CZECH TECHNICAL UNIVERSITY IN PRAGUE
FACULTY OF ELECTRICAL ENGINEERING
DEPARTMENT OF TELECOMMUNICATION ENGINEERING

B2M32BTSA - Bezdrátové technologie
BE2M32BTSA - Wireless Technologies and Sensor Networks

Routing in wireless sensor networks

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WSN principles

Wireless Sensor Network (WSN)

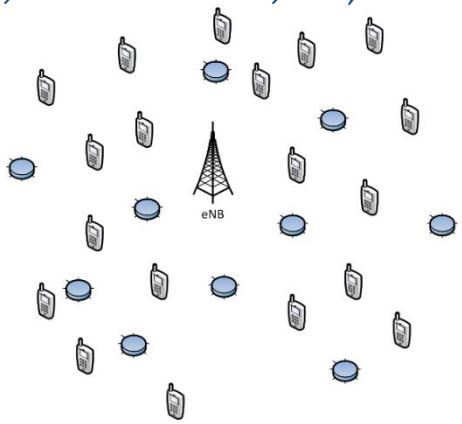
- Set of nodes (sensors) distributed in a field and exchanging information
- Deployed in structured or unstructured manner (with changing topology)

Each Node (Sensor) can act as

- **Source** - Generates data to be sent
- Sink / **Destination** - Receives data generated by Source
- **Relay** of data (Source to Sink)

Challenges and issues for WSN routing

- Dynamic time varying wireless channel and topology (movement, fading, ...)
- Asymmetric wireless channels (multipath propagation, interference, ...)
- Limited resources for route management (signaling)
- Energy constraint for nodes



Flooding

Principle

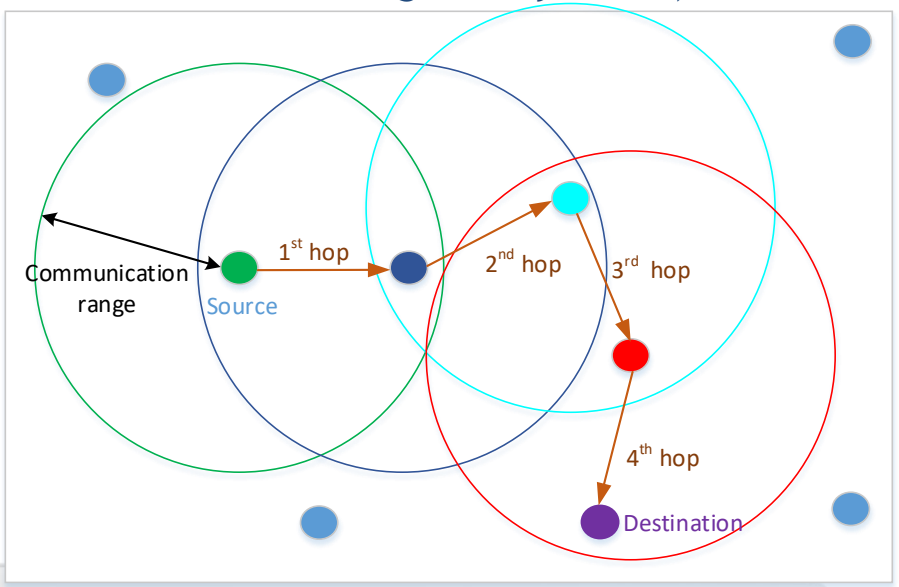
- 1. Source node (sensor) sends a message
- 2. All nodes in the communication range receive the message and retransmits it further to all nodes in their communication range
- 3. This is done as long as the message reach destination or maximum number of hops (TTL) is met

Advantages

- No need to keep any tables, topology or route info

Drawbacks

- Very high overhead (nodes may transmit the same message many times)
- High energy consumption



How to improve flooding?

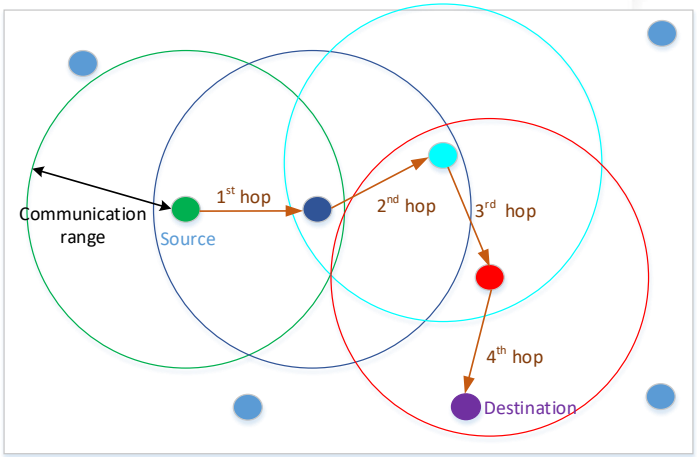
Motivation

- Minimize number of transmitted messages while keep the same probability that message is received at the destination
- Reduce energy consumption

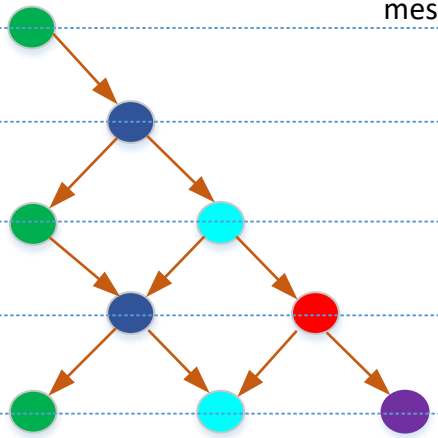
Methods to improve flooding

- **Do not forward the same message again**
  - If the node receives the same message, it is discarded
  - Efficient especially in static scenario where the neighbors do not change
- **Gossiping**
  - Message is forward with just certain probability of *p (p* set to 1 -> flooding*)*
  - Efficient especially if there are huge number of nodes and does not matter if some nodes do not retransmit the message
  - *p* should be properly optimized
    - Low *p* -> take longer to deliver the message (may not be delivered at all)
    - High *p* -> huge number of overhead similarly as in case of flooding
- **Heuristic improvements of gossiping**
  - Hops 1..k => p = 1
  - Hops >k => p < 1
  - Optimize k and p

Illustrative example

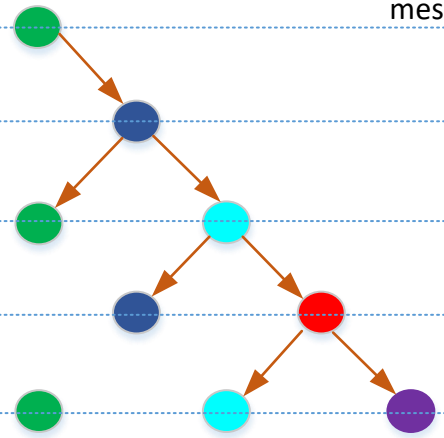


Basic flooding



	No. of transmitting messages (nodes)
1st hop	1
2nd hop	1
3rd hop	2
4th hop	2

Improved flooding (do not forward the same message again



	No. of transmitting messages (nodes)
1st hop	1
2nd hop	1
3rd hop	1
4th hop	1

Objectives

Implement flooding and its improvement(s) in Matlab

Show 2 figures

- Number of generated messages and number of hops depending on communication range (See slide 11 for more details)

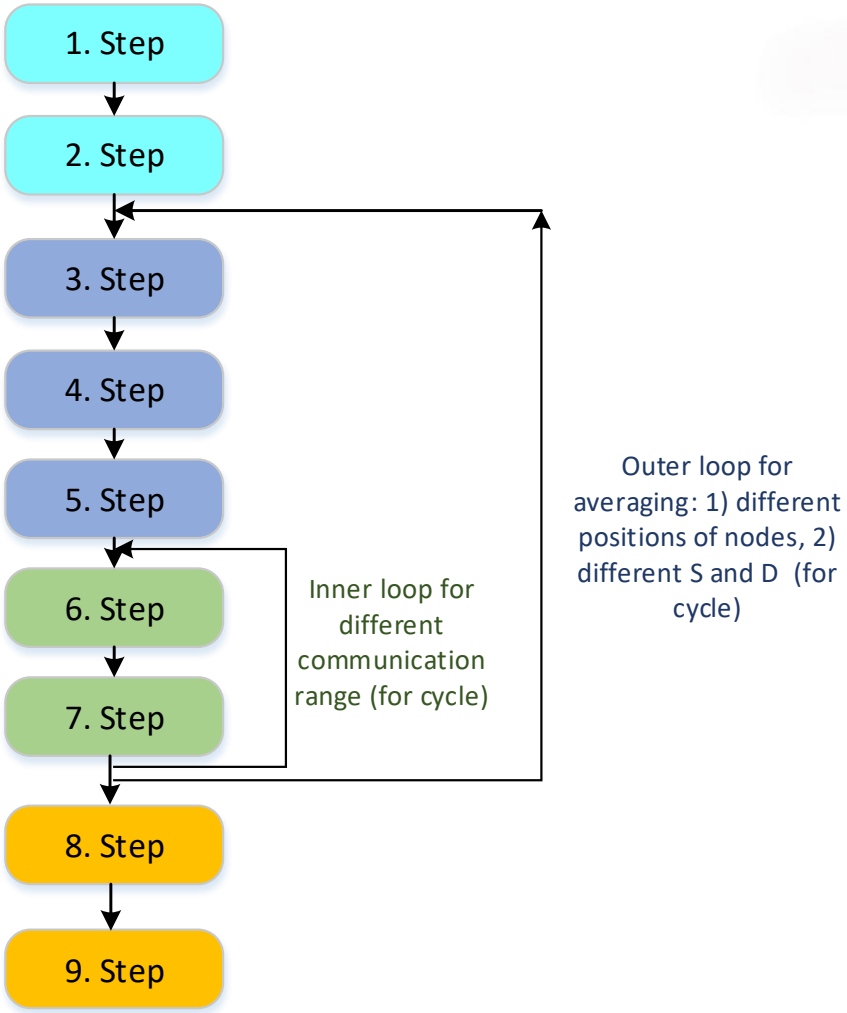
Assumptions

- Simulation area is 500x500m
- Number of nodes (N) is 500
- Communication range between 10 and 100m (one step is 5m -> 19 values)
- Average results over at least 1000 simulation drops
  - Simulation drop
    - Random distribution of nodes in the area
    - Random selection of source and destination nodes (always just one source and one destination node in each drop)

Template

- It is possible to use a template (available at moodle)
- **You can write your own code without the use of template!!**

How to proceed?



How to proceed?

- 1. Define basic parameters
  - **Matlab example:**

```
Simulation_area = [500 500];  % Simulation area in m
No_nodes = 500; % Definition of number of nodes
Sim_drops = 1000;  % Definition of number of drops (for outer loop)
Max_comm_d = 10:5:100; % Definition of max. comm. distance in m (for inner loop)
```

  - Note: Each drop represents different random positions of nodes, S and D
- 2. Define variables to save results
  - **Matlab example:**

```
Total_messages=zeros(19,3);
Total_hops=zeros(19,3);
```

- 3. Randomly generate positions of each node
  - Predefine variable to insert X and Y coordinates of each node (e.g., Nodes_position)
  - Use **"for"** cycle and function **rand**
  - **Matlab example:**

```
Nodes_position=zeros(No_nodes,2);
for node=1:No_nodes
    Nodes_position(node,1)=rand*Simulation_area(1,1); % x coordinates
    Nodes_position(node,2)=rand*Simulation_area(1,2); % y coordinates
end
```

How to proceed?

- 4. Select randomly one source (S) and one destination (D)
  - Use function **rand** to randomly generate indexes of S and D
  - S and D must be different node
  - **Matlab example:**

```
Index_S_D=zeros(2,1); % parameter to store indexes of S and D
Index_S_D(1,1)=ceil(rand*No_nodes); % Index of S node
D=0;
while D==0
    Index_S_D(2,1)=ceil(rand*No_nodes); % Index of D node
    if Index_S_D(2,1)~=Index_S_D(1,1) % Check if S and D are different
        D=1;
    end
end
```

- 5. Calculation of distance between any two nodes
  - **Matlab example:**

```
Node_distance=zeros(No_nodes,No_nodes);
for i=1:No_nodes
    for j=1:No_nodes
        Node_distance(i,j)=sqrt((abs(Nodes_position(i,1)-Nodes_position(j,1)))^2 + (abs(Nodes_position(i,2)-Nodes_position(j,2)))^2);
    end
end
```

How to proceed?

- 6. Set communication range
  - Communication range varies between 10 and 100m
  - **Matlab example:**

```
Max_comm_distance = Max_comm_d(1,CommRange); % Calculation of current comm range
```

- 7. Flooding principles for specific communication range
  - Determine how many messages have been sent
    - Use variable “Total_messages” for saving the number of messages
  - Determine how many hops (time steps) it takes to reach message from S to D
    - Max number of time steps is set to 100 => If message does not reach D in 100 time steps, terminate the cycle (use while cycle)
    - Use variable “Total_hops” for saving the number of hops
- 8. Average the results over K (1000) simulation drops
  - **Matlab example:**

```
Total_messages=Total_messages/Sim_drops;
Total_hops=Total_hops/Sim_drops;
```

- 9. Plot the results

Expected results and rating

Basic flooding (1 point)

Improved flooding (Do not forward the same message again) (1 point)

Gossiping (up to 2 BONUS points)

- Comparison with basic flooding and improved flooding (1 BONUS point)
- Analyze impact of *p* on performance (1 BONUS point)
  - E.g., how *p* should be set with respect to density of nodes in the simulation area

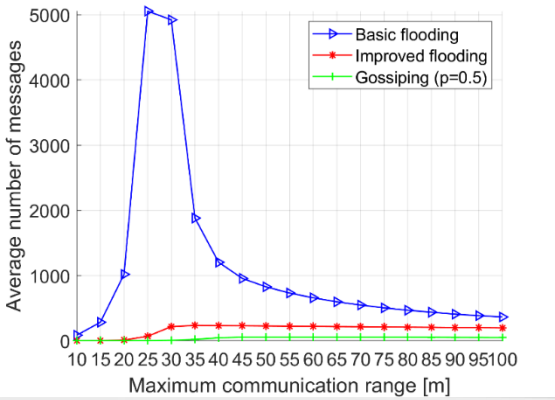
Heuristic optimization of Gossiping (up to 2 BONUS points)

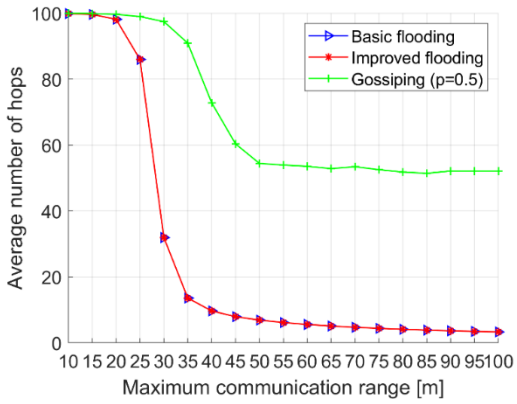
Optional (each student can select what can be done)

Maximum is 4 points!

Evaluation

- During courses
- 4th week of the semester (17.3.)
  - Short discussion on results and code understanding
  - Points given only if student is understanding the code and basic principle of routing mechanisms!!





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Questions?

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