Universidad de los Andes
Colombia

Facultad de Ingeniería
Departamento de Ingeniería de Sistemas y Computación

COMIT – Optimización de Redes / Ingeniería de Sistemas

*Asesor: Yezid Donoso, ydonoso@uniandes.edu.co*

# A Distributed Routing Approach using a Markov Model Mobility Prediction based on RSSI Measurements in a Mobile Wireless Sensor Network

**Germán A. Montoya and Yezid Donoso**

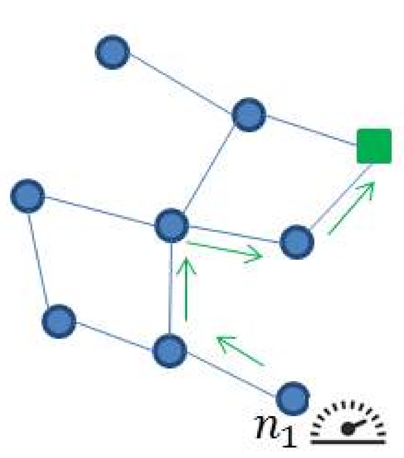
ga.montoya44@uniandes.edu.co, ydonoso@uniandes.edu.co

## Abstract

Communication disruptions caused by mobility in wireless sensor networks introduce undesired delays which affect the network performance in delay sensitive applications. To overcome the negative effects caused by mobility, we propose to use a prediction mobility method to forecast future network disconnections in order to avoiding transmission interruptions. Moreover, we propose a mathematical model to find the minimum cost path between a source node and destination node in spite of the network is changing across time. To contrast the mathematical model results we have designed two kinds of algorithms: the first one take advantage of the closest neighbours to the destination in order to reach as fast as possible the destination node. The second one simply reach the destination node if a neighbour is precisely the destination node.

## Introduction

### *What is a Mobile Wireless Sensor Network?*

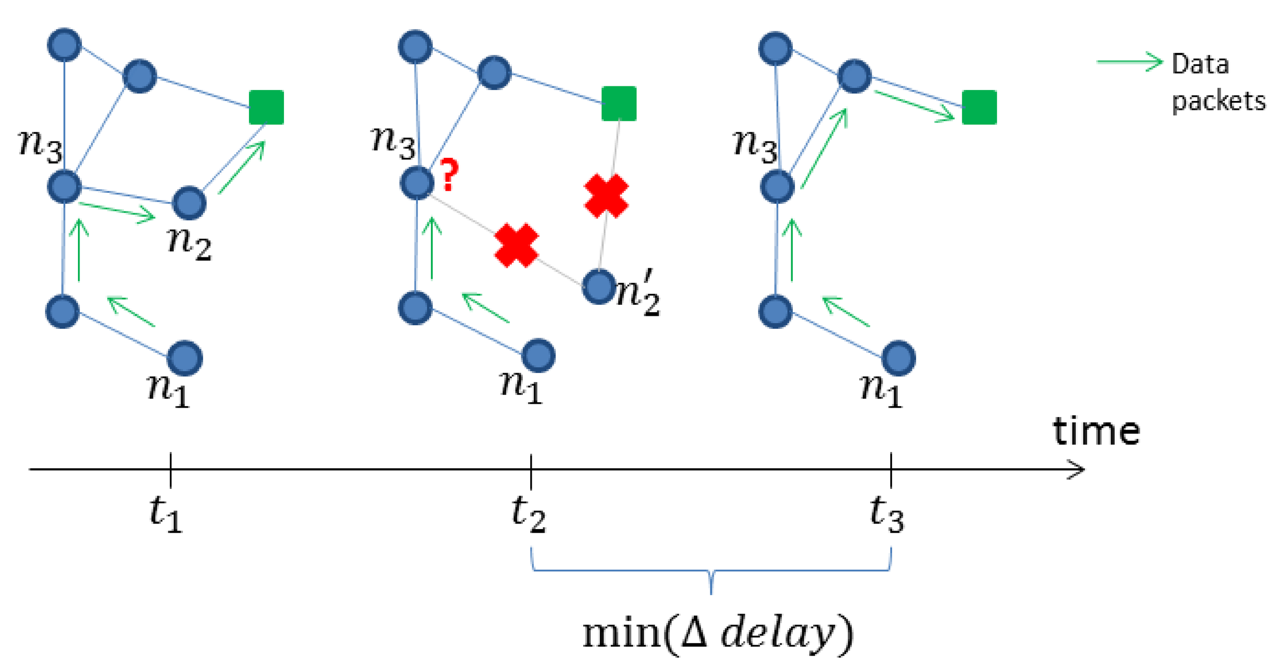



- Mobile sensor node
- Fixed base station
- Communication link between nodes

Without a GPS device

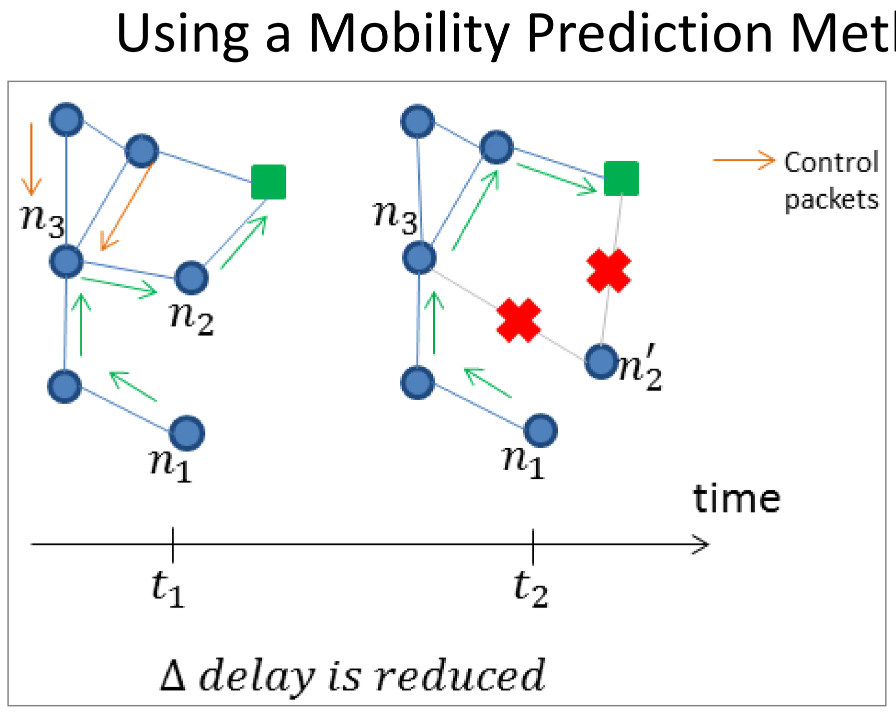
- Limited energy resources
- Limited computational resources
- Main goal: find a path between the source and the base station for sending information.
- Mobility changes

### *Problem*

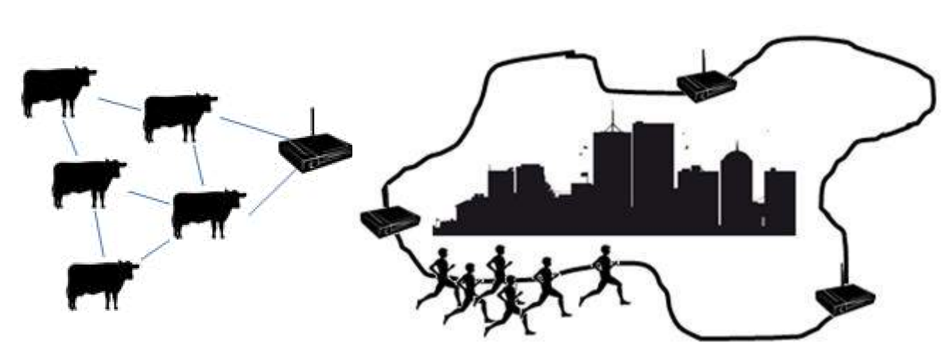



### *Hypothesis*

Using a Mobility Prediction Method



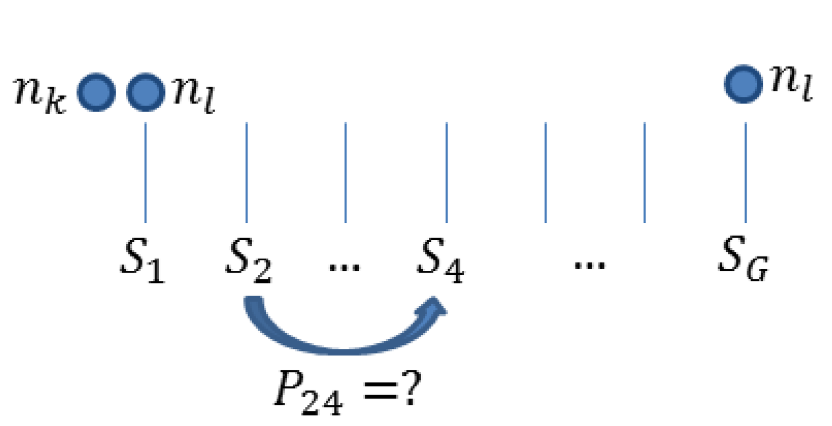

- Unknown Sensor and Base Station Positions (nodes without GPS devices)
- Neighbors proximity based on Distance (RSSI measurements)
- Applications:



## Methodology

### Markov Model

*Defining $P_{ij}$ for $n_k$ and $n_l$ :*



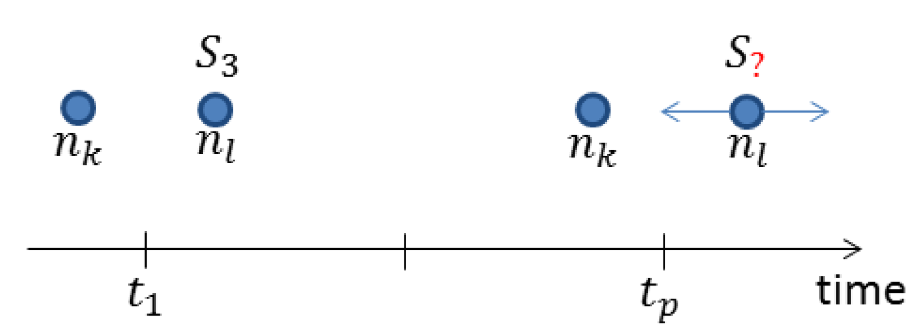

$N(S_i,S_j)$: *number of times that state $S_i$ follows state $S_j$.*

$$P_{24}=\frac{N(S_2,S_4)}{\sum_{j=1}^{G}N(S_2,S_j)}$$

$$P_{ij}=\frac{N(S_i,S_j)}{\sum_{j=1}^{G}N(S_i,S_j)}$$

$$T=\begin{bmatrix}P_{11} & \cdots & P_{1G}\\ \vdots & \ddots & \vdots\\ P_{G1} & \cdots & P_{GG}\end{bmatrix}$$

*Establishing the future state of $n_l$:*




$\pi$: *initial probability distribution of the set $S$*

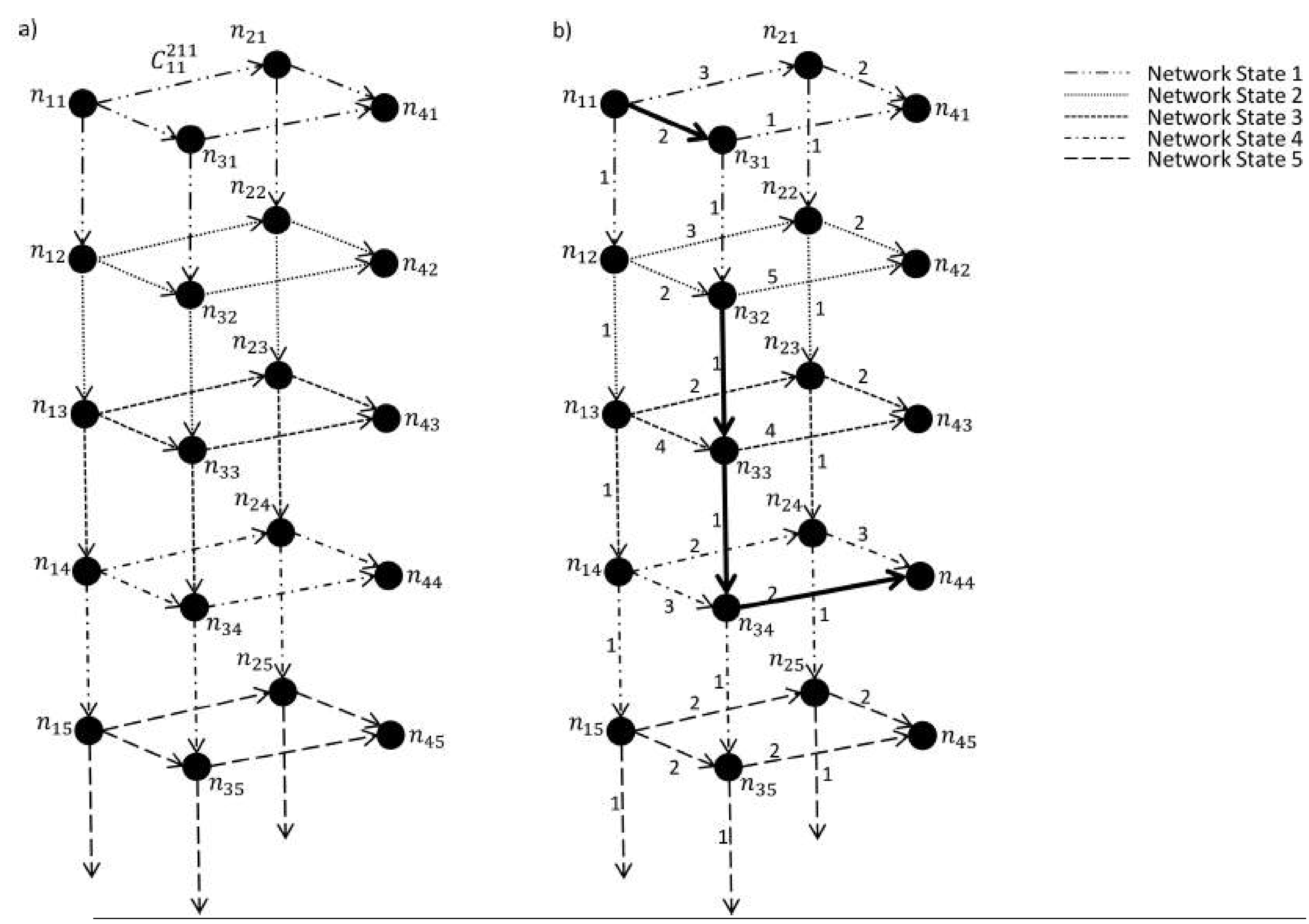
$$\pi=\{P_{S_1},P_{S_2},\dots P_{S_G}\}\qquad P_{S_i}=1/G$$

$$\pi_p=\pi * T^p$$

$$S_p=\max\{\pi_p\}$$

$$S_p=\max\{P_{S_1},P_{S_2},\dots,P_{S_G}\}$$

### Mathematical Model




| Parameters | Description |
|---|---|
| *Source* | Source node. |
| *Destination* | Destination node. |
| $C_{it}^{jul}$ | Link cost from the node *i* at the state *t* to the node *j* at the state *u* at the network state *l*. |
| **Variables** | **Description** |
| $X_{it}^{jul}$ | Determines if the link at the state *l* from the node *i* at the state *t* to the node *j* at the state *u* is selected (Binary variable). |
| $D_{jl}$ | Determines if the node *j* is selected at the destination state *l* (Binary variable). |
| $DS_l$ | Determines if the state *l* is selected as a destination state (Binary variable). |
| $Y_{i,l}$ | Determines if the node *i* at the state *l* is selected for constructing the path (Binary variable). |

## Results (partial)

**Mathematical Model:**

| Parameters and Variables | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| Nodes | 7 | 10 | 12 |
| States | 14 | 20 | 24 |
| Source node | 1 | 1 | 1 |
| Destination node | 7 | 10 | 12 |
| Solution Path | 1,3,7 | 1,2,8,7,10 | 1,8,12 |
| Delay | 2 | 4 | 2 |

**SIPCOS Algorithm:**

| Parameters and Variables | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| Nodes | 7 | 10 | 12 |
| States | 14 | 20 | 24 |
| Source node | 1 | 1 | 1 |
| Destination node | 7 | 10 | 12 |
| Solution Path | 1,3,7 | 1 2 9 7 10 | 1,8,2,12 |
| Delay | 2 | 4 | 3 |

**SIP Algorithm:**

| Parameters and Variables | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| Nodes | 7 | 10 | 12 |
| States | 14 | 20 | 24 |
| Source node | 1 | 1 | 1 |
| Destination node | 7 | 10 | 12 |
| Solution Path | 1,4,3,7 | 1,2,8,9,7,10 | 1,3,5,9,2,12 |
| Delay | 3 | 5 | 5 |