Modification of STC Algorithm

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STC→M-STC

STC----a distributed topology control algorithm

- Reduces energy consumption while preserving connectivity between nodes;
- Makes no assumption about distance or direction between nodes;
- Achieves same or less complexity and saves more energy compared with other known algorithms.

However, STC doesn't consider remaining energy of a node, which decides lifetime of a node.

M-STC----pays attention to lifetime to network.

Catalogue

STC Algorithm

→Topology Control Algorithm

- Basic idea
- Pseodo-code

M-STC Algorithm

- Goals
- Terminology
- Design of M-STC
- Evaluation

Topology Control Algorithm

Topology Control Algorithm VS. Routing Algorithm

Topology Control Algorithm:

Changes topology of wireless network.

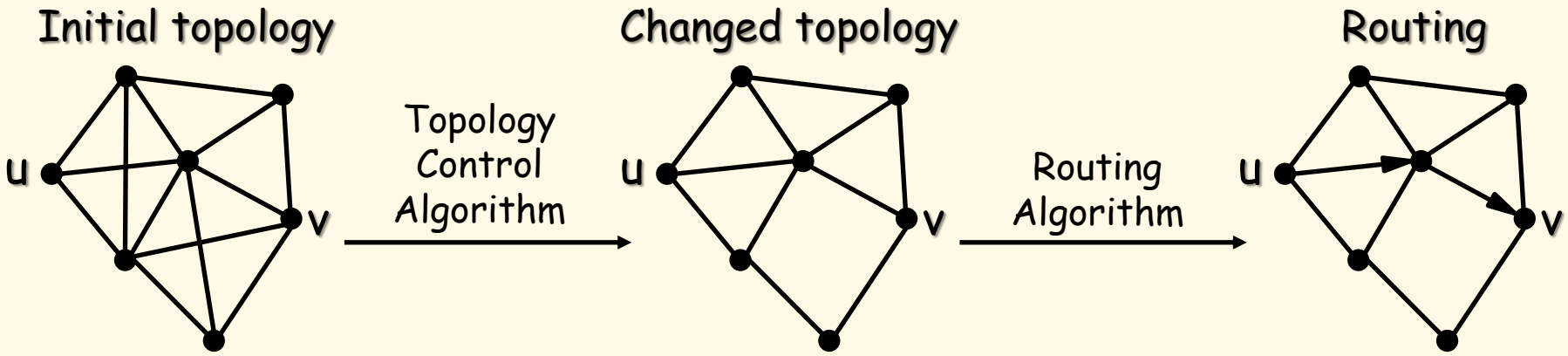
Routing Algorithm:

Selects paths for transmission between nodes.

Topology Control Algorithm

Topology Control Algorithm VS. Routing Algorithm

Topology Control Algorithm and Routing Algorithm can be viewed as **two phases** to form a transmission of wireless network.



Topology Control Algorithm

Topology Control Algorithm can be viewed as the set of all directly connections of nodes.

Initial topology:

$G_{max} = (V, E_{max})$

V: set of nodes

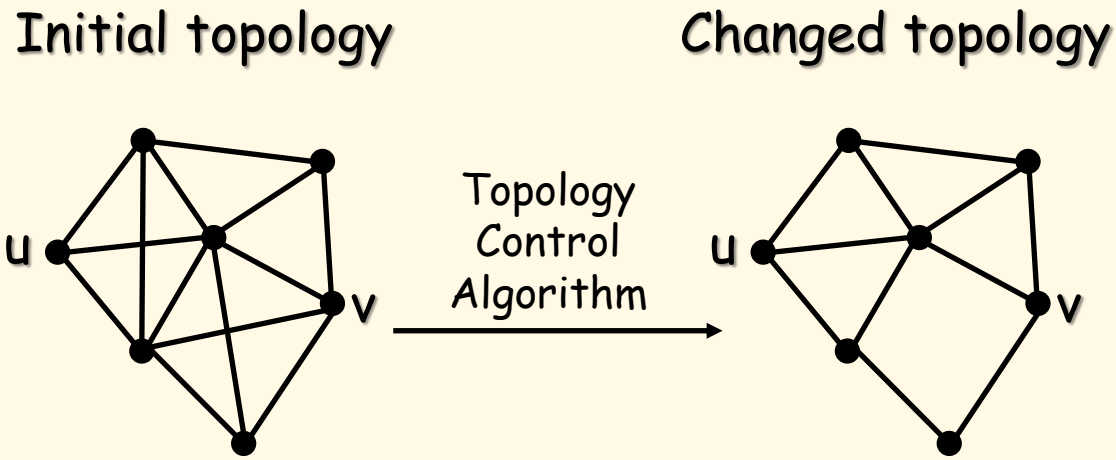
E_{max}: set of all connections

Changed Topology:

G = (V, E)

V: set of nodes

E: set of reduces connections



Topology Control Algorithm

Objectives:

- Minimize average energy consumption of all nodes in V:

$$\min\left[\sum_{u\in V} C_G(u)\right],$$

- Minimize average energy consumption of all transmission paths:

$$\min\left[\sum_{s,t\in V} C_G(s \longrightarrow t, \text{Energy})\right].$$

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STC Algorithm: Basic idea

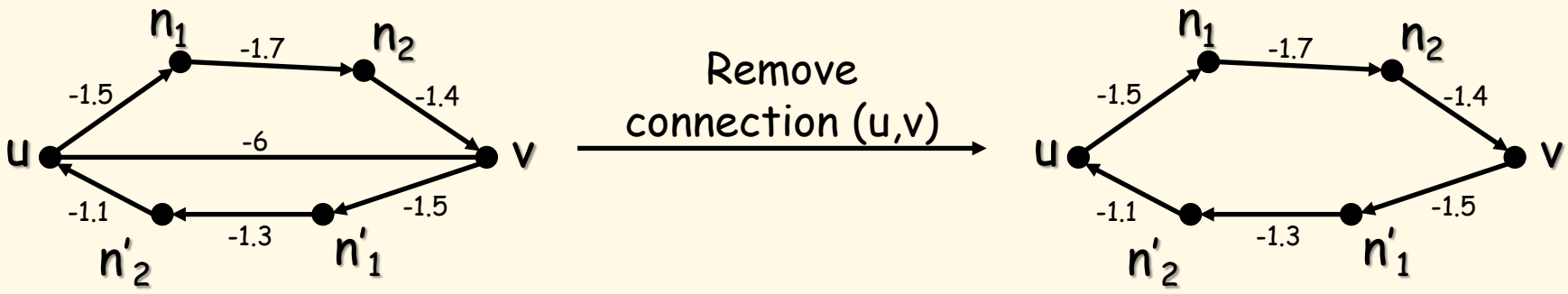
Basic idea: Remove a connection if there exists

(a) a forward path that $\max\{C(u,n_1)\ldots C(n_k,v)\}<C(u,v)$, $k\leq 3$

And

(b) A backward path that $\max\{C(v,n'_1)\ldots C(n'_k,u)\}<C(u,v)$, $k\leq 3$.

$C(u,v)$: Energy cost in a transmission from u to v.

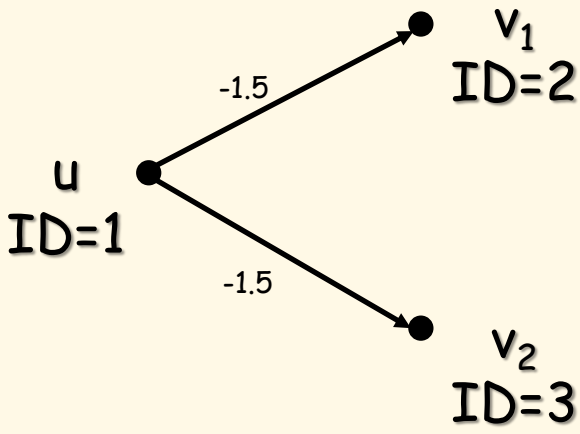


STC Algorithm: Energy Comparison

Compare energy cost between connections:

Define tuple $t(u,v)=(t_1,t_2,t_3)$

$t_1=p_{min}(u,v)$, $t_2=ID_u$, and $t_3=ID_v$



$Tuple(u,v_1) < Tuple(u,v_2)$

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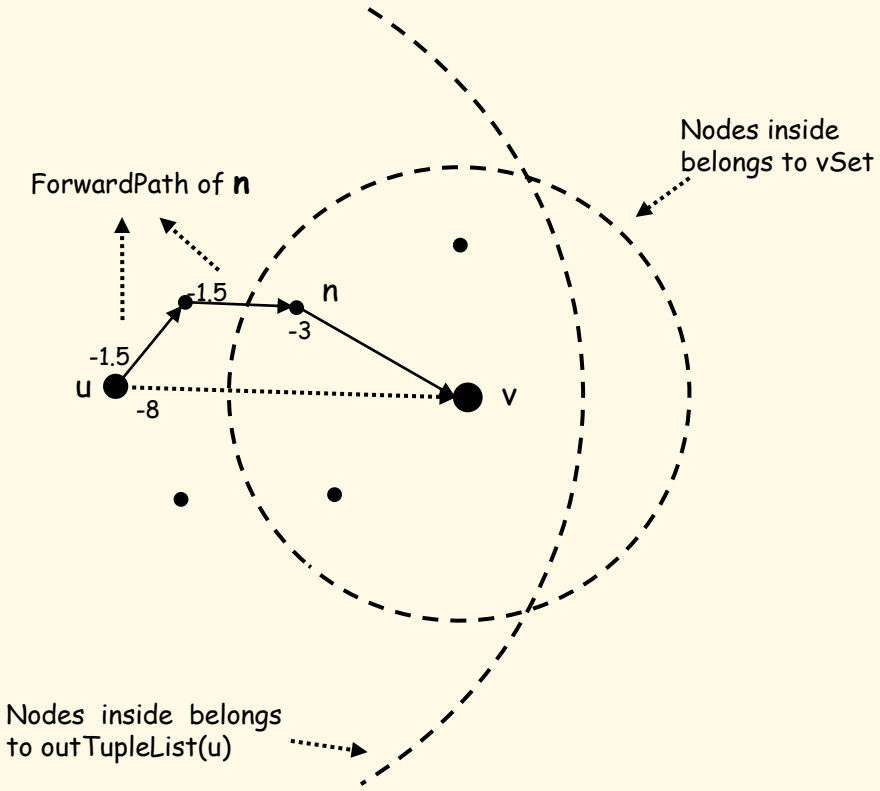
STC Algorithm: Pseudo-Code

```
01: Function STC at node (u):
02:       G←(V, φ) /* directed graph with no edges */
03:       Compile outTupleList(u) and inTupleList(u)
04:       Broadcast outTupleList(u) and inTupleList(u) at maximum power P_u
05:       Receive outTupleList(n) and inTupleList(n) from each neighbor n in G_max
06:       Compute fPairOfPaths(n) for each n two or fewer hops away from u
07:       Compute bPairOfPaths(n) for each n two or fewer hops away from u
08:       Sort outTupleList(u)
09:       k←degree of u in G_max
10:       do k-1 times
11:             t(u,v) ←the largest tuple in outTupleList(u)
12:             remove t(u,v) from outTupleList(u)
13:             vSet = {i | t(i,v)∈inTupleList(v), t(i,v)<t(u,v)
14:             NoForwardPath = Ture
15:             NoBackwardPath = True
16:             for n∈vSet
17:                   p = the first path in fPairOfPaths(n) without v
18:                   if max{r | r∈p} < t(u,v)
19:                         NoForwardPath = False
20:                         break (out of for loop)
21:                   end if
22:             end for
23:             vSet = {i | t(v,i)∈outTupleList(v), t(v,i) < t(v,u)}
24:             for n∈vSet
25:                   p = the first path in bPairOfPaths(n) without v
26:                   if max{r | r∈p} < t(v,u)
27:                         NoBackwardPath = False
28:                         break (out of for loop)
29:                   end if
30:             end for
31:             if NoForwardPath or NoBackwardPath
32:                   add a directed edge (u,v) to G
33:             end if
34:       end do
```



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Goals

GOALS:

1. Prolong the lifetime of the network

2. Decrease the cost energy

3. Decrease the complexity

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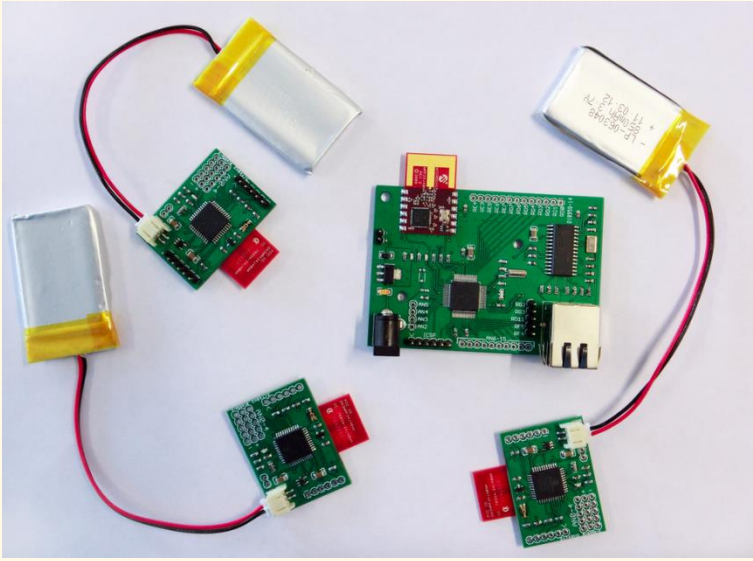
Terminology

Remaining Energy

We use remaining energy to describe the ability to keep communication with other nodes.

Nodes all have limited energy in battery-powered sensor networks



Terminology

Lifetime of the nodes and communication networks

Lifetime of a node (T_{node})=remaining energy/energy cost per second

Energy cost per second contains transmission power, the power of computing data and so on, however, we simplify the energy cost per second to transmission power to highlight the main part of the energy cost.

Lifetime of the communication networks

So we define the lifetime of the communication network or a link as min(T_{node1}, T_{node2}...T_{noden}), where [node1, node2,..., noden]∈the communication network or a link.

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Hypothesis

1. We assume the energy in every node is limit and cannot be replenished.

2. The remaining energy in each node can be different. We did not show the domain of the remaining energy. Because the different domain of the remaining energy can make the complexity of the algorithm very different.

3. Every node has an ability to get the power information from the signal it received.

Hypothesis

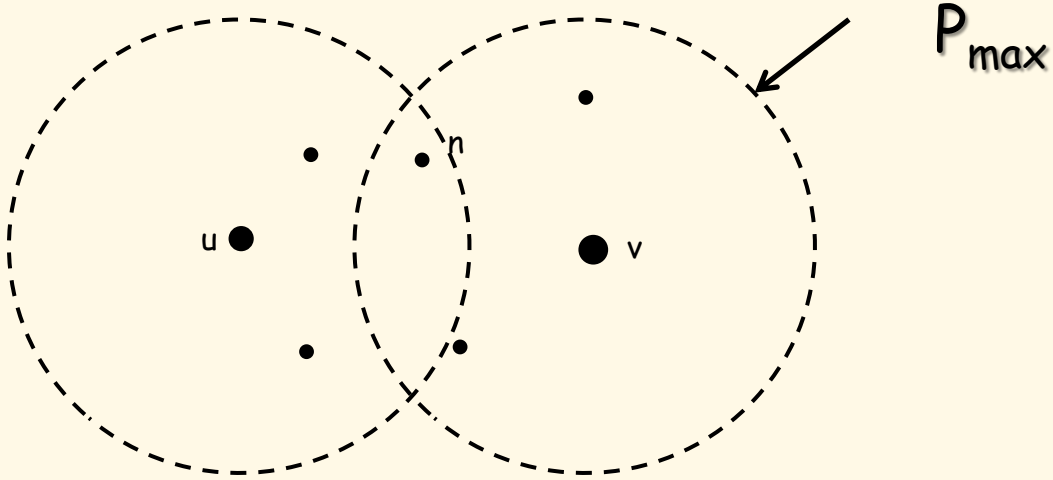
4. At the beginning of the topology, every node can transmit its own remaining energy information to other nodes. And we also assume that every node has enough memory to store these energy cost information and remaining energy information.

5. Every node has an ability to compute the relation between the energy cost and the remaining energy to get the lifetime of the communication.

6. When the remaining energy goes to a specific number, the whole communication network will do the topology again.

Beginning of the M-STC

Find neighbors



Beginning of M-STC

Information in the Hello signal:

Each node will broadcast the information about its remaining energy, the ID of the node and the P_{max}, which is the maximum transmission power of the node, in its maximum power.

Beginning of M-STC

The STC algorithm relies on each node exchanging information with each of its neighbors regarding the energy costs of communication to all of its neighbors. The modification of STC also follows this rule. And we assume the information the nodes transmitted includes the remaining energy of the nodes and the list of their neighbors. By using these information, the nodes can compute the lifetime of the communication network and find an appropriate connection.

How to Choose Nodes

We also propose an ordered tuple $t(u, v)=(t1, t2, t3, t4)$, where $t4$ is the lifetime of the link

So we need two parameters α and β. And we assume that

$$(t1, t2, t3,t4)<(t'1, t'2, t'3, t'4)$$

if and only if

(1) $t4<t'4$, and $t1<t'1$
(2) $t4<t'4$, and $t1>\alpha t'1$
(3) $t4>\beta t'4$, and $t1<t'1$
(4) $t4=t'4$, and $t1<t'1$
(5) $t4<t'4$, and $t1=t'1$,
(6) the other conditions are follow the rules in the STC algorithm.

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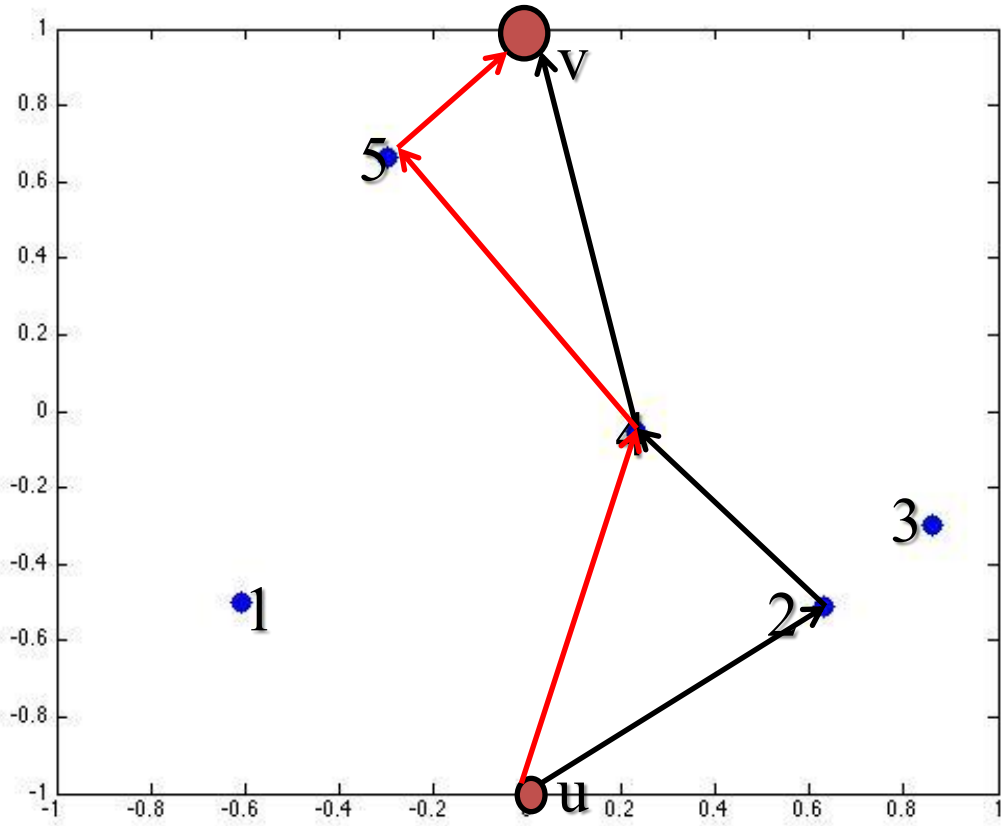
Evaluation

	Remaining energy	Location
u	42	(0.-1)
1	31	(0.6,-0.5)
2	95	(0.9,-0.3)
3	3	(-0.6,-0.5)
4	43	(0.2,-0.1)
5	38	(-0.1,0.7)

Evaluation



t(u,v)=u-2-4-v

t(u,v)=u-4-5-v

Evaluation

	Path loss	lifetime
Path A	2.5	53
Path B	2.4	42