Extending Self-configuration Algorithms of Energy Constraint Wireless Sensor Networks to Emergency Environment

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Abstract

Wireless Sensor Networks have recently gained interest in building monitoring applications as a low cost and easy to install alternative. Some examples are smart/green buildings and emergency/rescue operations. These types of networks require that a large number of sensors be positioned easily and that they configure themselves to perform the tasks needed without human intervention. This raises the issue of self-organization of sensor nodes.

In the recent past, many researchers have investigated this topic. However, there is a lack of suitable self-organization algorithms which can be used in emergency monitoring applications in an indoor environment. This thesis proposes a self-organization algorithm for Wireless Sensor Networks suitable for an emergency detection and monitoring application by considering emergency environment issues.

A distributed unequal clustering algorithm with a suitable node dying pattern for an emergency monitoring application is proposed and simulated. The proposed algorithm optimizes the energy usage of the network and prolongs the network lifetime by multi-hop communication. The simulation result shows that the proposed algorithms prolong the network lifetime while maintaining the coverage of the building with existing nodes in a 2D environment. EDCR-LGRUC algorithm prolong the lifetime of the network by 1000 rounds more than the EDCR algorithm. Additional, SCAE algorithm delayed and reduced the CH failures compared to EDCR. Also, the communication failure occurred due to the CH failure is reduced by 10% compared to EDCR. Moreover, 500 data rounds are optimized in the proposed multi-hop algorithm compared to EDCR-MH algorithm.

From the application point of view, the proposed algorithm is simulated in a 3D environment. The result shows that, it achieves the same outcome as in 2D environments and that the algorithm is suitable for a wireless sensor network deployed in a multi-story building.

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Nomenclature

$Bel(i,t)$	Severity of node i at time t
c_i	Dynamic re-clustering threshold
D_{ch-ch}	Average distance between two Cluster Heads
$dist_{i.j}$	Distance between node i and j
Δ	Re-clustering threshold
$e_{cpu-change}$	energy consumption of one time state transition
e_{off-on}	One time energy consumption of opening sensor operation
e_{on-off}	One time energy consumption of closing sensor operation
E_{const}	Constant Energy Level
E_{cpu}	Processor energy consumption
$E_{cpu-change}$	Sum of the state transition energy consumption
$E_{cpu-state}$	Sum of the state energy consumption
E_{DGR}	Total energy cost of data transmission in global re-clustering
E_{elec}	Energy at the transmitter or receiver circuitry
$E_{j,i,p}$	Residual energy of node p, at the beginning of node i Cluster Head period in the Epoch j
E_{OGR}	Total energy cost of transmitting overhead data in global re-clustering
E_{sensor}	Sensor energy consumption
E_{static}	Static re-clustering threshold
$E_{rel-max,i}$	Relative maximum energy of sensor i's neighborhood
$E_{res,i}$	Residual energy of sensor i
$E_{Rx,i}$	Energy consumption in receiving state of node i
E_{TLD-P}	Total energy cost in partial local delegation
$E_{Tx,i}$	Energy consumption in transmitting state of node i
ε_{amp}	Energy at the transmitter amplifier
h	Average hop count

J_{CH}	Energy cost in a Cluster Head
J_{CM}	Energy cost in a Cluster Member
J_{total}	Total data gathering cost of one data round
k_i, γ	Random numbers
l	Length of a message
n	The radio propagation path loss exponent
$N_{cpu-change}$	Frequency of state transition
N_d	Number of nodes in partial local delegation
$N_i^{R_{max}}$	Set of nodes within the neighborhood of radius R_{max} around node i
$P_{cpu-state}$	Power consumption in a CPU state
P_{end}	Power of end state
$P_{initial}$	Power of initial state
Pl	Plausibility function
$R_{comp,i}$	Maximum compatible radius of node i
$R_{d,i}$	Radius of partial local delegation
R_{max}	Maximum communication range od a sensor node
R_{min}	Minimum communication range od a sensor node
T	Limited time interval for CH candidacy
$T_{candi,i}$	Cluster Head candidacy time of node i
$T_{cpu-state}$	Time interval in a state
$T_{initial-end}$	Time interval for the state transition
$T_{local-candi,i}$	Local Cluster Head candidacy time of sensor i
$w_i, W_{i,j}$	Weight parameters
$X_{j,i}$	number of data transmission rounds that node i serves as a CH in the Epoch j
X_S_i	Number of data rounds that node i serves as a CH after triggering static re-clustering