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Final Report - Vacant Parking Space Detector

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WSN Final Report

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1 Introduction

An important part of city planning involves estimating the amount of traffic a certain street or city district will support. Cars going to a certain destination will ultimately have to find a parking space. This means that obtaining information on parking space usage could greatly contribute to improvement of urban spaces and regulate parking pricing.

For instance, a study conducted between 1927 and 2001 [1] in several cities around the world showed that between 8 and 75% of the traffic on the streets in the study areas were looking for parking. The average time spent cruising for a parking space in urban public parking areas varies from 3.5 to 12 minutes, with distance traveled ranging from 1 km to over 1.5 km. When multiplied by the number of cars looking for a parking space, this translates into a considerable amount traffic, wasted fuel, and unnecessary air pollution.

A parking space monitoring system could help alleviate such problems. However, current vacant parking space systems are almost exclusively used in multi-story car parks. The reason behind it is that the typical sensor-based parking space detection system are costly and require a considerable amount of time and effort for installation. Intrusive sensors (e.g. pneumatic tubes, weight-in-motion sensors, piezoelectric cables) need to be embedded in floor and non-intrusive sensors are wired to the ceiling or walls (e.g. ultrasonic sensors, CCTV-based detection).

In this project we want to demonstrate a cost-effective alternative to such systems with a prototype using interconnected wireless sensors. By using Crossbow MicaZ motes, the sensors could be used in parking lots without roof, or even on the streets for curb parking slots. The statistics are then fed to a web server that could be accessed, for example, by the parking lot operator or by smart devices on cars. This means that such a system could provide benefits for both parties:

Benefits for operators	Benefits for drivers
Near-real-time parking lot occupancy information.	Guided assistance in finding a free space.
More efficient and safer traffic flow.	Reduced carbon dioxide emissions.
Parking usage trend analysis.	Lower fuel consumption.
Improved space utilization.	Cruising time savings.
Valuable statistics.	Less frustration.

Table 1.1: Examples of benefits for a cost-effective Vacant Parking Space Detector system.

2 Project Description

2.1 Requirements

Our proposed solution will feature the following:

- Low power consumption – The system will focus on event-driven updates in order to conserve as much energy as possible and prolong time between sensor battery replacements.
- Ease of installation – With a wireless sensor network approach, this system will avoid cabling installation. Also, dynamic routing makes it possible to install sensors in a plug-and-play fashion.
- Reliability – The routing protocol focuses on reaching the control center keeping several alternate paths ready in case of connectivity loss.
- Error detection – By keeping track of each device's power level on every message, sensors running low on battery can be quickly identified and get a replacement before losing connectivity.
- Fast reaction times – The system is designed to notify of parking status changes within 5 to 10 seconds.

2.2 Topology

The two scenarios where this solution could be applied would be mainly in parking lots, and multi-story car parks, but also curb parking spaces. In order to communicate the status of the parking spaces, Crossbow MicaZ motes are programmed with one of three roles (see figure 2.1):

1. Sensor - Mote running on two AA batteries equipped with a light sensor and encased in a protective shell that is fixed to the floor or pavement. It is responsible for monitoring parking space occupancy and inform its immediate gateway of a status change.

2. Gateway - Mote connected to a power source in an elevated position (e.g. a street lamp). It provides network access to the sensors by forwarding their status messages towards the control center. It also builds a distance-based routing table that consists of neighbor gateway addresses and their distance to the control center.

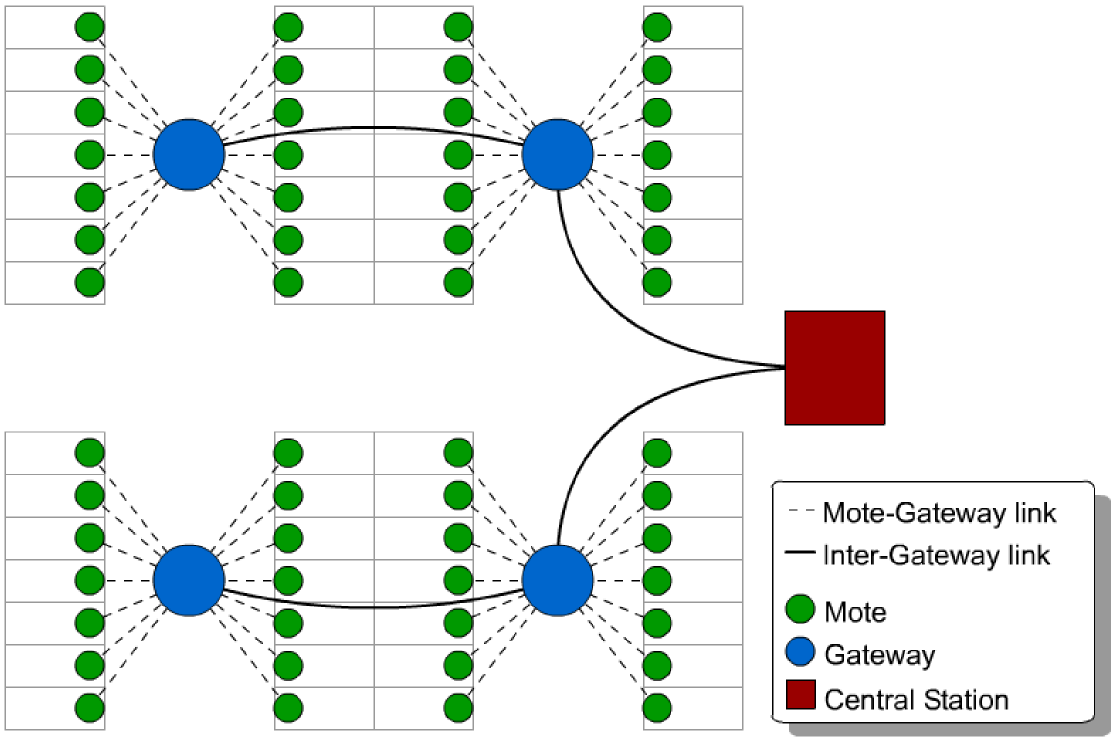

Figure 2.1: Example topology of a small parking lot

3. Control Center (CC) - Mote connected to a computer or web server. This device will receive and process all status messages from every gateway. It also provides statistical information and GUI for the parking lot operator and information to be printed in an outdoor display for the drivers.

2.3 Routing

The routing protocol proposed is dynamic and meant to ease installation in a plug-and-play fashion. The objectives of our implementation is to develop a simple, yet effective and fast route selection. It should provide quick reaction times and backup path switch-over in case of gateway saturation or connectivity loss. Lastly, it should allow new sensors or gateways to be added to the network with as little configuration effort as possible, if any. We decided a protocol mix of Dijkstra and rumor routing could meet all these requirements.

2.3.1 Rumor Routing

Each node has its neighbor list, and an events table, with forwarding information to all the events it knows. After a node witnesses an event, it sends a special long-lived packet to the network known as an agent. The agent travels around the network hopping from node to node creating a path towards the event. Each agent contains an events table, including the routing information for all events it knows. Since an event happens in a zone, composed of several or many nodes, it's possible more than one agents are created from the zone and moving in the network. An agent's routing table will be updated if there's a shorter path to an event within the routing table of the node it is visiting. Also, the routing table of the currently visited node will be updated if its route to an event is more costly than the agent's.

Once there are events, agents and paths on the network, any node may query for a particular event. If it knows the route to the event, it will transmit the query. Otherwise, the query will be sent and propagated in a random direction until the query reaches a node with a route to the event.

Properties

- Power saving, improves network longevity.
- Robust in dealing node failure.
- Tunable, allow tradeoff between setup overhead and delivery reliability.

Assumptions

- No coordinate system is available so location information is not known by nodes.
- Static topology.

2.3.2 Dijkstra's algorithm for best path selection

Disadvantages

- Looking for the shortest path by flooding consumes a lot of energy.
- Flooding increases the chance of collision.
- This application only requests a small amount of data back (ACK).

How have we combined them.

The first device in the network should be the control center. Afterwards, the gateways can be installed and turned on. Upon booting, the gateways will start exchanging routing information and converge once a wireless path towards the CC is found. If at least one gateway is online, sensors can be installed. These will attempt to discover any gateway within range and create an ordered list of gateways based signal strength. When a parking status event triggers a message, the sensor will attempt to send it to the nearest gateway for forwarding. If this gateway fails to process the packet, the sensor is notified and will then repeat the process with the next gateway on its list.

3 Implementation Details

3.0.3 Network Discovery

3.0.4 Parking Status Propagation

3.0.5 Packet Format

3.0.6 Hardware used

3.0.7 Graphical User Interface

4 Test results

5 Summary

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B Bibliography

[1] Donald Shoup. Cruising for parking. *Access Magazine*, 2007.

[2] D.B.L. Bong, K.C. Ting, and K.C. Lai. Integrated approach in the design of car park occupancy information system (COINS). *IAENG International Journal of Computer Science*, 2008.

[3] Amin Kianpisheh, Norlia Mustaffa, Pakapan Limtrairut, and Pantea Keikhosrokiani. Smart parking system (SPS) architecture using ultrasonic detector. *International Journal of Software Engineering and Its Applications*, 2012.

[4] David Braginsky and Deborah Estrin. Rumor routing algorithm for sensor networks. In *First Workshop on Sensor Networks and Applications (WSNA)*, pages 1–12, 2002.