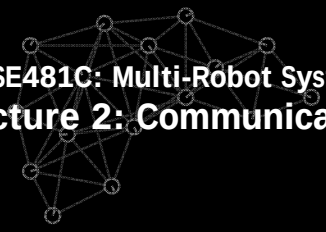
CSE481C: Multi-Robot Systems
Lecture 2: Communications



Communications is Necessary

This is the main difference between multi-robot systems and single robot systems
- All the data is not on a single computer
- Some kind of communications is required to cooperate

The communication cost of getting the data onto a single computer is often high
- Often too high to pay
- Multi-robot communications needs to consolidate this data somehow

OSI 7-Layer Network Stack

7. application

6. presentation

5. session

4. transport

3. network

2. data link

1. physical

Concepts

End-to-end Principle
- Put the intelligence at the ends
- Let the stuff in the middle be stupid

Best-Effort Routing
- "We'll do out best to deliver your packet"
- No guarantee on time or path

Time
- Asynchronous: Ethernet CSMA, Exponential Random backoff
- Synchronous: Big global clock, distributed synchronizers

Routing

Flooding
- simple
- lots of wasted messages

Routing tables
- distance vector (RIP) routing
- each node has a routing table to all other nodes

Hierarchical routing
- requires much smaller routing tables
- need asymmetrical hardware to handle lots of packets
- but what if the network is changing frequently?

Graphical routing
- You can use the position of the node as a type of hierarchy
- Get packet close to the destination, then simple routing tables can do the rest

Ad-hoc networks

Sensor networks
- simple hardware
- limited bandwidth and processing

Building trees
- Use a broadcast flood
- Build efficient routing structures dynamically

SwarmBot Summary

7. application: **Shared memory API**

6. presentation: n/a

5. session: n/a

4. transport: n/a

3. network: **Broadcast trees**

2. data link: **8-byte packets**

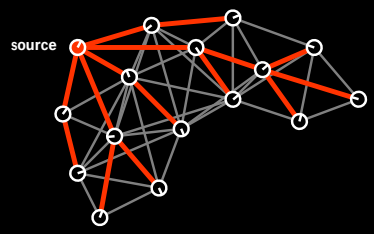
1. physical: **IR with Manchester encoding**

Multi-Robot Networks

Multi-Robot Networks

Broadcast Tree Construction

Broadcast flood



Message Speed

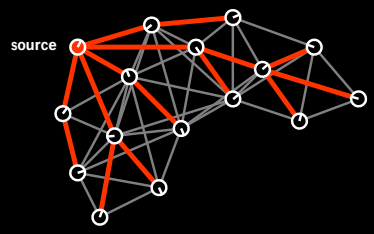
$s_{message}$ (computed)= 3.66 m/s
$s_{message}$ (measured)= 3.64 m/s

n = 44, τ = 0.250s, speed = 0, RSR = 0

Broadcast Tree Path Distance

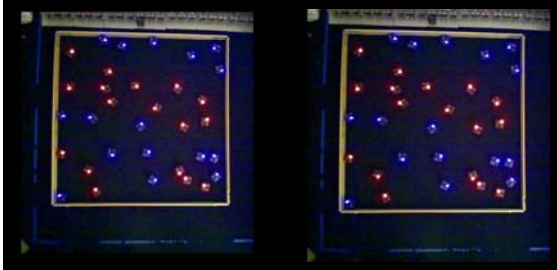
Purpose:
- To estimate the distance to the source of a message

Accuracy Metric:
- correlation coefficient between measured and actual distances



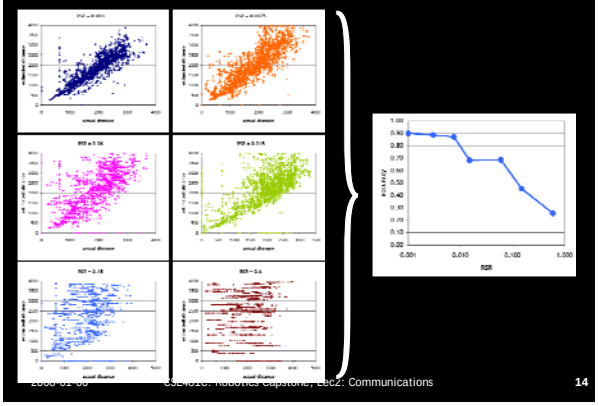
Dynamic Networks

Motion "smears" network and reduces the correspondence between network topology and physical positions



n = 33, τ = 0.250s, speed = 0.08, RSR = 0.02

Broadcast Tree Path Distance



lab 2: communications

Lab 2: Communications

Distributed Algorithms in Communications Networks

What are you actually computing with a broadcast flood?

What kind of processing can you do by relaying messages to neighbors?

Lab 2: Communications

Goal

- Build a layered control system to guide a robot towards light and away from obstacles
- Measure the robot's estimate of its *pose* from odometry compared to ground truth

Pre-Lab Warmup Exercises