

## Monitoring With a Mix of IR Sensors and Cameras

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I-LENS

### Introduction: Applications and Technology

#### Application: balance privacy and security

- **Goal: Monitor building or areas**
  - Help prosecute theft in office environments
  - Monitor animals in natural habitat
- **But don't want cameras in every room**
  - Privacy concerns: people don't want to be watched everywhere.
    - People accept cameras in public areas like lobbies
    - Most don't want them in private offices
  - Cost and practicality: ubiquitous cameras expensive and difficult to deploy
  - **Our approach:** Augment cameras in lobbies with infrared sensors in hallways
    - Cameras can collect photos of people but only in public areas
    - IR sensors associate events (for e.g. theft), with place and time even in private areas
    - Challenge: relate IR-sensed events with camera photos, on demand

#### Technology: Demonstration of new sensor net technologies

- **Spatio-temporal search**
  - Use *Directed Diffusion* and stored readings.
  - Do processing only when needed, to save energy.
  - No transfer of data to central site.
- **Bulk image transfer**
  - Use *Reliable Multi-Segment Transport (RMST)*, a reliable data transport layered over Diffusion.

### Problem Description: Spatio-temporal search and reliable bulk transfer

#### Search through stored data in a sensor net

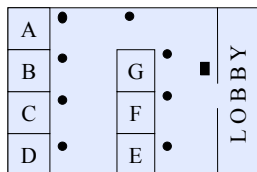
- **The scenario**
  - A building floor deployed with cameras, nodes and PIR sensors, stores information indicating when private areas are accessed.
- **The Problem**
  - To establish a *chain of events* tracking the movements of an intruder from site of theft to the entrance, where a picture of the intruder could be available.
  - All processing to be done only when needed i.e. after the theft.
  - No data transport to a central site. Save communication overhead.

#### Reliable image transfer over low-speed networks

- Demonstrate usability of RMST.
- RMST, a data transport protocol, layered over *Directed Diffusion*, which provides reliability and fragment reassembly.
- Once an image which is potentially correlated to a theft is found, it is transmitted to a display node using RMST.

### Proposed Solution: Recursive search using spatio-temporal queries

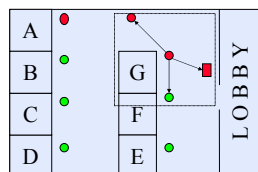
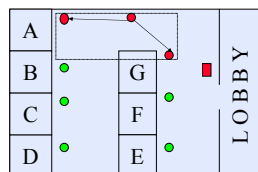
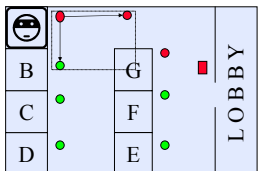
#### Observation Mode



- Node with only PIR sensor
- Node with PIR sensor and camera

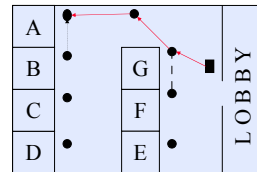
- **Layout of a typical building floor.**
  - A-G are private areas equipped with PIR sensors at entrance.
  - The lobby entrance is equipped with a PIR sensor and camera.
- **PIR sensors monitor private area occupancy.**
  - This is considered acceptable because there is no camera.
- **Camera photographs visitors when they enter floor**
  - This is considered acceptable, because lobby is public area.

#### Search Process



- **Suppose theft occurs in A.**
  - Red nodes have events related to theft. Green nodes don't. Dotted rectangle shows region which receives query
  - A queries nearby nodes, tagging the query with its geographical location and time of theft.
- **A receiving node, calculates a time window of interest and makes the query against local database.**
  - If it has matching events, it propagates the query tagging the query with appropriate timestamp and geographical information.
  - If there are no events, query is not propagated
- Hence the query moves in time (adjusting time windows) and space (from node to node), and reaches the camera node

#### Result



- **Red arrows indicate positive responses**
  - They are propagated to the initiator in this case A.
- **The dotted arrows indicate negative responses**
  - Negative responses are needed to indicate receipt of query.
- After image is found, RMST is used to send image over sensor net.

#### Conclusion

- Demonstrates spatio-temporal search through stored data.
- Demonstrates reliable bulk image transfer using RMST.
- Architecture reduces camera deployment which reduces cost and increases privacy.
- Since data is not transferred to a central site, communication cost is reduced.