Demo Abstract: Follow-Me Application - Active Visitor Guidance System *

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Categories and Subject Descriptors

C.2.2 [**Network Protocols**]: Applications
C.3 [**Special-Purpose And Application-Based Systems**]: Real-time and embedded systems
H.4.m [**Information Systems Applications**]: Miscellaneous

General Terms

Algorithms, Management, Design, Human Factors

Keywords

Deployment Order, Logical Location, Walkable Connectivity, Configuration, Sensor Networks, Guidance

1. INTRODUCTION

This demonstration will show two sensor network technologies:

- An active visitor guidance system
- *Deployment order* for location aware network configuration

For a visitor stepping into an office building for the first time, navigating unknown places can be difficult and unpleasant. While signs may guide the way, and computer kiosks may provide room numbers and maps, neither provides active assistance to visitors as they move through a building.

The *Follow-me* application is a sensor network based active visitor guidance system. It is easy-to-deploy and self-configurable. In the system, sensor nodes with LEDs and buttons are deployed throughout a building, one on the wall at each office doorway. They blink lights to indicate a path through the building, guiding a visitor with a "breadcrumb trail" to the destination.

The most important aspect of the follow-me application is location-aware configuration. GPS and similar systems determine location today, but they require substantial infrastructure in the environment or on sensor nodes to locate nodes in a physical coordinate system. For many applications, logical location — the relationship of nodes with each other and their environment — can be more important than physical location. For example, distance along a road and presence of intersections may be more relevant than Euclidean coordinates for applications that track or guide drivers.

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We developed *deployment order*, a new algorithm to configure logical location in a sensor network. Deployment order exploits node deployment patterns and simple user interactions to define logical topologies in a completely distributed manner with little human input. The logical topology connects nodes as a human would walk, as opposed to the radio or physical topologies. With minimal user interaction it can establish arbitrarily complex logical topologies.

2. DEMONSTRATION

We place sensor nodes in the demonstration area (on a table in this conference) and show how they will work in an in-building environment.

We will first demonstrate how follow-me shows paths to visitors. A visitor selects a destination from a touch screen (or press a button on a special node) to start a path finding process. The network will find the path and use synchronized blinking patterns to show this path to the visitor.

Second we will show how deployment order can configure logical locations of additional nodes. People can interact with sensor nodes to change system configurations.

3. CONTRIBUTIONS

Follow-me represents a class of applications where sensors are deployed to assist navigation. Other examples include marking paths in buildings damaged by earthquake or fire, or underground exploration. Sensor nodes can guide people and sense the environmental hazards at the same time.

The need for logical location extends beyond follow-me. In many applications, both indoors and outside, logical position information is not immediately apparent from physical node deployment. We expect applications that require exact physical location to warrant deployment and use of specialized hardware or infrastructure. However, deployment order fills two roles not possible by these approaches: a very small, light-weight approach for approximate location when simpler software and minimal hardware is required; and the consideration of logical connectivity such as "walkable connectivity" required by applications such as follow-me.

More details about deployment order and the follow-me application will appear in paper [1].

[1] Xi Wang, Fabio Silva, and John Heidemann. Infrastructureless Location Aware Configuration for Sensor Networks. To appear in *Proceedings of The Sixth IEEE Workshop on Mobile Computing Systems and Applications*, Dec. 2004, (WMCSA 2004).

Center for Embedded Networked Sensing

Infrastructureless Location Aware Configuration for Sensor Networks and the Follow-Me Application

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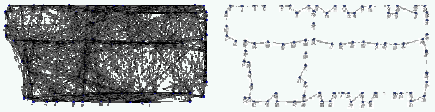
Introduction

- Sensor network
  - Configuration is important
    - Network: Ad hoc deployment
    - Nodes: Numerous, small and inexpensive
  - Location information is important
    - Essential environmental parameter
- This demo includes
  - ***Deployment order:*** New approach for easy configuration of ***logical location***
  - ***Follow-me:*** New application for sensor network assisted navigation, based on deployment order

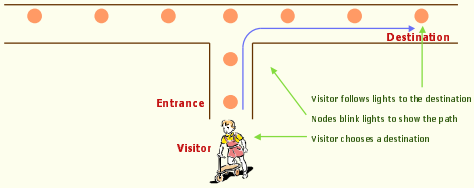


Comparison between radio connectivity (left) and logical topology (right)

Logical Location

- The main technical challenge of follow-me is to derive location information for path finding
- Network routing techniques are not directly applicable
  - Unlike radio wave, humans are constrained by physical walls and prefer to follow adjacent nodes
- Logical topology
  - Connects nodes as a human would walk, as opposed to the radio or physical topologies, or "walkable connectivity"
- Logical location
  - The relationship of nodes with each other and their environment
    - E.g. at room 1234, at the intersection of x and y
  - Logical location in this work means
    - In logical topology, which sensor nodes are adjacent to which other sensor nodes, expressed as a set of neighbors for each node
- We developed ***deployment order*** method to derive logical location

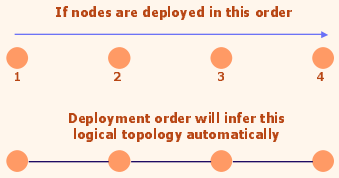
Follow-Me Application



- Guide a visitor from point A to point B
- Our approach
  - Sensor nodes are deployed around a building on walls, one at each office doorway
  - Nodes blink their lights to indicate a path, guiding a visitor with a "breadcrumb trail" to the destination
- Compared with existing systems
  - Follow-me guides visitors as they move through a building. Neither signs nor computer kiosks provides the same kind of active assistance
- Applications
  - In office environments follow-me demonstrates basic technologies of our approach
  - Other applications about sensor node assisted navigation can be derived, including
    - Emergency evacuation
    - Underground exploration
- Follow-me uses ***deployment order*** method for ***logical location*** configuration

Deployment Order for Logical Location

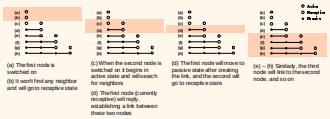
- Sensor nodes are often deployed sequentially
  - E.g. dropped one by one by a single person or vehicle
- Deployment order takes advantage of this information
  - When two nodes are deployed (switched on) one after the other within a short time, we assume that they are closest neighbors to each other
  - Links between these closest neighbors can create a path. If nodes can detect and remember this path, it can be used later to guide visitors
- "Intersections" (non-linear topologies) are handled by interactive configuration



Linear Topology

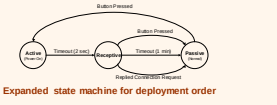
- Deployment order can be defined with a simple state machine
- Three states
  - Active: This is the state after a node is switched on. Nodes in this state send out connection request packets to look for neighbors
  - Receptive: Nodes in this state will reply to connection request packets (from active nodes). A reply establishes a link between the two nodes
  - Passive: Nodes in this state will not be involved in link operations. This is the state for normal operation

Basic state machine for deployment order

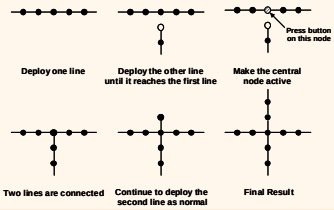


"Intersections" and Arbitrary Topologies

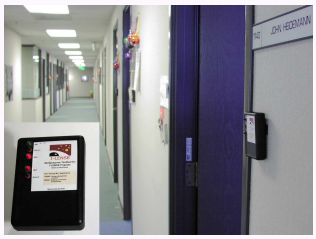
- If we give users a little bit of control over the state machine, they can then connect nodes to make arbitrary topologies
- We use a button on sensor node to toggle node states
- Updated state machine & example below



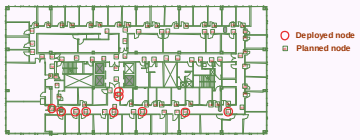
Expanded state machine for deployment order



Follow-Me Deployment at ISI



- Currently 8 nodes along a hallway, 2 nodes at an entrance (see above).
- A small subset of a possible whole floor deployment (see below)



Map of ISI 11th floor – follow-me deployment scheme example

Conclusion

- Contributions
  - Developed deployment order
  - Implemented and deployed follow-me
- Deployment order fills two roles:
  - A very small, light-weight approach for approximate location
  - The consideration of logical connectivity such as "walkable connectivity" required by applications such as follow-me
- Follow-me demonstrates sensor network assisted navigation

Other Issues Covered in Our Paper

- Physical location estimation and evaluation
  - Deriving physical coordinates from logical topology and landmarks
  - Useful alternative to traditional localization
- Initial evaluation of deployment order
- Link repairs and fault handling for deployment order
- Path finding and route catching
- User interface
- Implementation
  - Time synchronization
  - MAC layer interactions

This poster is based on: Xi Wang, Fabio Silva, and John Heidemann. Infrastructureless Location Aware Configuration for Sensor Networks. To appear in Proceedings of The Sixth IEEE Workshop on Mobile Computing Systems and Applications, Dec. 2004, (WMCSA 2004). URL: http://www.isi.edu/~xiw/papers/config_location.pdf

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