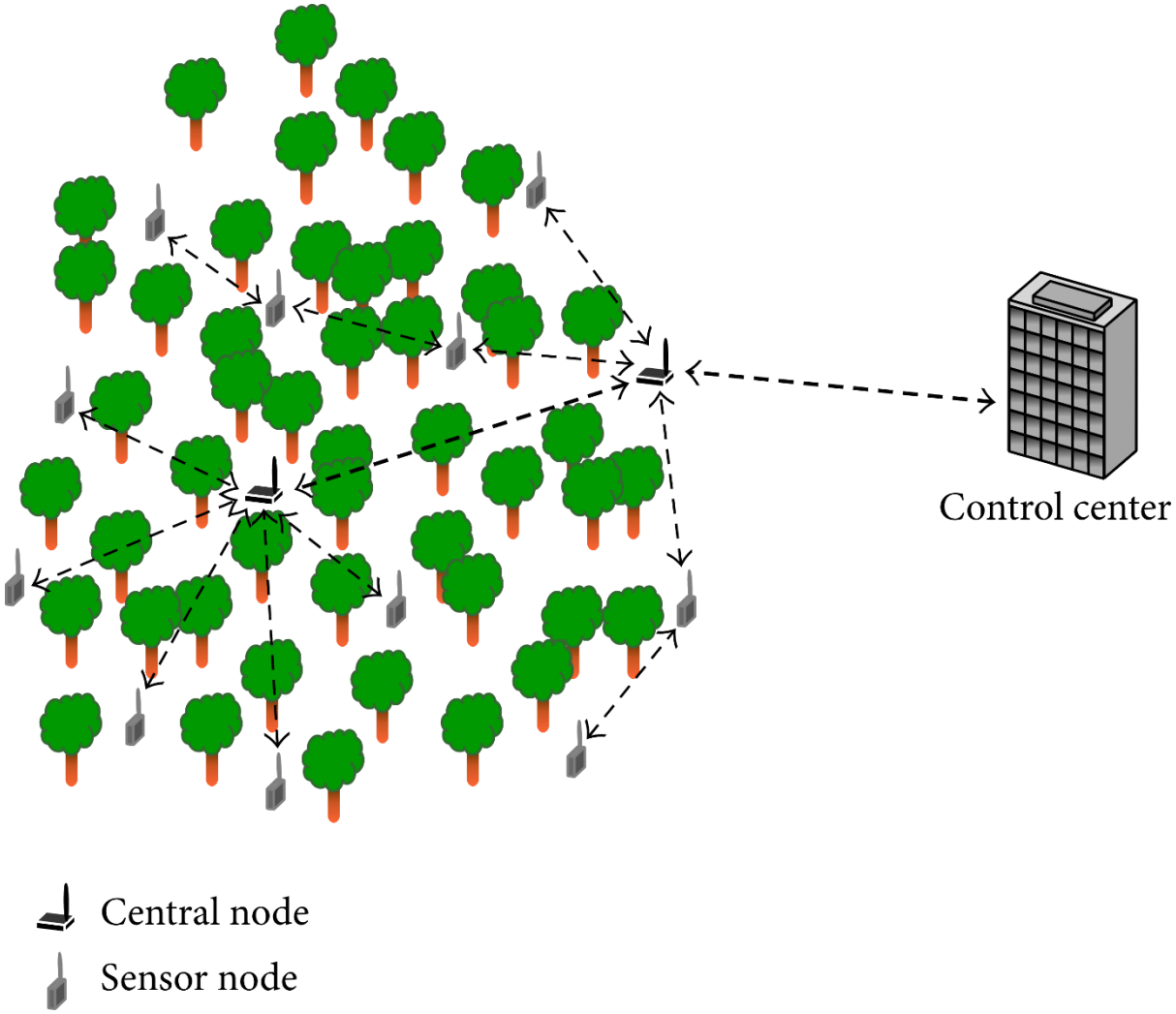
FUNCTIONAL FEATURES

Introduction

Forest fires are a recurrent phenomenon, natural or man-made, in many parts of the world. Vulnerable areas are mainly located in temperate climates where pluviometry is high enough to enable a significant level of vegetation, but summers are very hot and dry, creating a dangerous fuel load. Global warming will contribute to increase the number and importance of these disasters. Every season, not only are thousands of forest hectares destroyed by wildland fires, but also assets, properties, and public resources and facilities are destroyed. Moreover, firefighter and civilians are at risk, with a terrible toll in human lives each year.



Materials and Methods

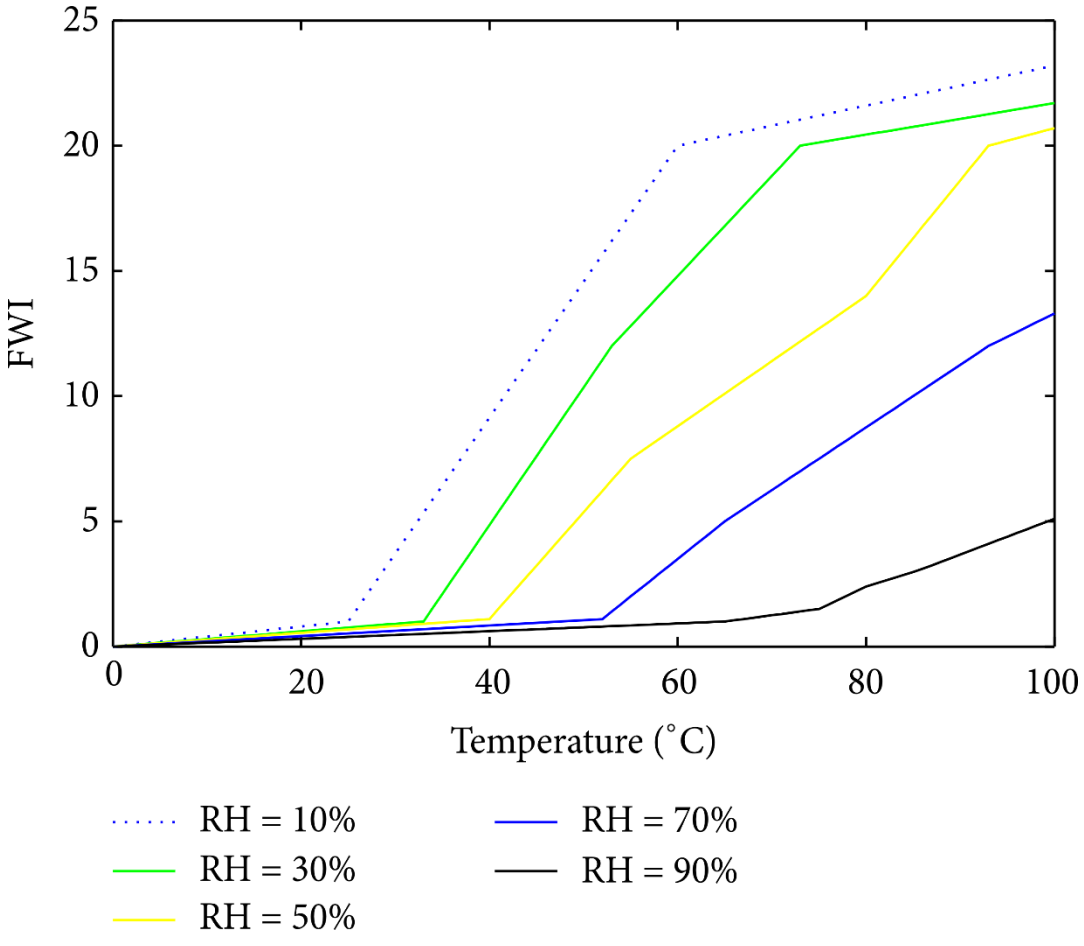
The main design and functional requirements of the WSN were

(i) Contribution to the forest fire fighting strategy, providing critical data to improve their safety and efficiency.

(ii) Providing of valuable forest and climate parameters input to the fire propagation models. This included temperature, humidity, rainfall, wind, smoke, and solar radiation.

(iii) Early detection of forest fires, alarm management, and real time reporting about the fire evolution. They provide alarms by integrating information from several nodes.

(iv) Following of a "deploy and forget" policy. Nodes will not need any kind of maintenance or battery recharging. Energy harvesting techniques and an optimized low power consumption will ensure uninterrupted functioning.



Central Nodes (CNs)

The CNs have more powerful communication and computation capabilities than the sensor nodes. Their main role is to gather and cluster data from the node sensors, manage alarms and commands, and build the core network. They can optionally also include sensing capabilities.

The processing unit is based on a PIC24FJ256GB110. This is a powerful microcontroller that fulfills the technical requirements of the WSN in terms of memory, input/output ports, and communication interfaces. The internal voltage was set as 2.5 V. The CPU includes an internal regulator that converts the battery voltage into 3.3 V. The CPU uses two external oscillators. One provides the required 8 MHz clock for the system, and the second one generates the real time clock. Power is supplied by rechargeable batteries connected to small solar panels for energy harvesting.

Sensor Nodes (SNs)

The SN network is composed of several end nodes with the usual characteristics of wireless sensor networks devices:

(i)Processing unit: it consists of a small ultralow power microcontroller from the Texas Instruments MSP430 family. It is specifically designed for energy efficient applications, which is the main reason for its inclusion in this approach.

(ii)communications system: it is featured by a radio transceiver and its corresponding radio frequency stage. In particular, the transceiver model is the CC1101 part, also from Texas Instruments. The field network operates on the 433 MHz radio region, an unlicensed ISM frequency band. The reason for working on this specific frequency region has to do with its high transmission range and the fact that it is relatively unused in forest environments.

(iii)sensing module: it is composed of several monitoring devices. Every end node has a relative humidity and temperature integrated sensor, SHT75 from Sensor. It can record the air temperature with an accuracy of ±0.3 and its relative humidity with a maximum error of ±1.8%. It also includes gas/smoke sensors. In addition, some special nodes have an attached pole, with an anemometer and a vane for measuring wind speed and direction and a precipitation sensor. The design and structure of the SNs enable their customisation for any other sensing need.

Link Search Mode (LSM): This mode enables the connection to other nodes becoming a node of the entire network.

Test/Reset Mode (TRM): This is a self-test mode to report about the node status to higher level nodes.

Automatic Monitoring Mode (AMM): This is the usual working mode when there is no alarm. Data are collected periodically and sent to the central nodes, using an optimized algorithm to minimize network traffic, memory requirements, and power consumption.

Fire Alarm Mode (FAM): This mode is reached if the node itself detects a fire and receives an alarm from a central node or an alarm from another node due to an alarm propagation.

Underrequest Monitoring Mode (UMM): A central node can send a request to a sensor node to collect environment data immediately.

Data Dump Mode (DDM): This mode is devoted to collect a set of data previously stored at the node memory.

Search messages: Search for an initial node link

Automatic data messages: Periodic messages containing sensor data.

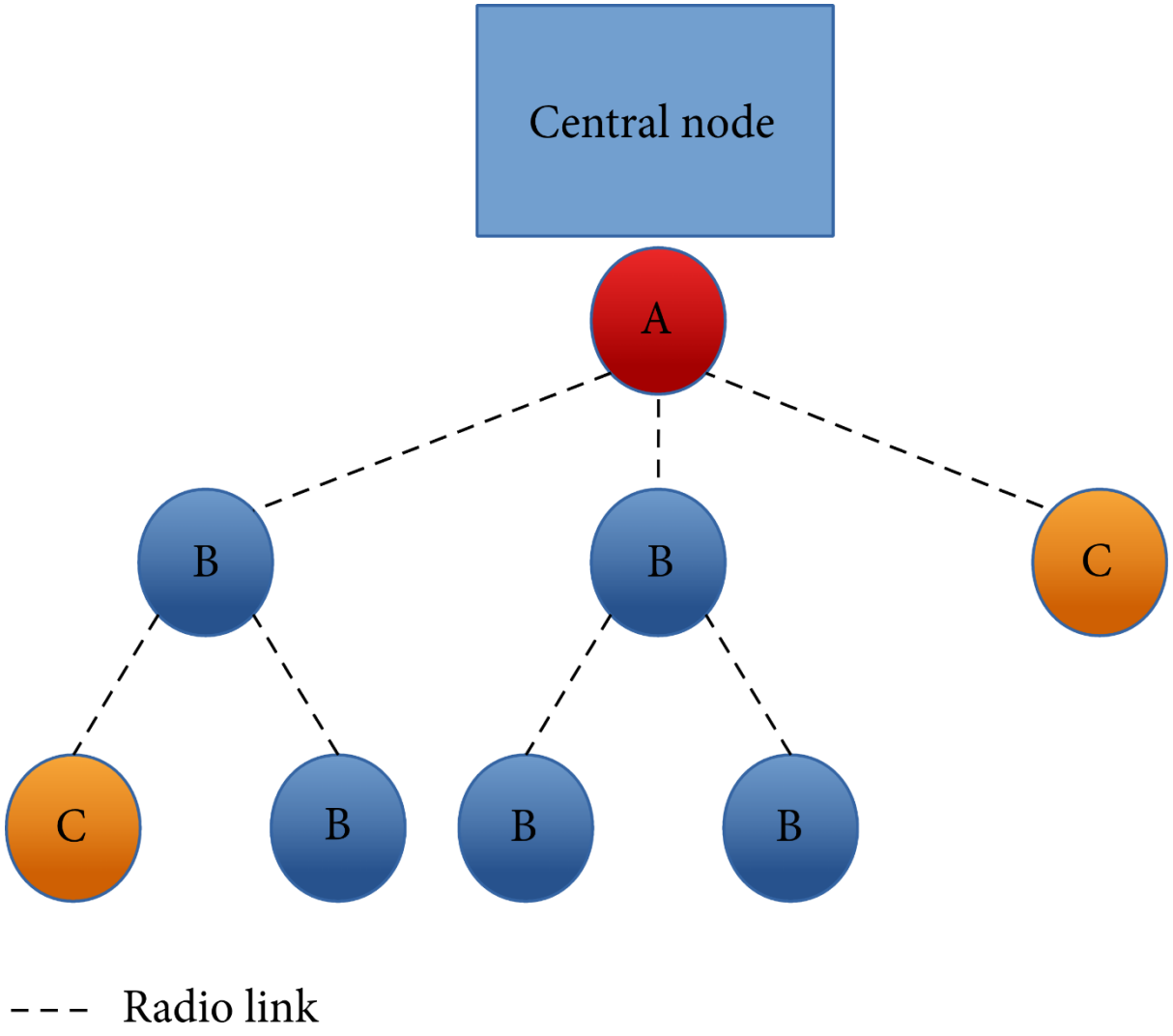
Specific data messages: Messages containing sensor data in response to a higherlevel node request.

Node status messages: Messages containing data regarding sensor status, power level, memory availability, additional status, and so forth.

Alarm messages: Not only the alarm messages themselves, but also the bidirectional confirmation messages (error checking messages) to ensure that the alarm message has been properly transmitted and received.

Command messages: Messages from higher level nodes with commands.

Rerouting messages: Message hopping corresponding to other messages from other nodes.


Central node
A
B
B
C
C
B
B
B
Radio link