Mobility support for wireless sensor networks

Filippe C. Jabour [*][•], Eugênia Giancoli [*][•], and Aloysio C. P. Pedroza [*]

[*] UFRJ - PEE/COPPE/GTA. [•] CEFET-MG - Campus Leopoldina. Brazil

Abstract. This work proposes a two-tier approach for mobility support in wireless sensor networks. Based on local interactions among sensors, on global tasks of mobile agents and on location prediction, we demonstrate the correctness of a location prediction model. We also propose, evaluate and compare two algorithms for mobile agents decision.

Key words: mobility; wireless sensor networks; mobile agents

Introduction: Wireless sensor networks (WSN) are composed of a large number of sensor nodes that cooperate among themselves to monitor an area of interest. The sensor nodes' mobility can result from environmental influences such as wind or water. Sensors may be attached to or carried by mobile entities or they may possess automotive capabilities. Mobility has a large impact on the expected degree of network dynamics and hence influences the design of networking protocols' algorithms. The speed of movement may also have an impact. In dynamic sensor networks, either the sensors themselves, the observer or the phenomenon are mobile. Whenever any of the sensors associated with the current path from the observer to the phenomenon moves, the path may fail. In this case, either the observer or the concerned sensor must take the initiative to rebuild a new path. This work proposes a two-tier approach for mobility support in WSN. Based on local interactions, the nodes maintain a present and future estimated localization, and a list of neighbours. The mobile agents (MA) play a global role, travelling towards a target region to bring back data. We intend to allow the collection and the transport of data in sensor networks wherein may exist sources, sinks and phenomena mobility.

Location prediction model: A localization algorithm computes periodically the node's location. With two of these measures $P_i(x_i, y_i)$ and $P_{i-1}(x_{i-1}, y_{i-1})$, the node computes the slope m of the straight line defined by P_i and P_{i-1}. In eq. 1, m_i represents the node's movement direction; m_{pred_i} (eq. 2) is the predicted next movement direction; $m_{pred_{i-1}}$ is the last prediction; and α is used to give more or less weight to the last computed slope m_i in connection with the history of the estimated directions $m_{pred_{i-1}}$. Fig. 1 and 2 show the predictor simulation results for two types of trajectories ($\alpha = 0.5$). As shown in the next section, these results are sufficient for a correct migration decision of MAs.

$$m_i = \frac{y_i - y_{i-1}}{x_i - x_{i-1}} \quad (1) \qquad m_{pred_i} = \alpha\, m_i + (1-\alpha)\, m_{pred_{i-1}} \;\; (0 \leq \alpha \leq 1) \quad (2)$$

MA support: Once local interactions maintain a neighbour set and a predicted trajectory for each node, MAs may be injected into the network with a given task. This task must have a **target region** and the data type to be collected. When the MA reaches the target region, it performs the same algorithm, searching for the **return region**. No routing algorithm is needed, no state must be stored in the network and all computing (location prediction and MA decision) are of linear complexity: *O(k)*, where k is the number of neighbours and $k < n$ (n is the number of nodes of the network). We propose two decision algorithms: one based only on distance from the target region. MA migrates to the node that is closer to the target region. The other one is hybrid. MA considers first the direction, migrating to the node where the movement direction is closer to the optimum straight line towards the center of the target region. If no neighbour node is moving towards the target region hemisphere (180°), the distance is considered. Simulations were made to validate and compare the algorithms. We conclude from fig. 3 that both algorithms scale with number of nodes and speed growth, i.e., we have more hits. We also observe that the "only distance" algorithm is the better one, but we are currently investigating situations where the direction of the movement has to be considered. Fig. 4 shows the number of migrations of MAs. Migrations are related to energy consumption. As expected, more hits mean more migrations and consequently more energy consumption.

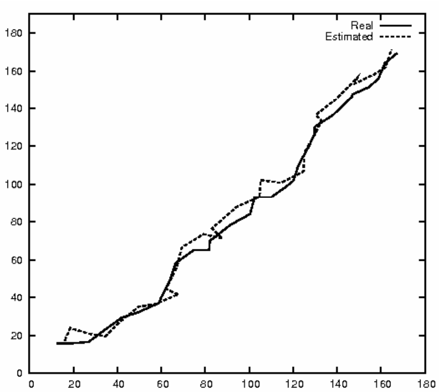

Fig. 1: Location prediction; random trajectory

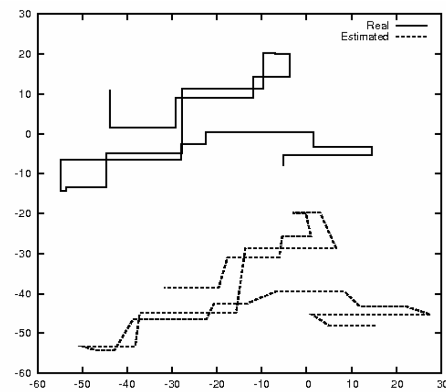

Fig. 2: Location prediction; Manhattan trajectory (y-axis translation for better visualization)

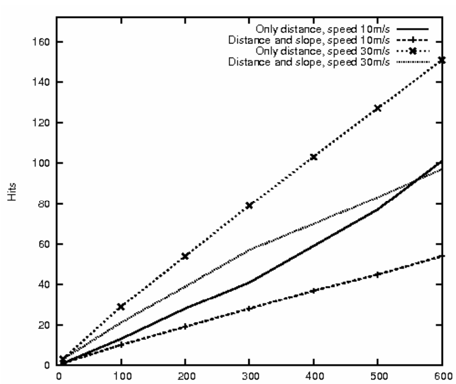

Fig. 3: MA simulation results. Hit means reach the target or the return region

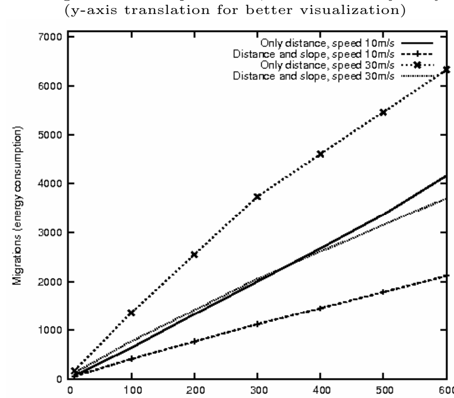

Fig. 4: MA simulation results. Migrations (energy consumption)