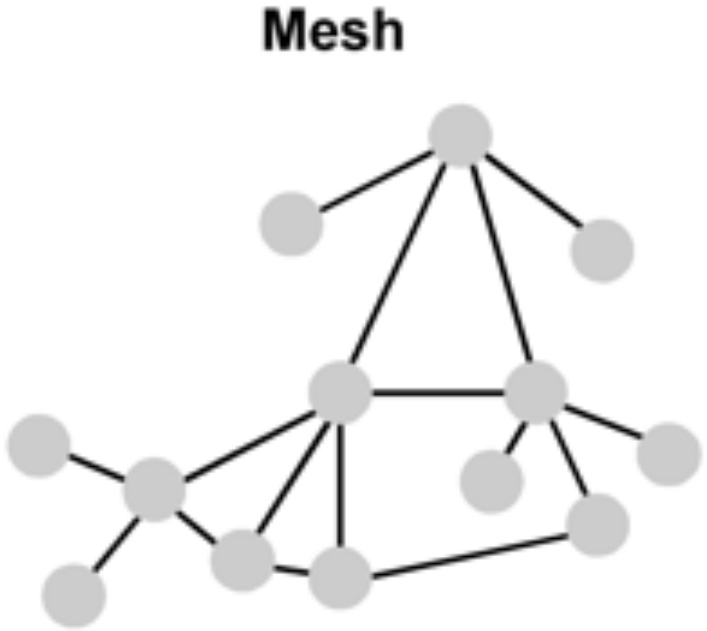
Zigbee - topology

Tree Topology: a Tree network has a top node with a branch/leaf structure below. To reach its destination, a message travels up the tree (as far as necessary) and then down the tree.



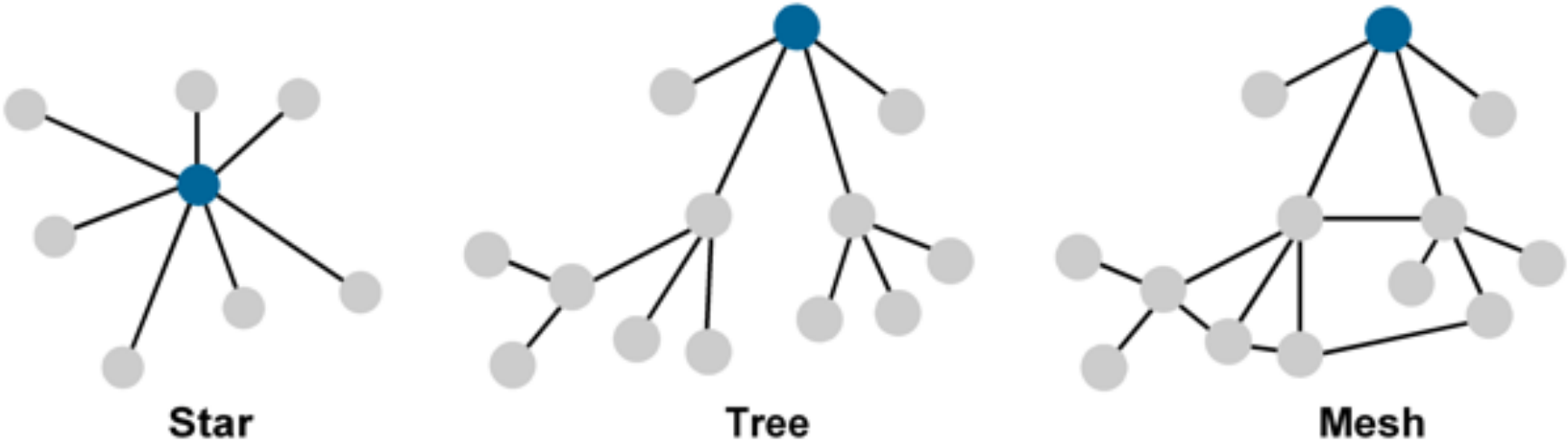
Zigbee - topology

Mesh Topology: a Mesh network has a tree-like structure in which some leaves are directly linked. Messages can travel across the tree, when a suitable route is available.



Zigbee - node types

Co-ordinator: all ZigBee networks must have one (and only one) Co-ordinator



Zigbee - node types

The tasks of the **Co-ordinator** at the network layer are:

- Selects the frequency channel to be used by the network (usually the one with the least detected activity)
- Starts the network
- Allows other devices to connect to it (that is, to join the network)

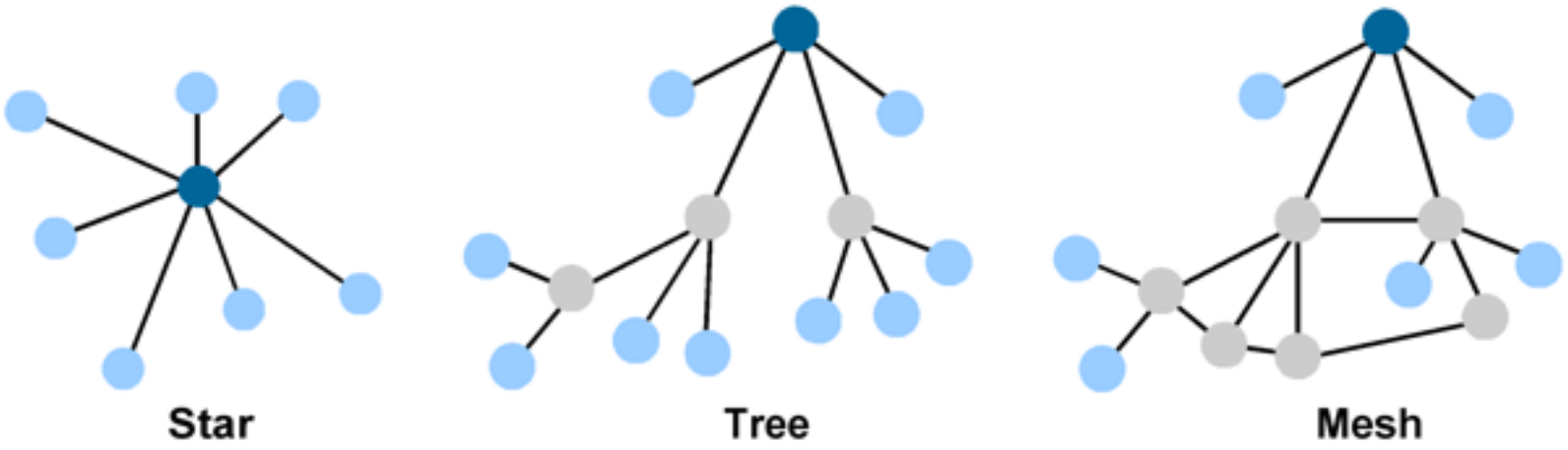
The Co-ordinator can also provide message routing (for example, in a Star network), security management and other services.

Zigbee - node types

End Devices are always located at the extremities of a network:

In the Star topology, they are perimeter nodes

In the Tree and Mesh topologies, they are leaf nodes



Zigbee - node types

The main tasks of an **End Device** at the network level are sending and receiving messages. Note that End Devices cannot relay messages and cannot allow other nodes to connect to the network through them.

An End Device can often be battery-powered and, when not transmitting or receiving, can sleep in order to conserve power.

Zigbee - node types

Networks with Tree or Mesh topologies need at least one **Router**. The main tasks of a Router are:

Relays messages from one node to another. Allows child nodes to connect to it.

In a Star topology, these functions are handled by the Co-ordinator and, therefore, a Star network does not need Routers.

Zigbee - node types

In Tree and Mesh topologies, Routers are located as follows:

- In a Tree topology, Routers are normally located in network positions that allow messages to be passed up and down the tree.
- In a Mesh topology, a Router can be located anywhere that a message passing node is required.

Note that a Router cannot sleep.

Zigbee - characteristics

1.	Range		10m
2.	Multihop capabilities	yes	
3.	Battery consumption	low	
4.	Security		yes
5.	Cost (device)	low	
	Cost (service)	free	
	Availability		good
	Regulation		good

WiFi based WSN

Advantage: use existing WiFi network infrastructure.

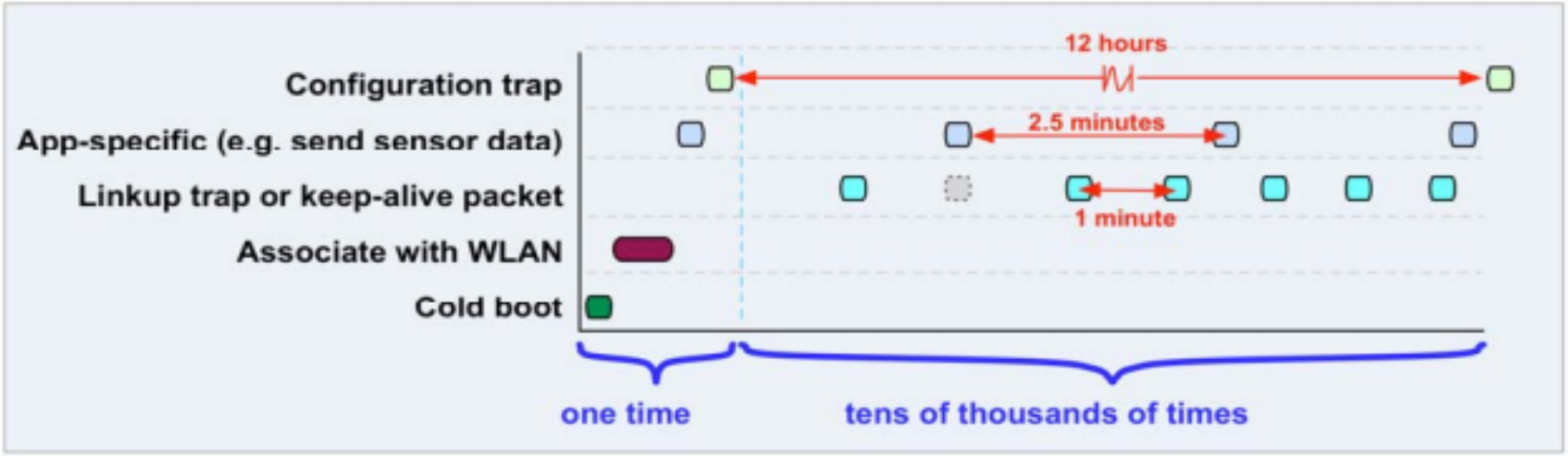
High power Wi-Fi chips are optimized for fast response, low latency, and high data rates.

Low power Wi-Fi chips are optimized for low power consumption, particularly when the device is in Standby mode.

WiFi based WSN

Parameter		Conventional Wi-Fi	Low-Power Wi-Fi	units
Power consumption	Standby / Idle	NA*	<4	µW
	Processor + clock sleep	13	0.2	mW
	Data processing	115	56	mW
Receive sensitivity, 1 Mbps		-91	-91	dBm
Time to wake from Standby		NA*	10	ms
Time to wake from processor+clock sleep		75	5	ms

WiFi based WSN

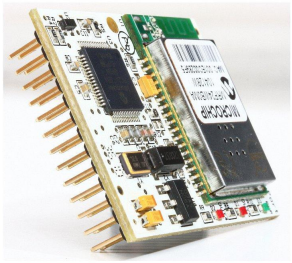


WiFi based WSN

Examples

The **XBee Wi-Fi** modules from Digi International come in 1mW and 2mW versions.

The **Flyport** provides the following services: Webserver (even Ajax apps can be run), TCP Socket, UDP Socket, SMTP Client.



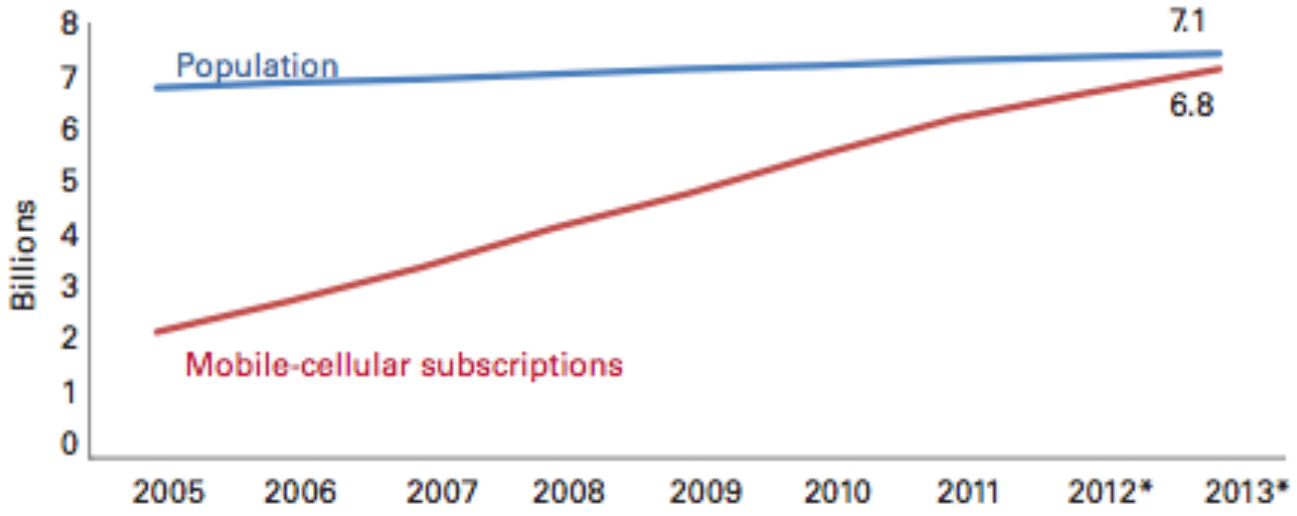
The **Gainspan** modules.

WiFi based WSN: Arduino WiFi Shield

Low Power WiFi - characteristics

1.	Range	100m
2.	Multihop capabilities	no
3.	Battery consumption	low
4.	Security	yes
5.	Cost (device)	medium
	Cost (service)	free
	Availability	good
	Regulation	good

GSM - widely available

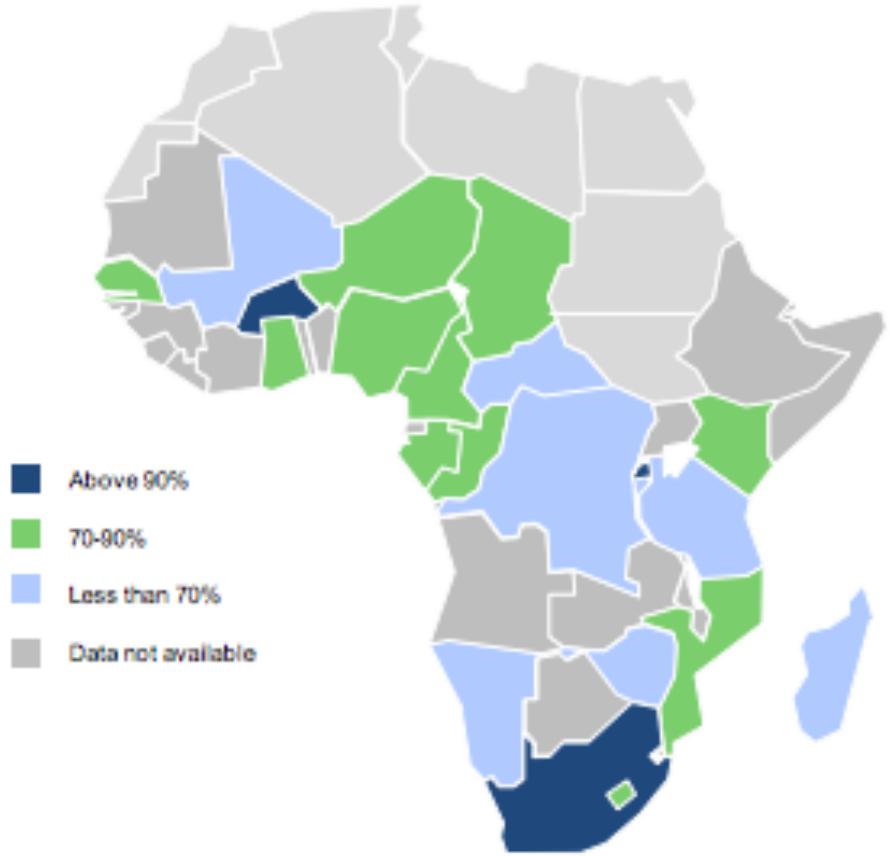


Source: ITU World Telecommunication /ICT Indicators database
Note: * Estimate

Africa is the region with the highest growth rates over the past three years and mobile-broadband penetration has increased from 2% in 2010 to 11% in 2013.

GSM - coverage

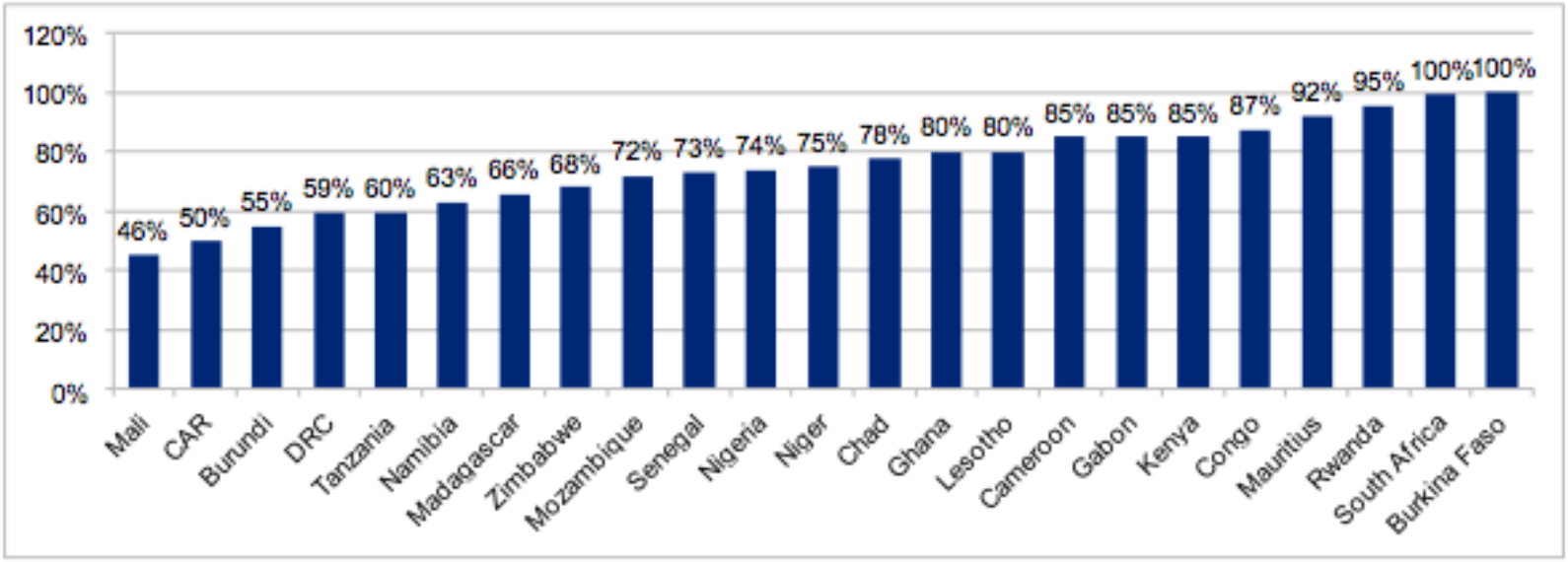
Figure 16: Coverage by country (2012)



Source: Wireless Intelligence

GSM - coverage

Figure 17: Coverage levels in selected SSA countries (2012)



Source: Wireless Intelligence. Data for available countries

GSM - costs

By early 2013, the price of an entry-level mobile-broadband plan represents between 1.2-2.2% of monthly GNI p.c. in developed countries and between 11.3-24.7% in developing countries, depending on the type of service.

GSM: GPRSbee


SIM900
S2-10405-Z0955
GPRSbee Rev.4


SIM900
S2-10405-Z0955
GPRSbee Rev.4

GSM - characteristics

1. Range infinite
2. Multihop capabilities no
3. Battery consumption medium
4. Security no
5. Cost (device) medium

Cost (service) high

Availability

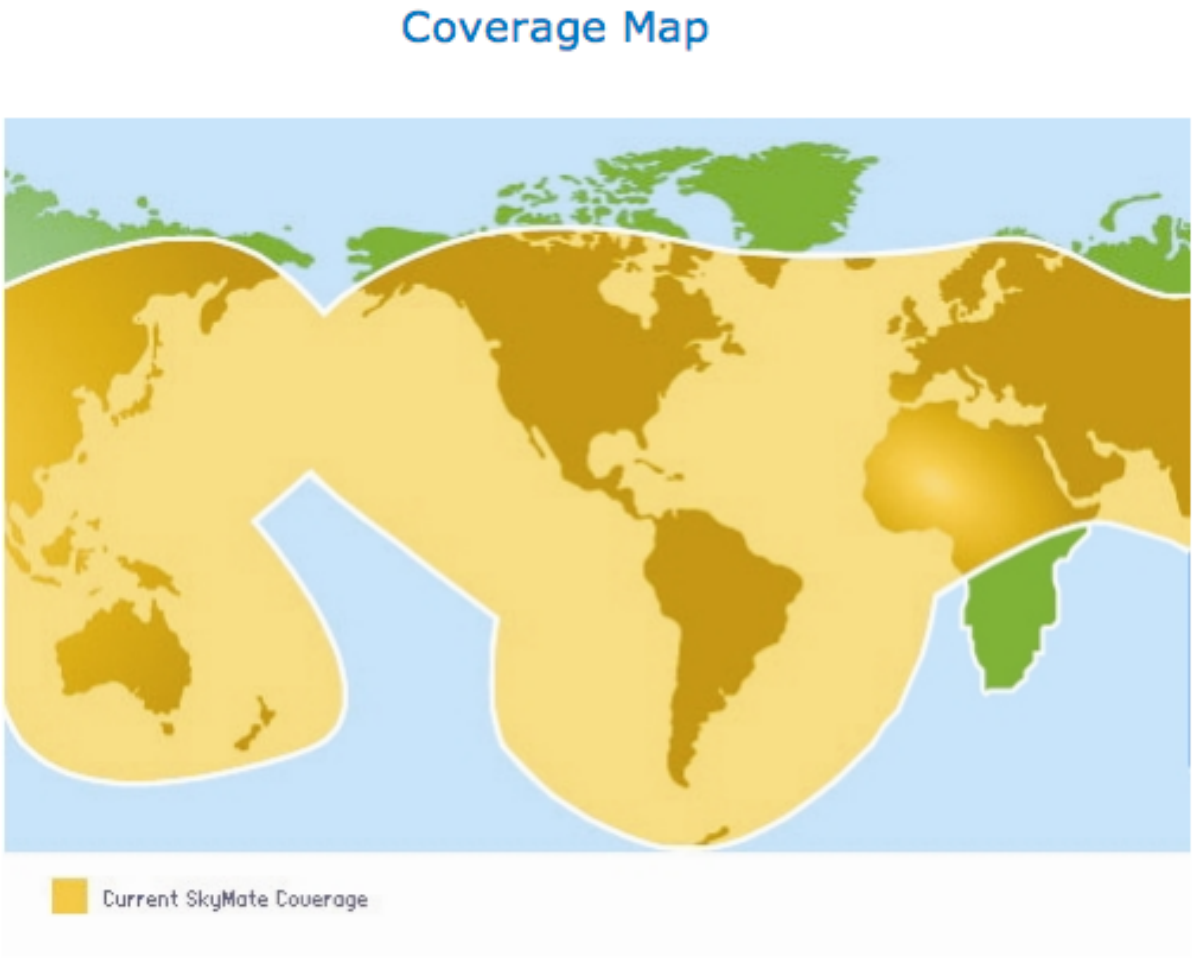
medium

Regulation good

Satellite

1. Digi m10 satellite modem
2. $139.00

Satellite



Satellite

Platinum Plan

Send or receive 50,000 characters per month for just $69.99. Additional data costs only $1.40 per 1000 characters.

Gold Plan

Send or receive 20,000 characters per month for just $34.99. Additional data costs only $1.90 per 1000 characters.

Silver Plan

Send or receive 8,000 characters per month for just $17.99. Additional data costs only $2.25 per 1000 characters.

Satellite - characteristics

1. Range — infinite
2. Multihop capabilities — no
3. Battery consumption — high
4. Security — no
5. Cost (device) — medium

Cost (service) — medium

Availability — low

Regulation — poor

TVWS

In telecommunications, **white spaces** refer to frequencies allocated to a broadcasting service but not used locally.

In addition to white space assigned for technical reasons, there is also unused radio spectrum which has either never been used, or is becoming free as a result of technical changes.

TVWS - weightless

Weightless is a royalty-free open standard focussed on M2M (Machine to Machine Communication).

It uses frequency hopping at the frame rate to minimize the impact of interference - both received and caused.

It has been designed to minimize costs and power consumption employing a highly efficient MAC-level protocols that result in small headers per transmission.