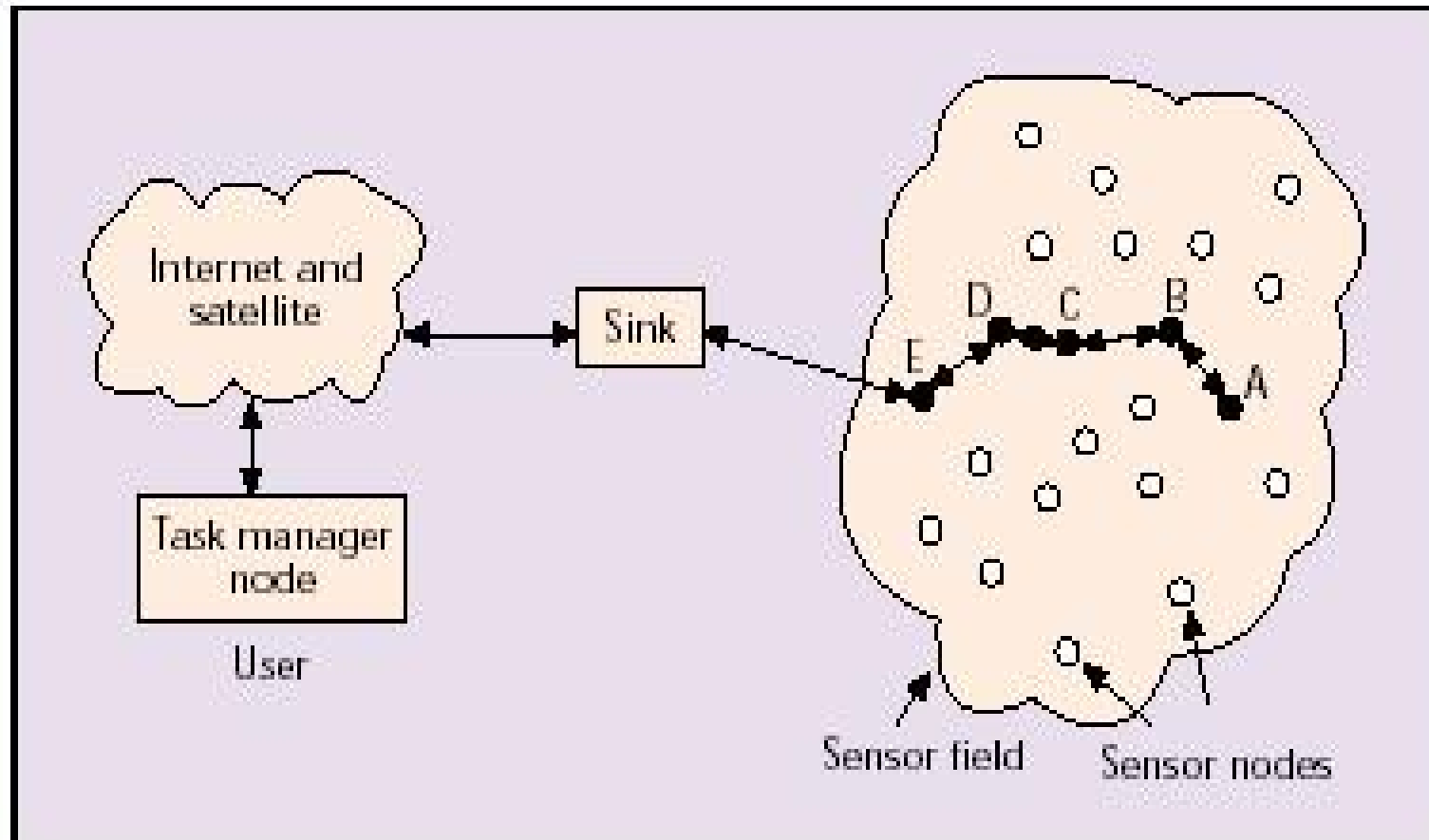
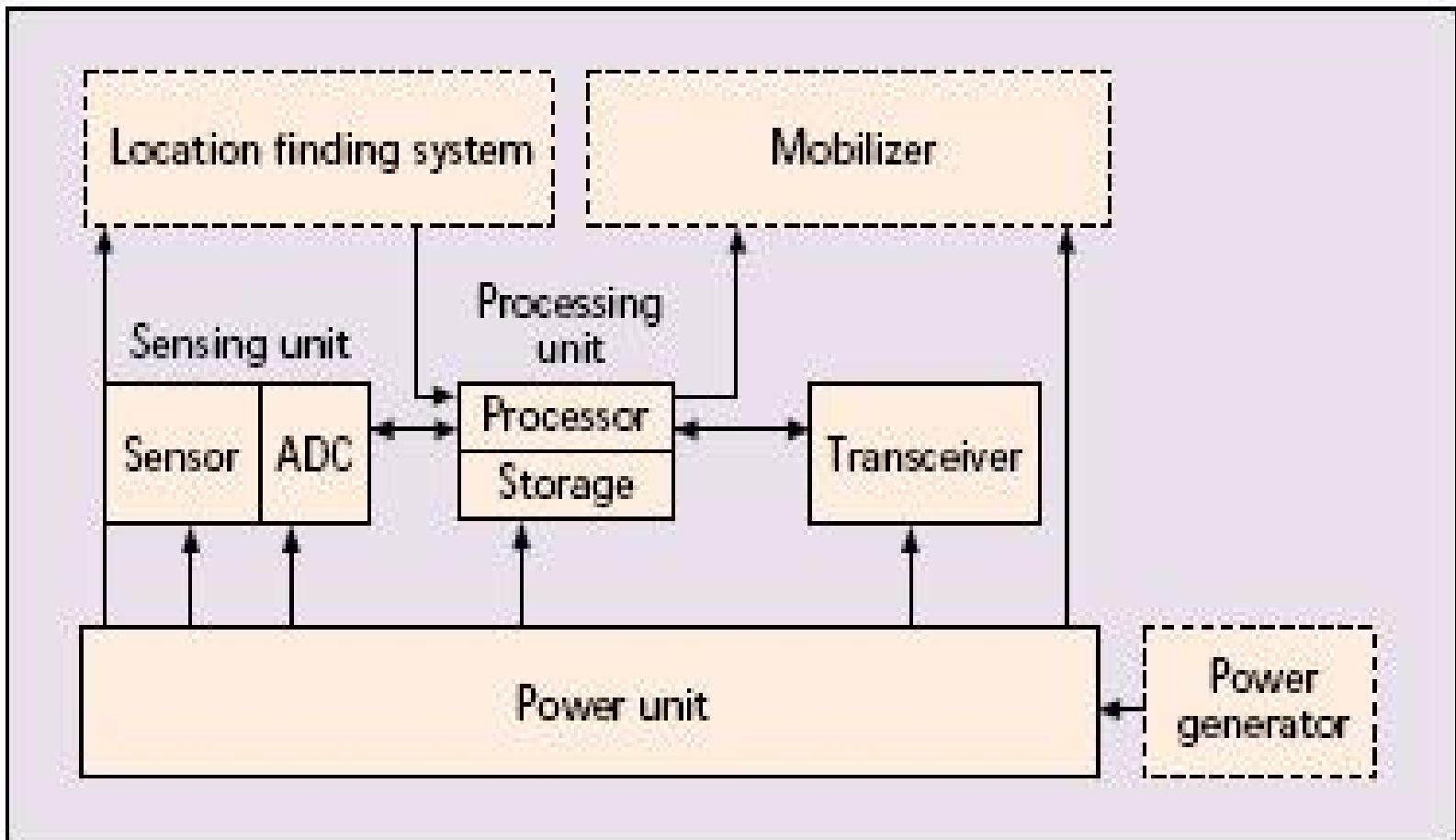


A solar-aware wireless sensor network based on low energy adaptive clustering hierarchy

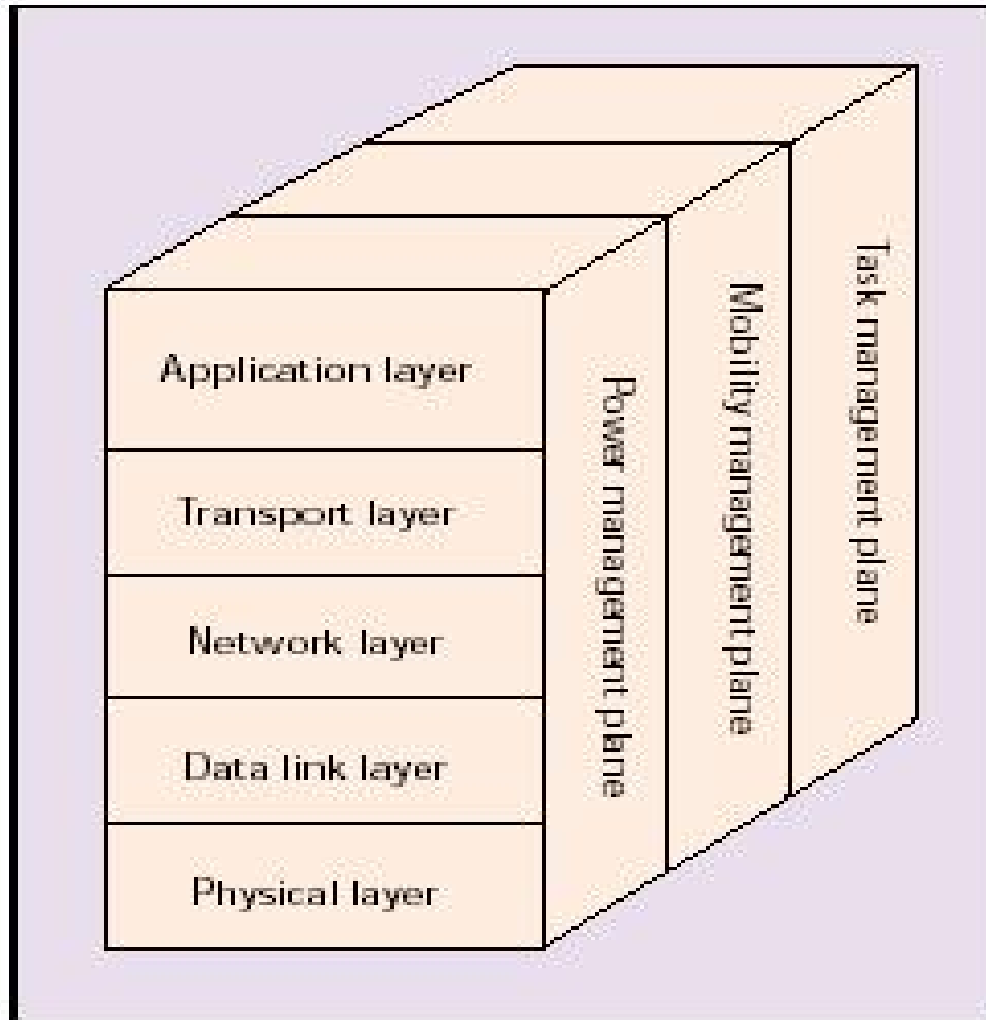
An Overview of Wireless Sensor Network



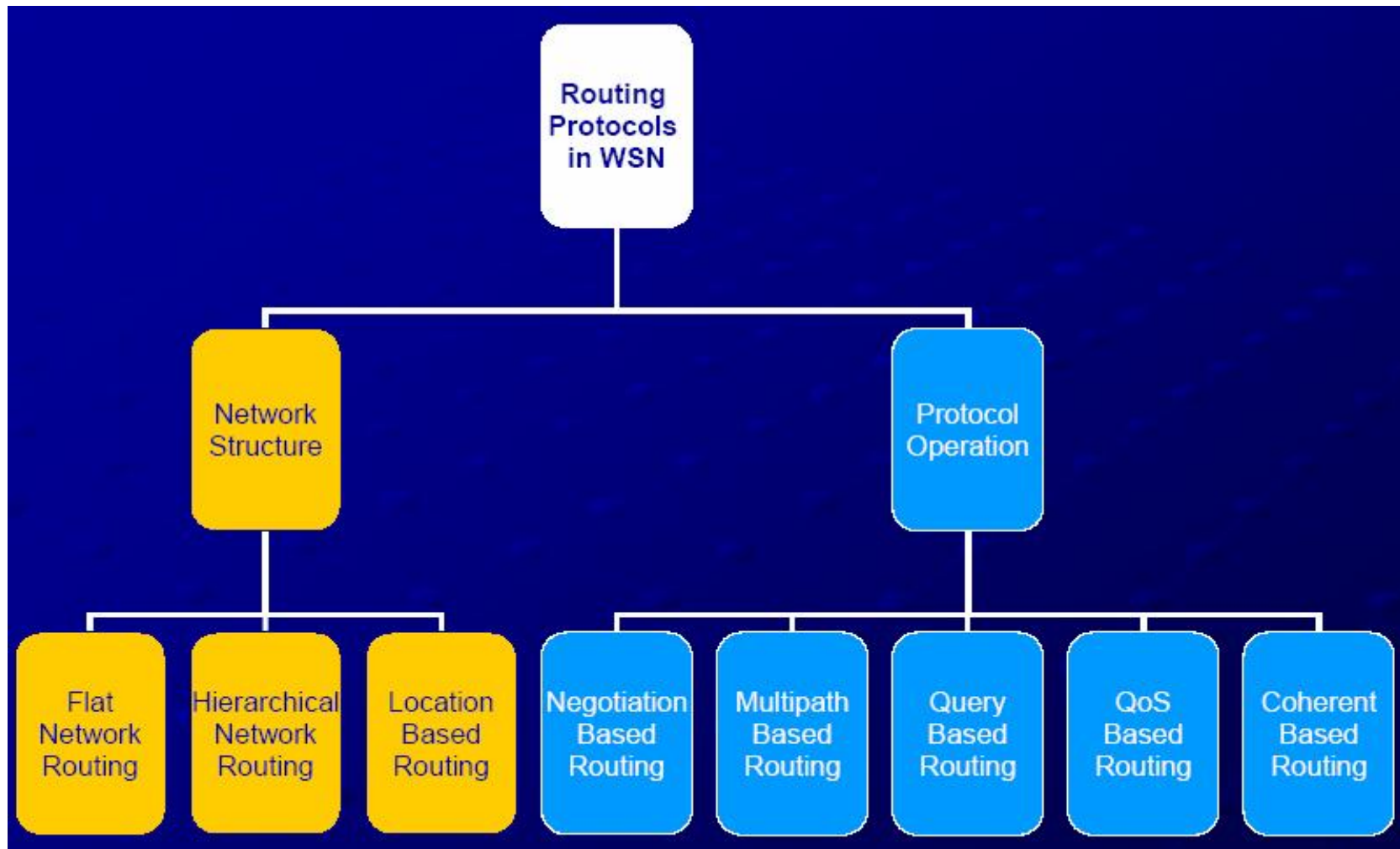
The components of a sensor node



Sensor Networks Communication Architecture



Network Layer Routing Protocols



Hierarchical Based Routing Protocol

“ When sensor density increases single tier networks cause

- . Gateway overloading
- . Increased latency
- . Large energy consumption

To allow the system to cope with additional load and to be able to cover a large area of interest without degrading the service, networking clustering has been pursued in some routing approaches.

Hierarchical Based Routing Protocol

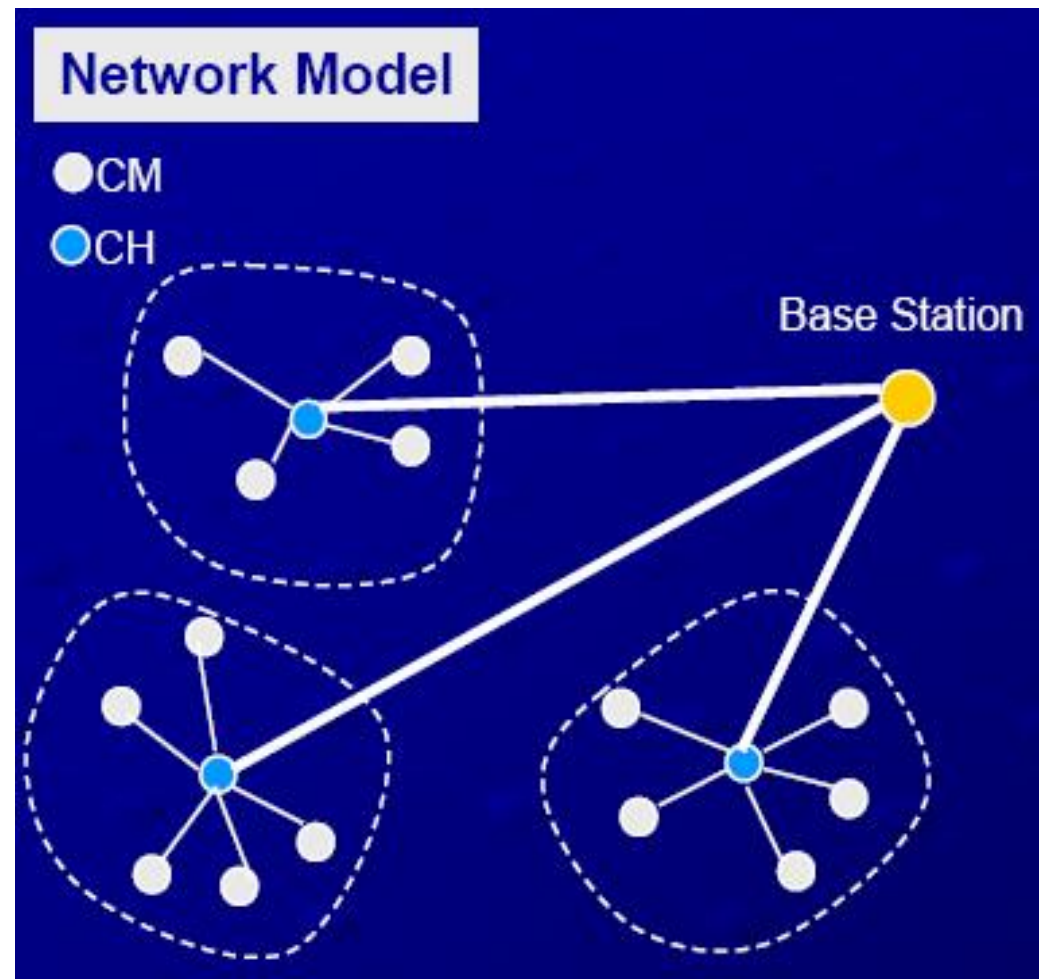
- . Uses Multi - hop communication within a cluster
- . Performs data aggregation and fusion on data to reduce number of transmitted messages to the sink
- . Maintain the energy reserves of nodes efficiently

Examples

- “ **LEACH** . Low-Energy Adaptive Clustering Hierarchy
- “ Power-Efficient GAthering in Sensor Information Systems (**PEGASIS**)
 - . Hierarchical PEGASIS
- “ Threshold sensitive Energy Efficient sensor Network protocol (**TEEN**)
 - . Adaptive Threshold TEEN (**APTEEN**)
- “ Energy-aware routing for cluster-based sensor networks
- “ Self-organizing protocol

Low-Energy Adaptive Clustering Hierarchy (LEACH)

- “ Randomized, adaptive, self-configuring cluster formation;
- “ Localized control for data transfer;
- “ Low-energy media access control;
- “ Data compression and aggregation process



LEACH Algorithm Details

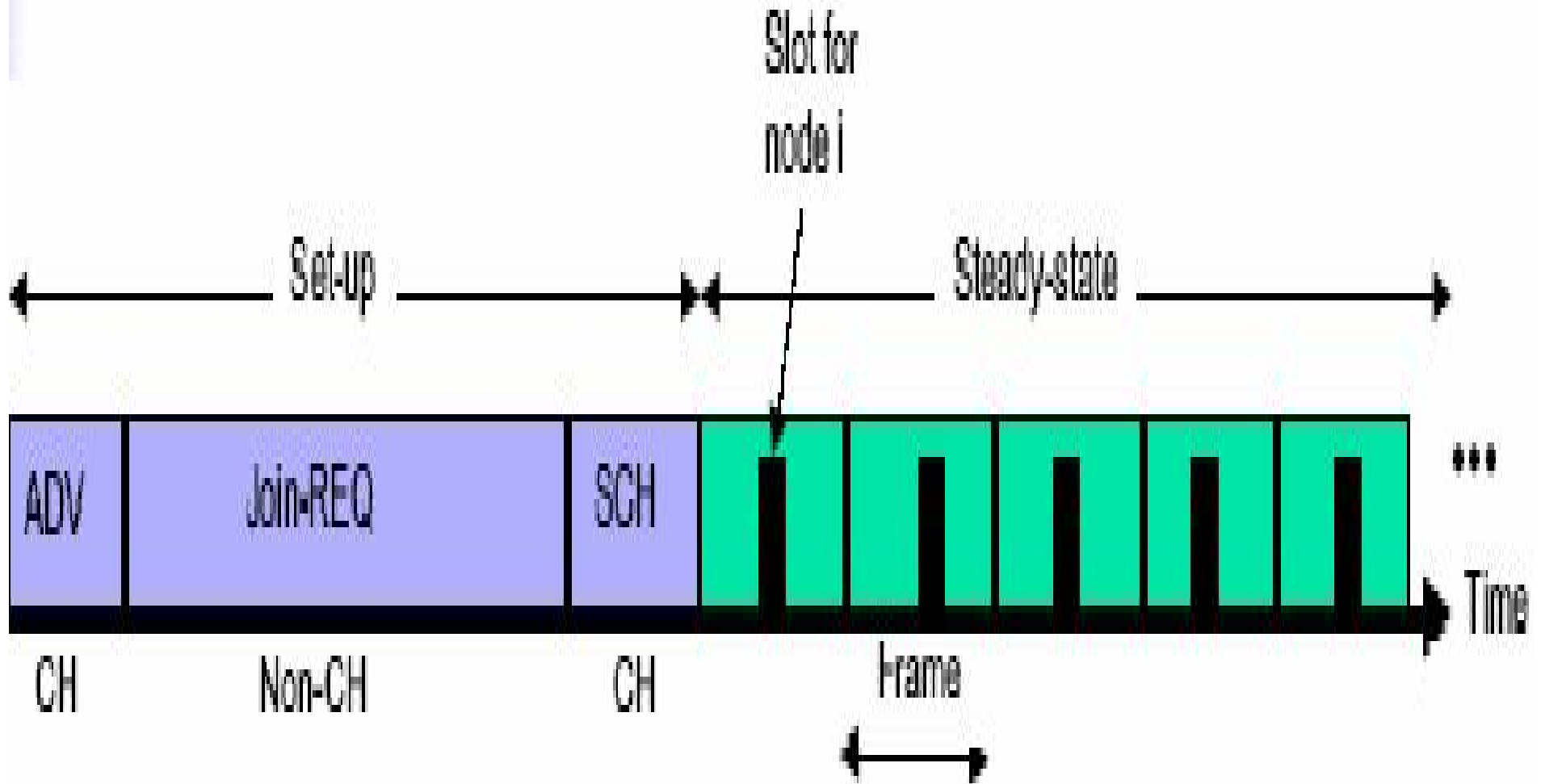
Set-up Phase

- ” Cluster-head advertisement
- ” Cluster set-Up
- ” Transmission schedule creation

Steady-state Phase

- ” Data transmission to cluster heads
- ” Signal processing (Data fusion)
- ” Data transmission to the base station

Two phases that describe the operation of LEACH



Solar-aware LEACH [sLEACH]

- “ use of renewable energy sources such as solar power prolong the lifetime of a sensor network
- “ letting nodes powered by solar energy to perform the most energy demanding tasks
- “ choosing solar-powered nodes as clusterheads is feasible and energy savings

Thus LEACH can be extended to become solar aware, a new version of **LEACH**, **sLEACH**

Solar-aware LEACH [sLEACH]

- “ Sensor nodes transmit their remaining energy level and position to the base station. They also transmit their solar status (if a node is powered by solar energy or by battery).
- “ Solar-driven nodes that have a high remaining energy level have a high chance of becoming cluster head. Clusterheads, chosen by the base station remain as clusterheads for a certain time called round.

OMNeT++, Discrete Event Simulator

- “ Allow the design of modular simulation models
- “ Object-oriented approach allows flexibility in the simulation kernel
- “ Offer an extensive simulation library
- “ Model components are compiled and linked with the simulation library and one of the user interface libraries to form an executable program
- “ Simulation kernel uses C++ to be embedded in larger applications
- “ Models are built with **NED** and **omnetpp.ini** and do not use scripts

Building Simulation Programs

An OMNeT++ simulation model physically consists of the following parts:

- “ NED language topology description(s).
These are files with the .ned suffix.
- “ Message definitions, in files with .msg suffix.
- “ Simple modules implementations and other C++ code, in .cpp files on Windows

Network Description File (.ned) Window

The screenshot displays the GNED software interface for editing a Network Description File (.ned). The window title is "GNED - H:/A-sLEACH/solar.ned - Solar". The menu bar includes "File", "Edit", "View", "Draw", "Options", and "Help". The toolbar contains icons for file operations, navigation, and drawing.

The left pane shows a tree view of the network description file structure:

- nedfile Untitled
- nedfile solar.ned
 - imports
 - import node
 - import bs
 - module Solar
 - params
 - param numNodes
 - param trRange
 - param rounds
 - param frames
 - param solarOn
 - param sunDuration
 - param sunNodes
 - param xMax
 - param yMax
 - submods
 - bs: BS
 - substparams
 - substparam id = 1
 - substparam xpos = xMax
 - substparam ypos = 1750
 - Sensor_Node: Node[numNodes]
 - substparams
 - substparam energy = intuniform(499900,500000)
 - substparam sunstart = intuniform(0,(sunNodes)*sunDuration)
 - substparam id = index+2
 - substparam xpos = intuniform(0, xMax)
 - substparam ypos = intuniform(0, yMax)
 - conns
 - network solar

The right pane, titled "Graphics NED source", shows a visual representation of the network. It features a "Solar" source (represented by a sun icon) connected to a base station (bs, represented by a tower icon) and a sensor node (Sensor_Node[numNodes], represented by a wireless router icon).

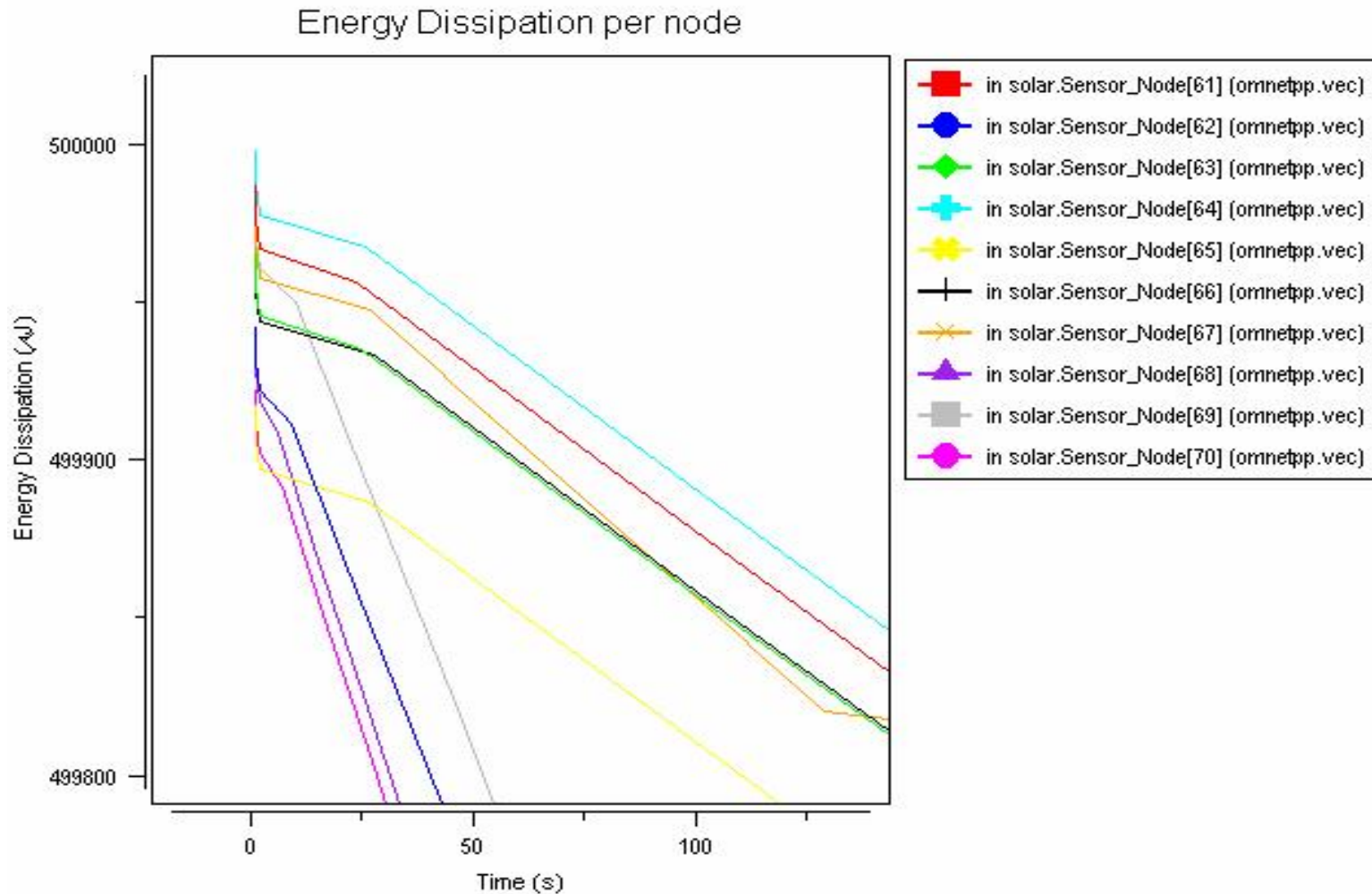
Setting Module Parameters in the Configuration File: omnetpp.ini

```
" solar.trRange = 190;  
" solar.numNodes = 100;  
" solar.xMax = 1000;  
" solar.yMax = 1000;  
" solar.rounds = 280;  
" solar.frames = 10;  
" solar.solarOn = 1;  
" solar.sunDuration = 600;  
" solar.sunNodes = 5;
```

Model of Scenario for Simulation



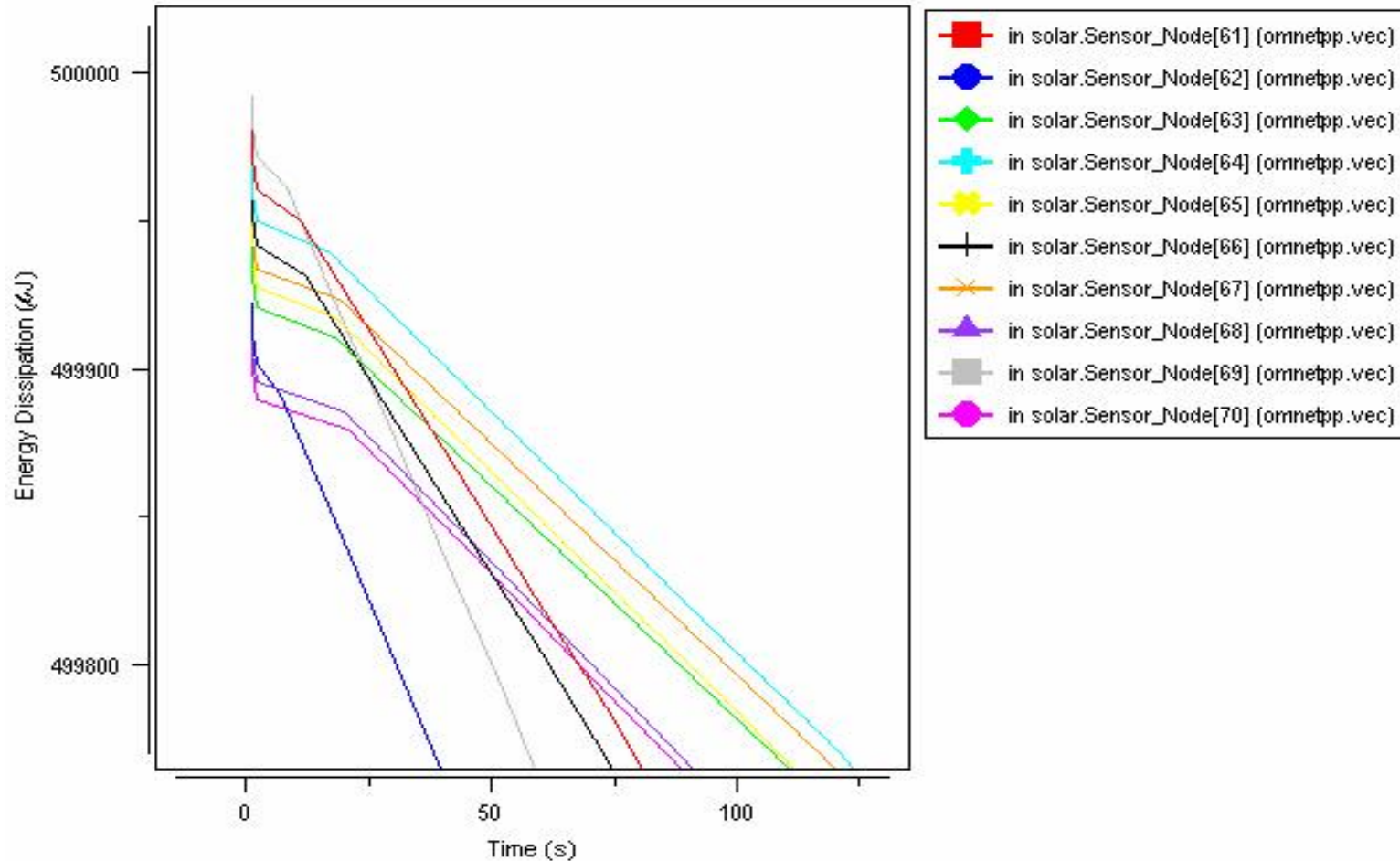
Analyzing Simulation Results



Simulation results with sunDuration=600

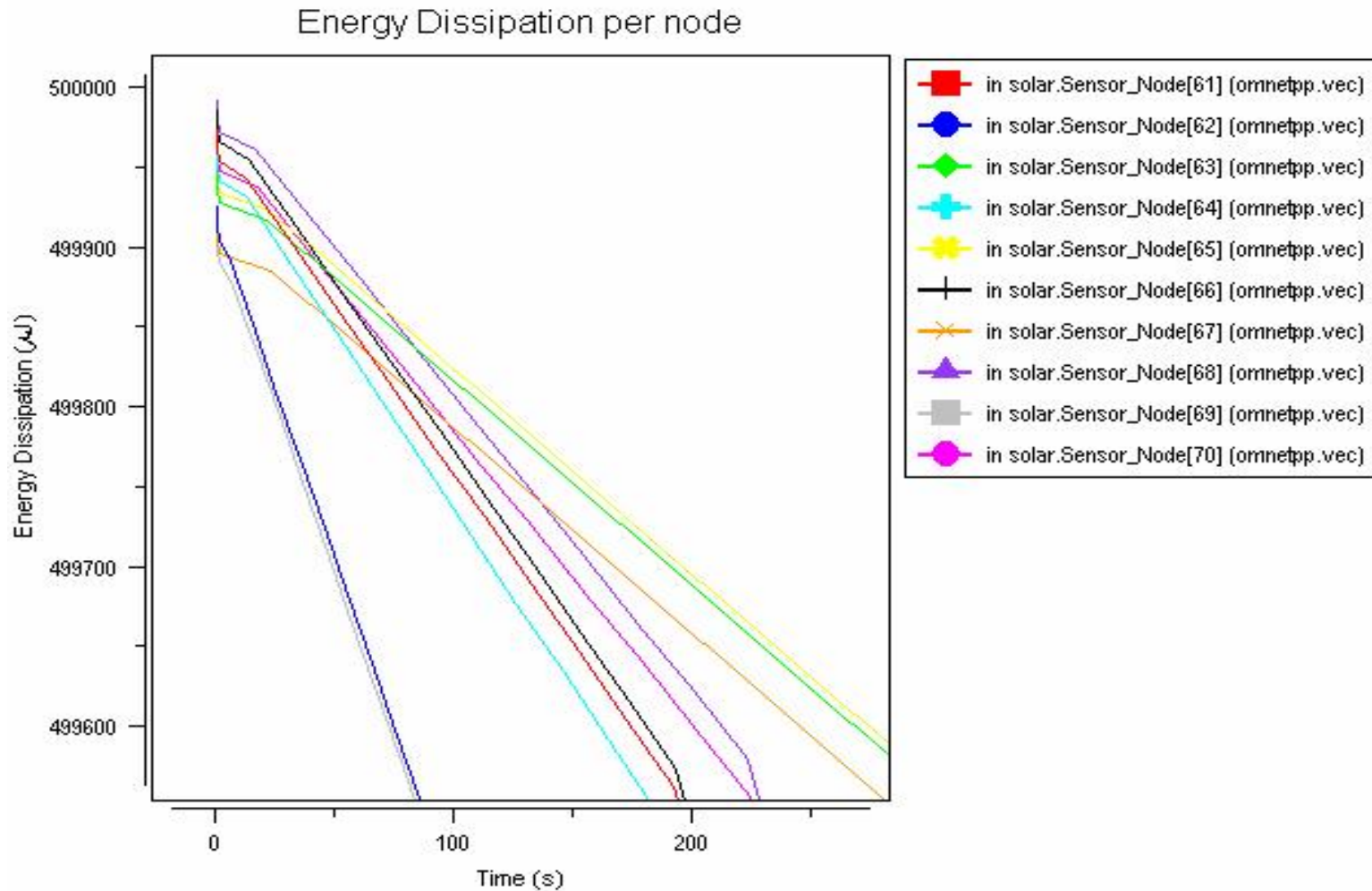
Analyzing Simulation Results

Energy Dissipation per node



Simulation results with sunDuration=1200

Analyzing Simulation Results



Simulation results with sunDuration=2400

Output scalars are used to compare designed network model behavior under various parameter settings which is shown in the following

Frames 10, Sun-Duration 600

solar.sunNodes	5	10	15	25
" solar on	120F/142H	144F/157H	152F/173	162F/168H
" solar off	104F/118H	107F/124H	117F/113H	133F/146H

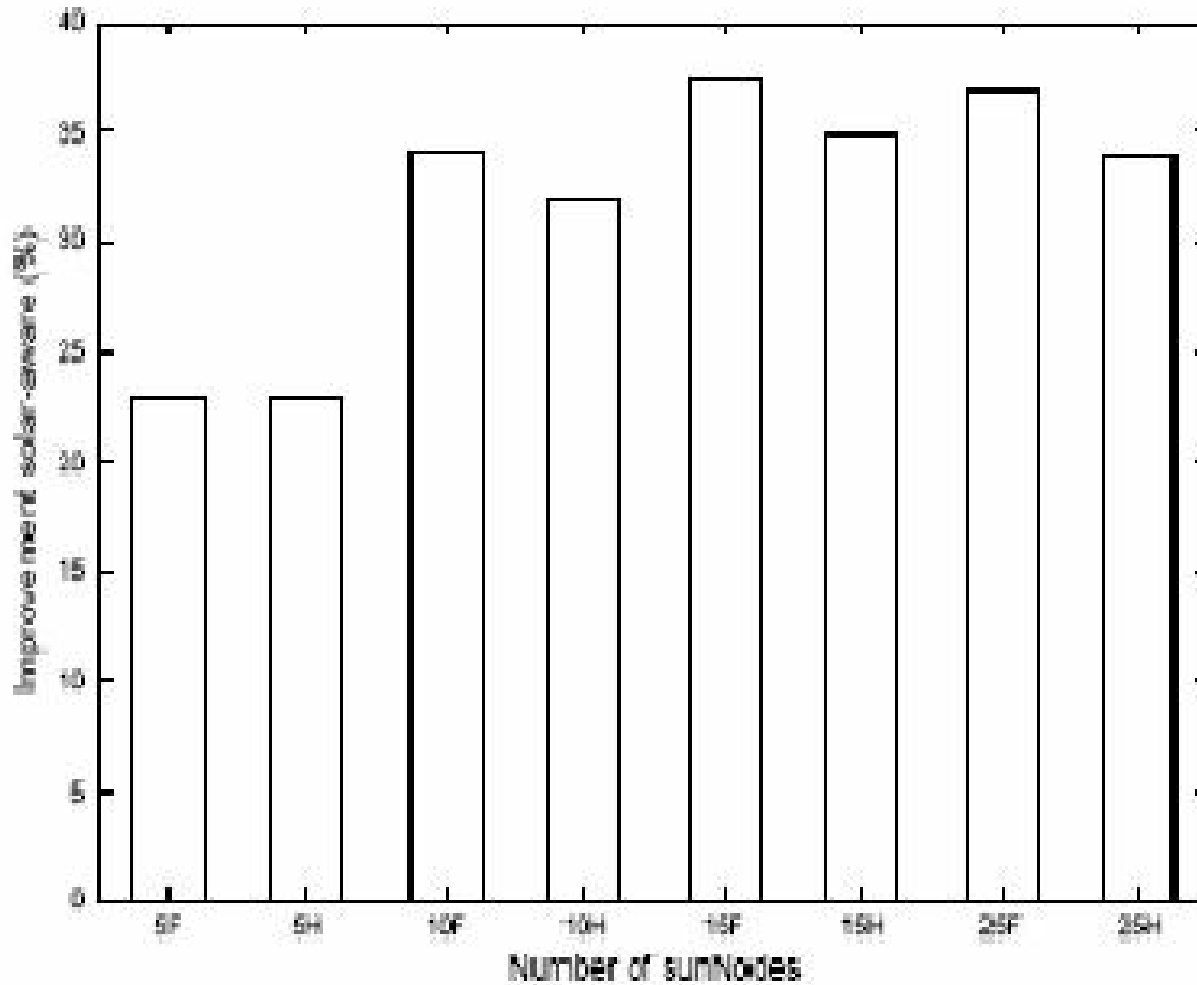
Frames 10, Sun-Duration 1200

solar.sunNodes	5	10	15	25
" solar on	128F/150H	159F/176H	165F/193H	192F/211H
" solar off	107F/123H	120F/139H	129F/142H	136F/159H

Frames 10, Sun-Duration 2400

solar.sunNodes	5	10	15	25
" solar on	140F/155H	170F/190H	188F/199H	213F/235H
" solar off	110F/127H	132F/146H	147F/165H	160F/177H

Improvement of solar-aware LEACH over the standard LEACH protocol



A solar aware sensor network has been presented. The network model has been verified through experimentation and found

- “ For longer sun-Duration the energy dissipation per node decreases with respect to time.
- “ When the node is solar powered, the number of rounds (until the first node dies) increase with increased sun - Nodes.

These features led to design solar-aware LEACH [sLEACH]. So, letting sensor nodes powered by solar energy to perform the most energy demanding tasks in sensor networks significantly extends the lifetime of sensor networks.

THANK YOU ALL