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Maintaining Connectivity in Multi-Robot Systems through Connectivity Awareness

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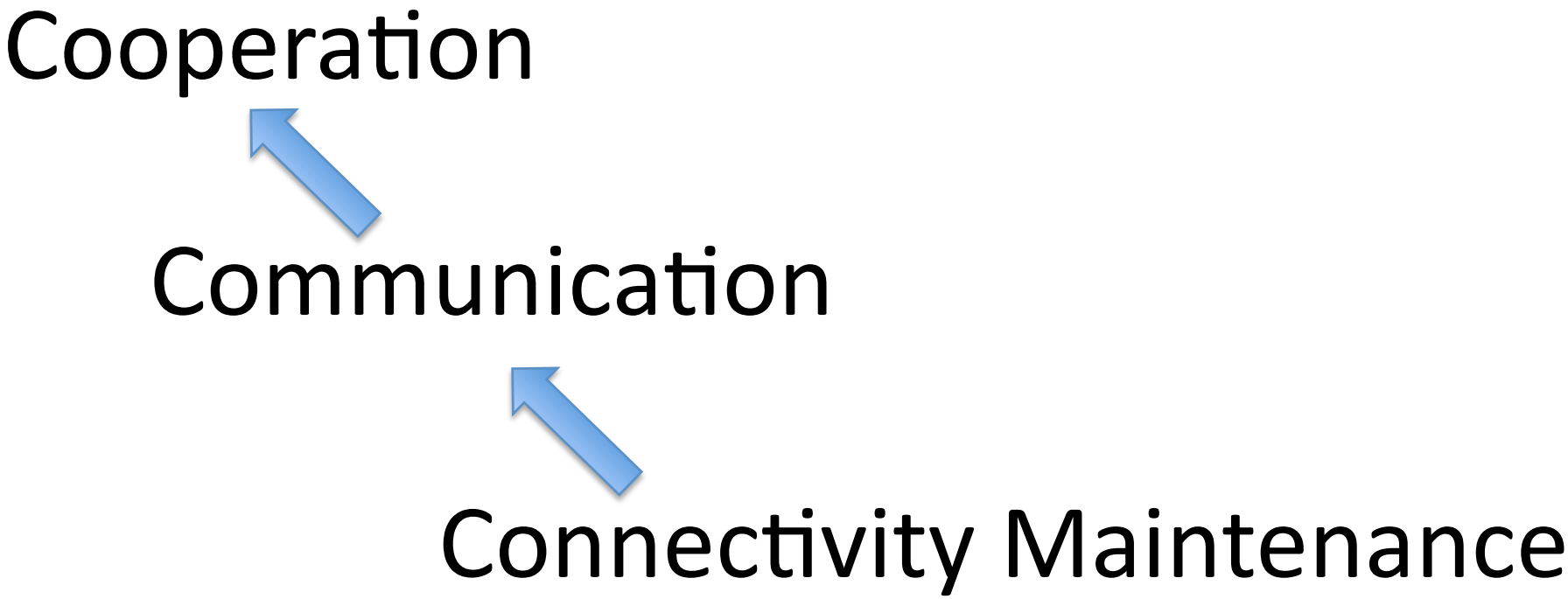
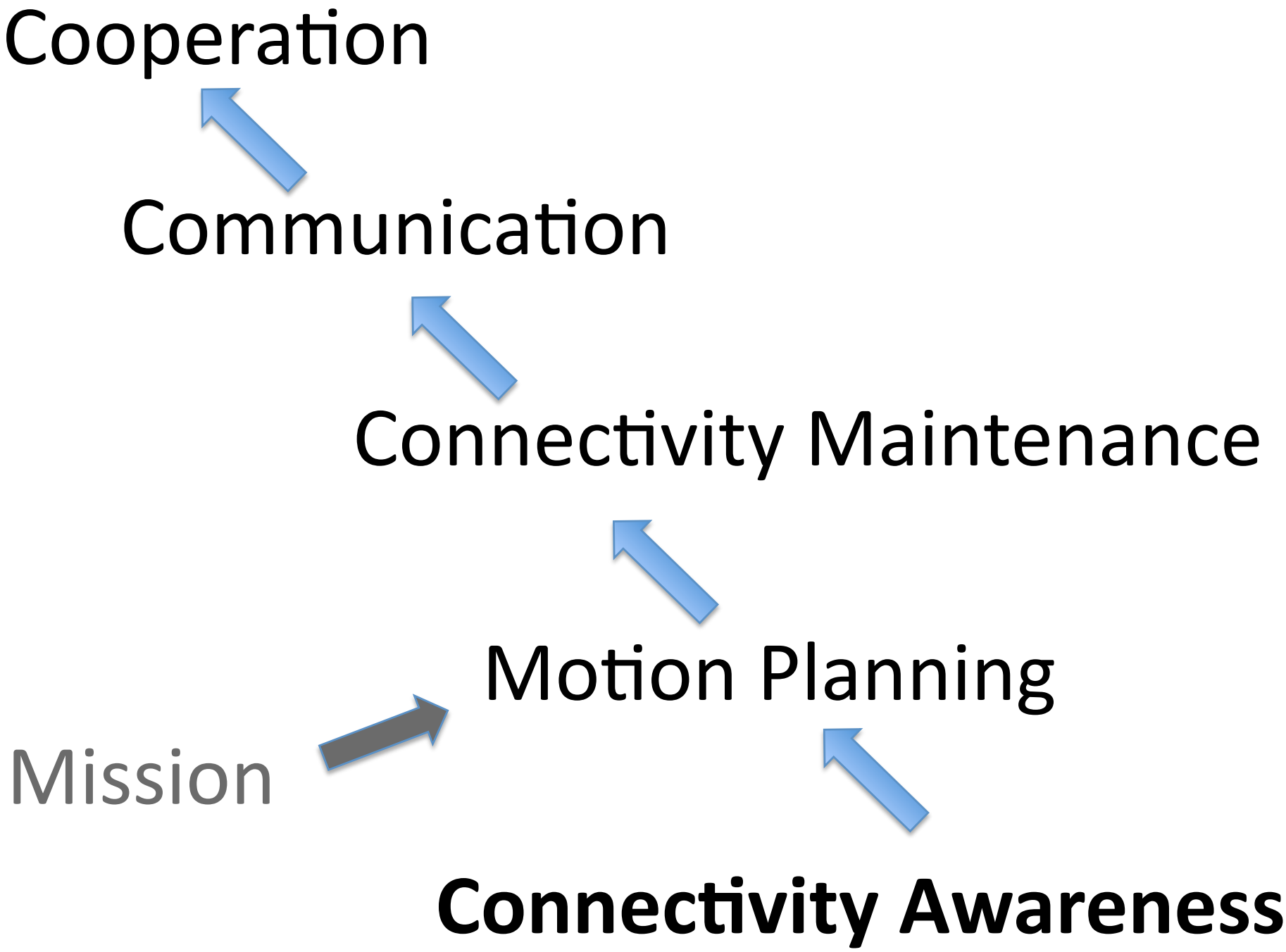
CAR, Douai 18-19 May 2010


Cooperation
Communication
Connectivity Maintenance


Cooperation
Communication
Connectivity Maintenance
Motion Planning
Mission
Connectivity Awareness

Connectivity = Network structure

Awareness = Knowledge

1) Which robot?
2) What to be aware of?

Distributed + Uniform Solution

1) Which Robot?

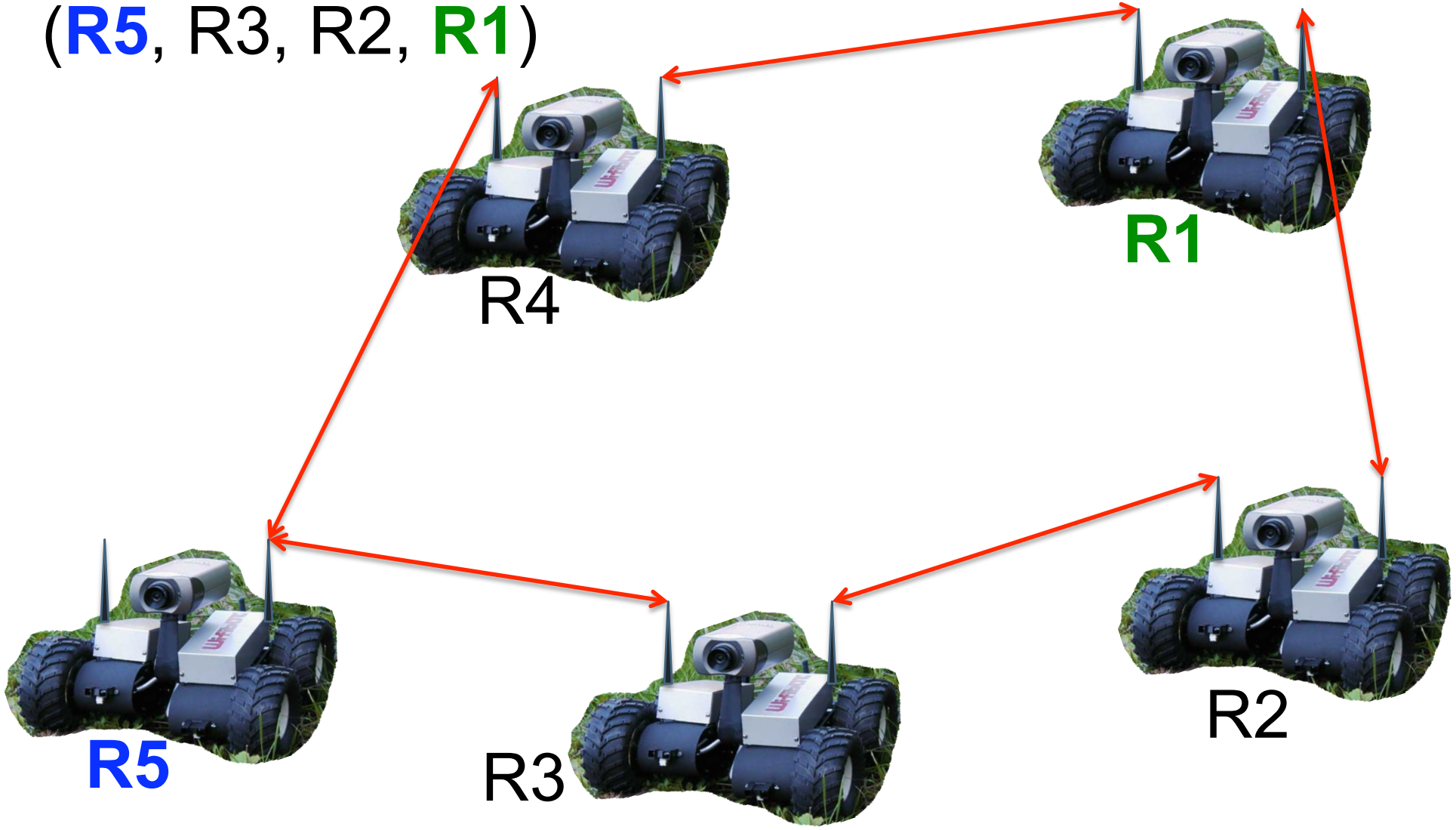
Every Robot

2) What to be aware of?

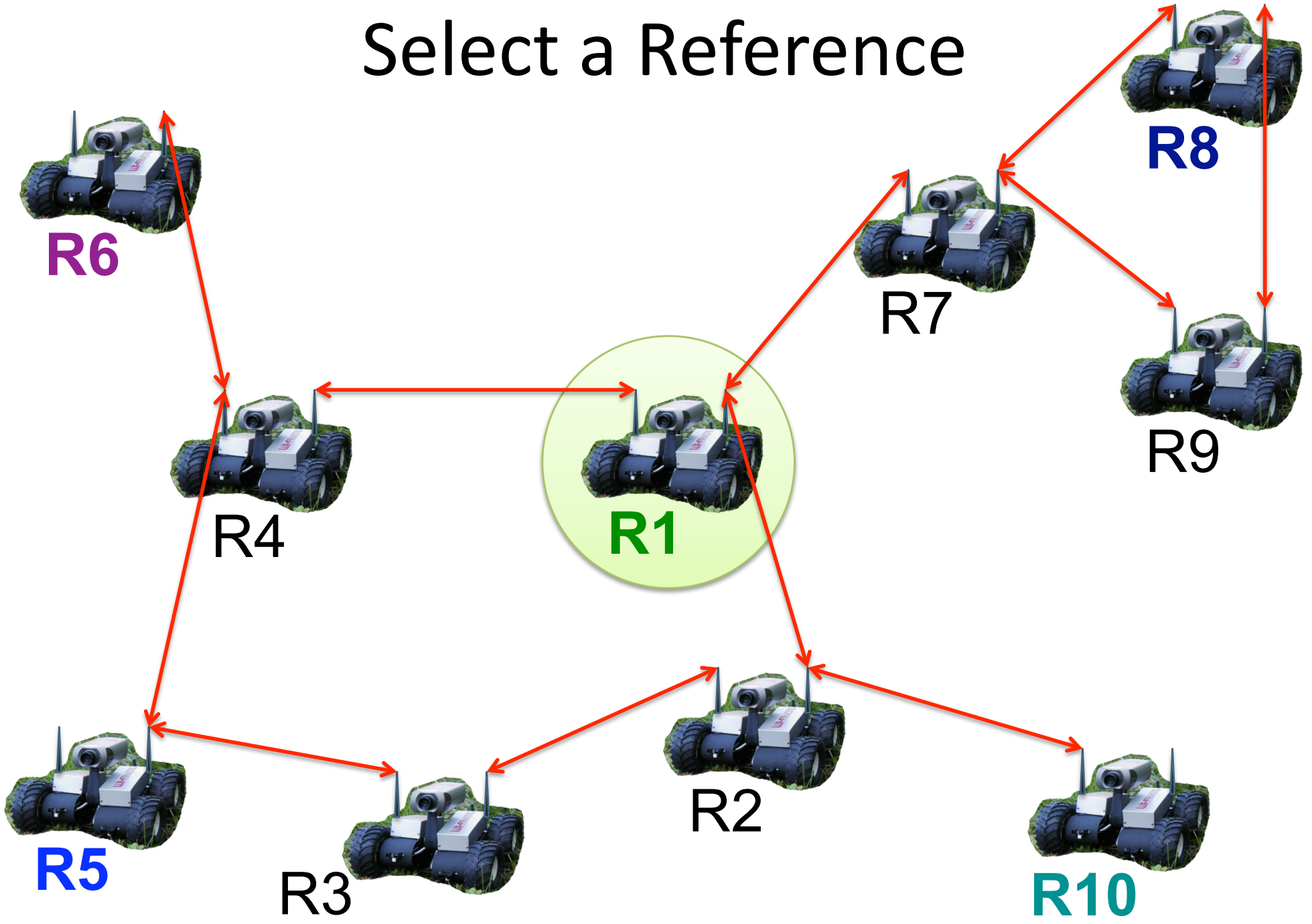
Communication paths

Communication Path

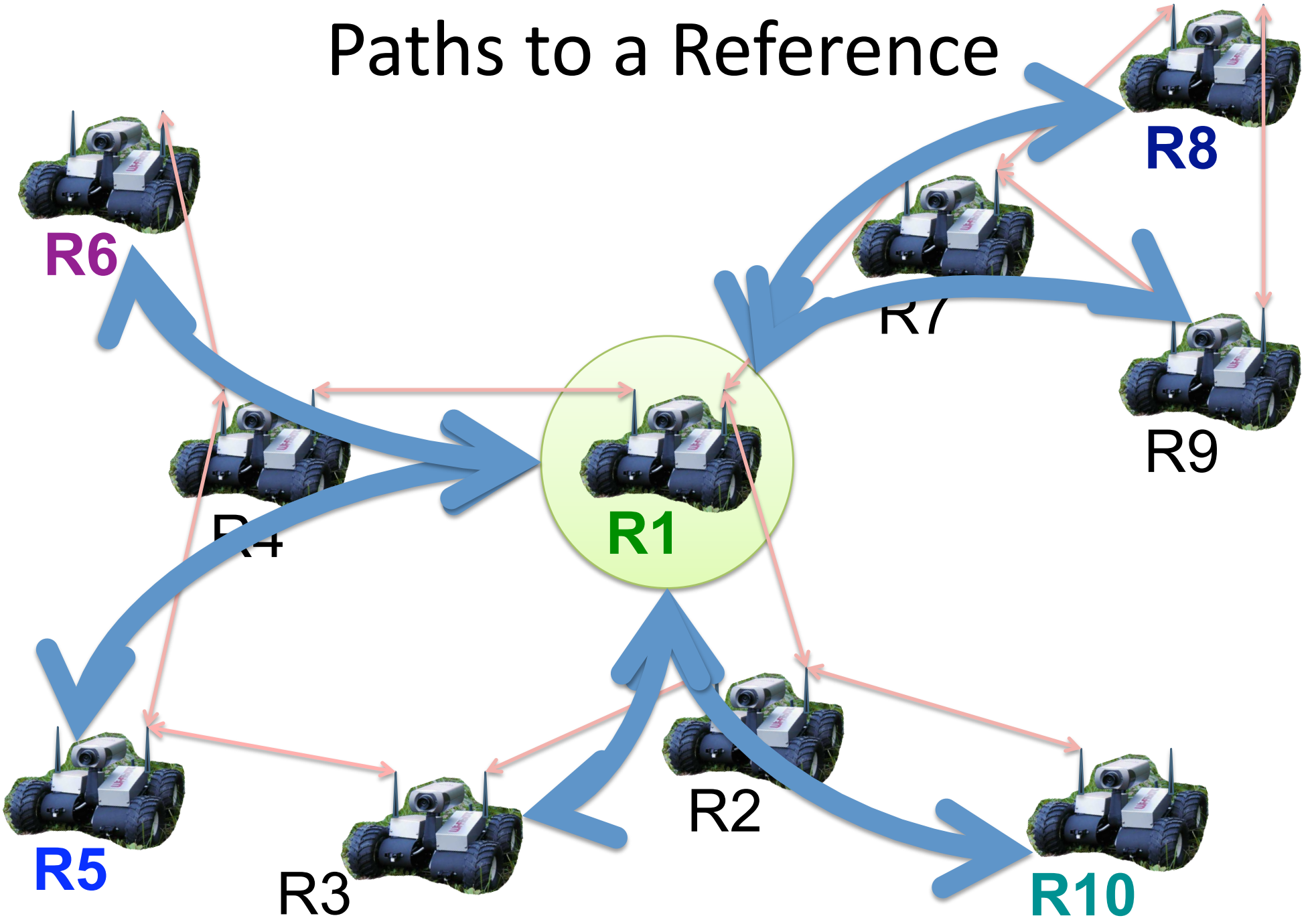
(**R5**, R4, **R1**)
(**R5**, R3, R2, **R1**)

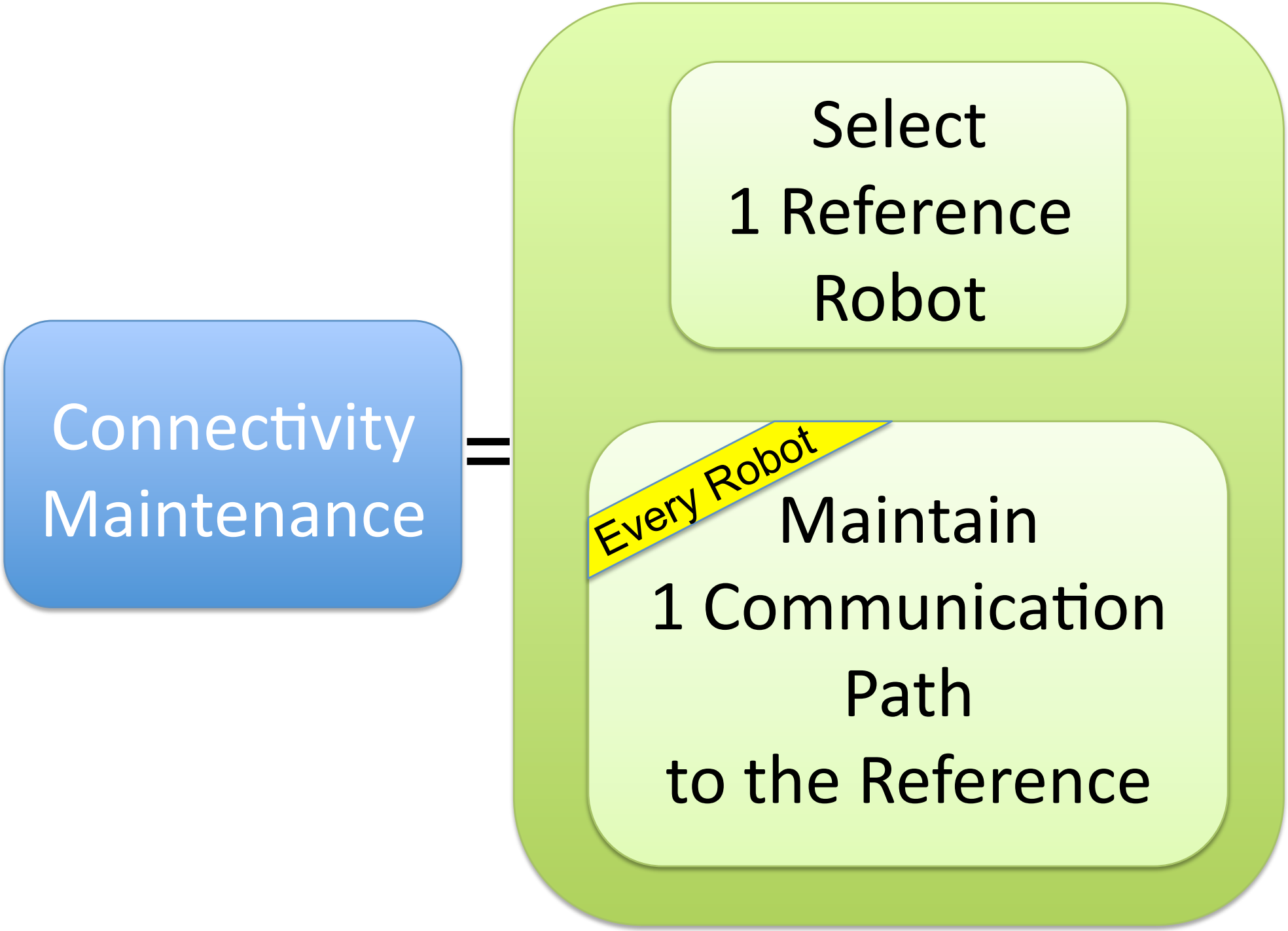


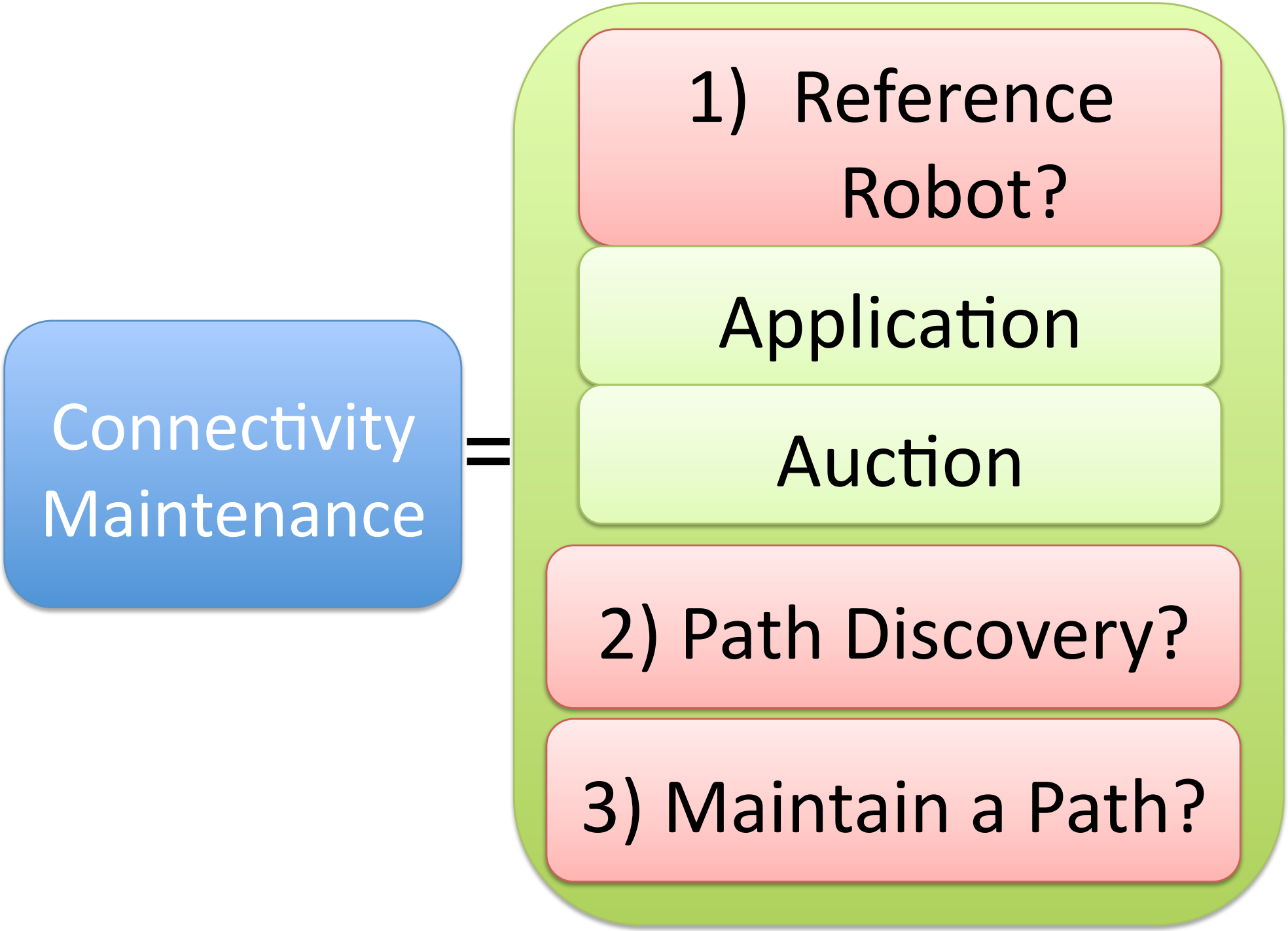
Select a Reference



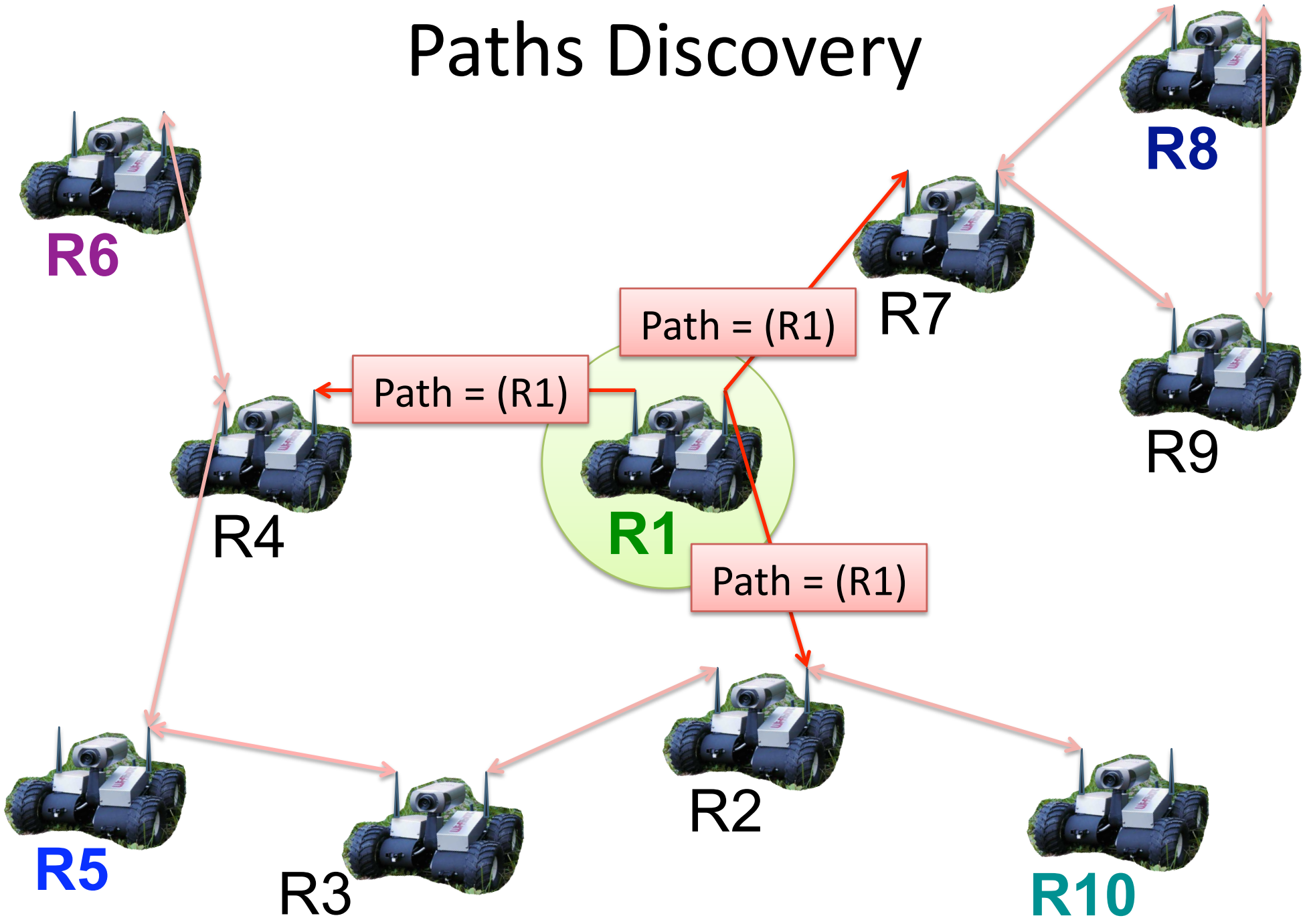
Paths to a Reference

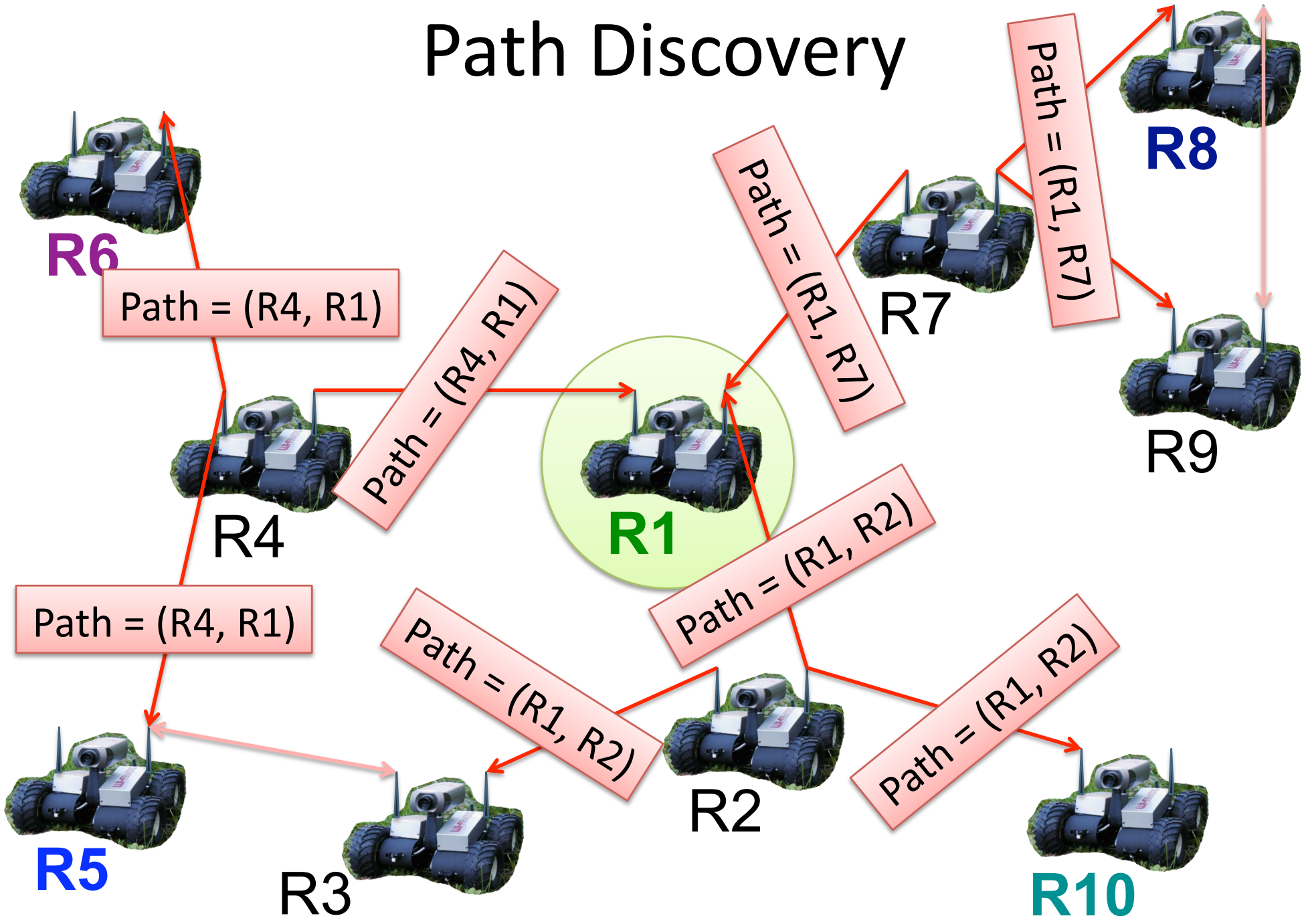



Connectivity Maintenance
=
Select 1 Reference Robot
Every Robot
Maintain 1 Communication Path to the Reference

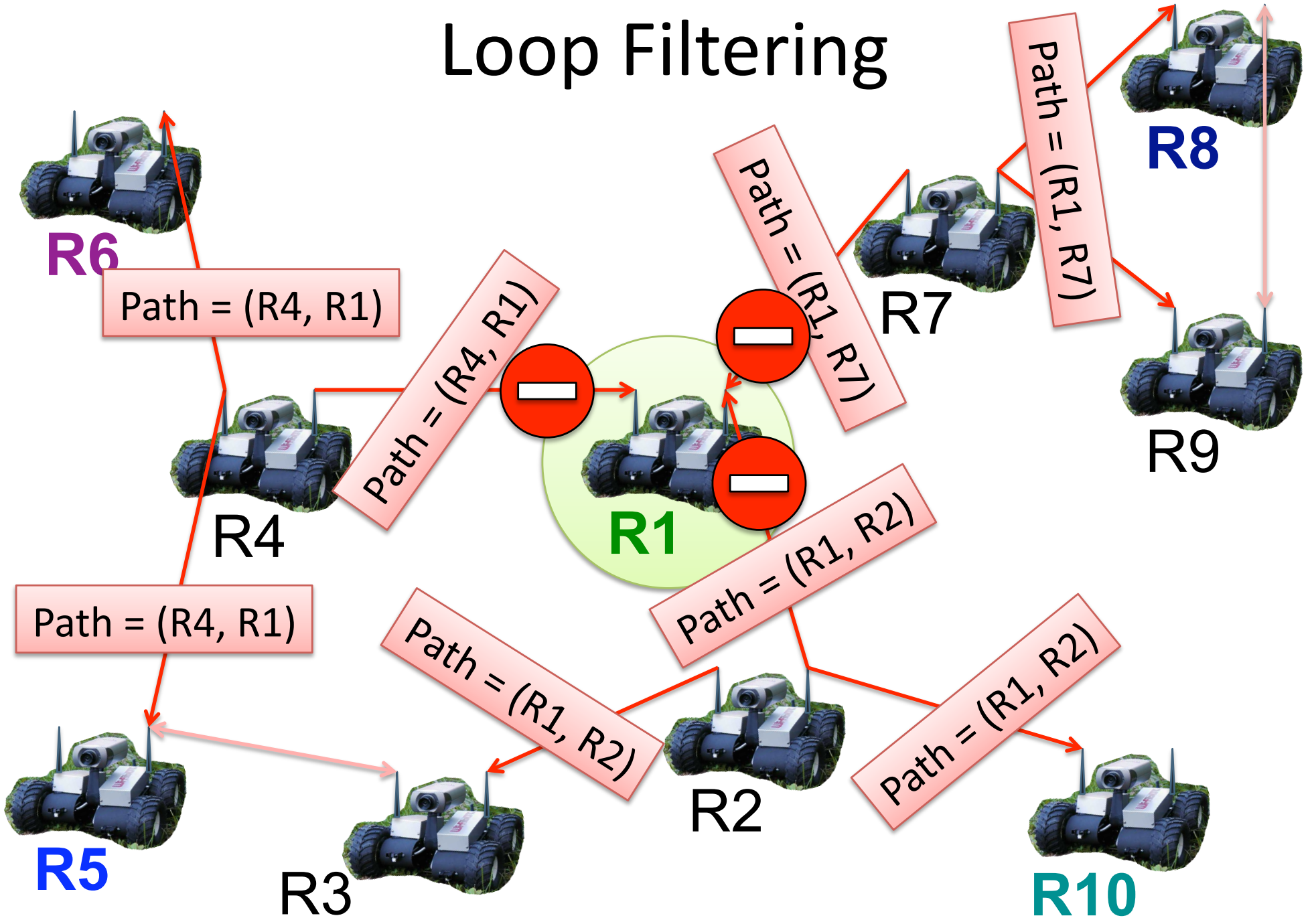

Connectivity Maintenance
=
1) Reference Robot?
Application
Auction
2) Path Discovery?
3) Maintain a Path?

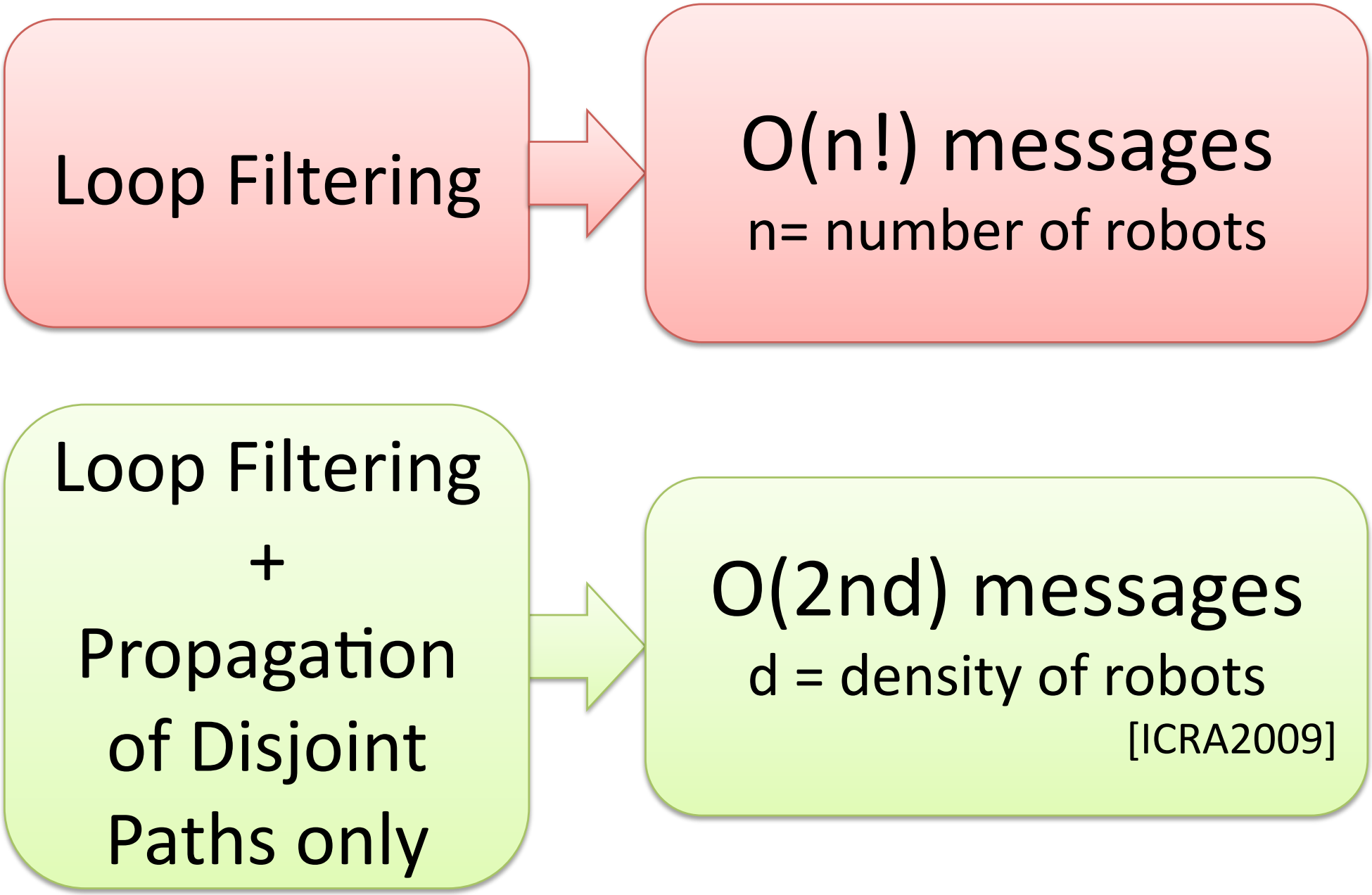
Paths Discovery

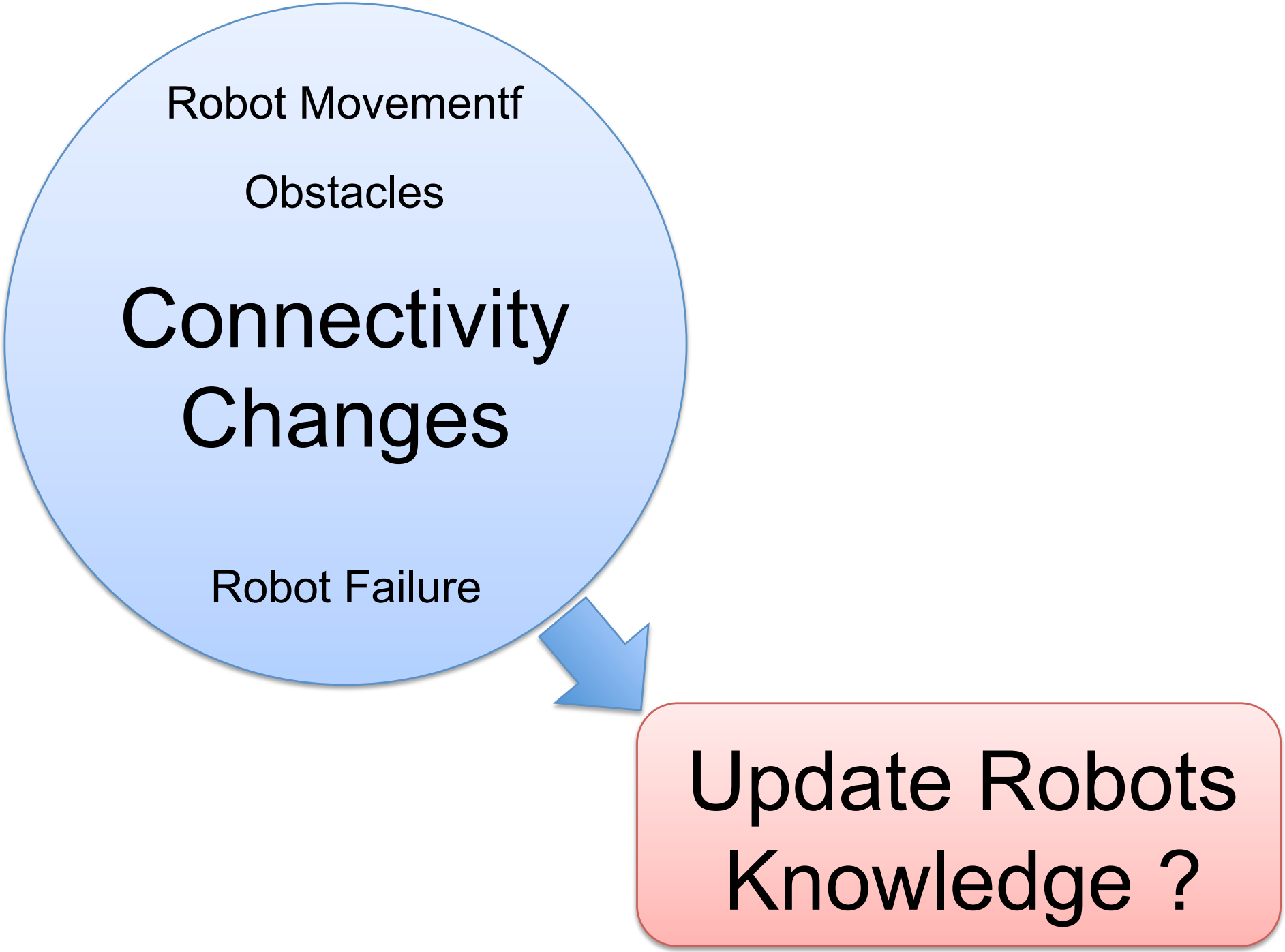


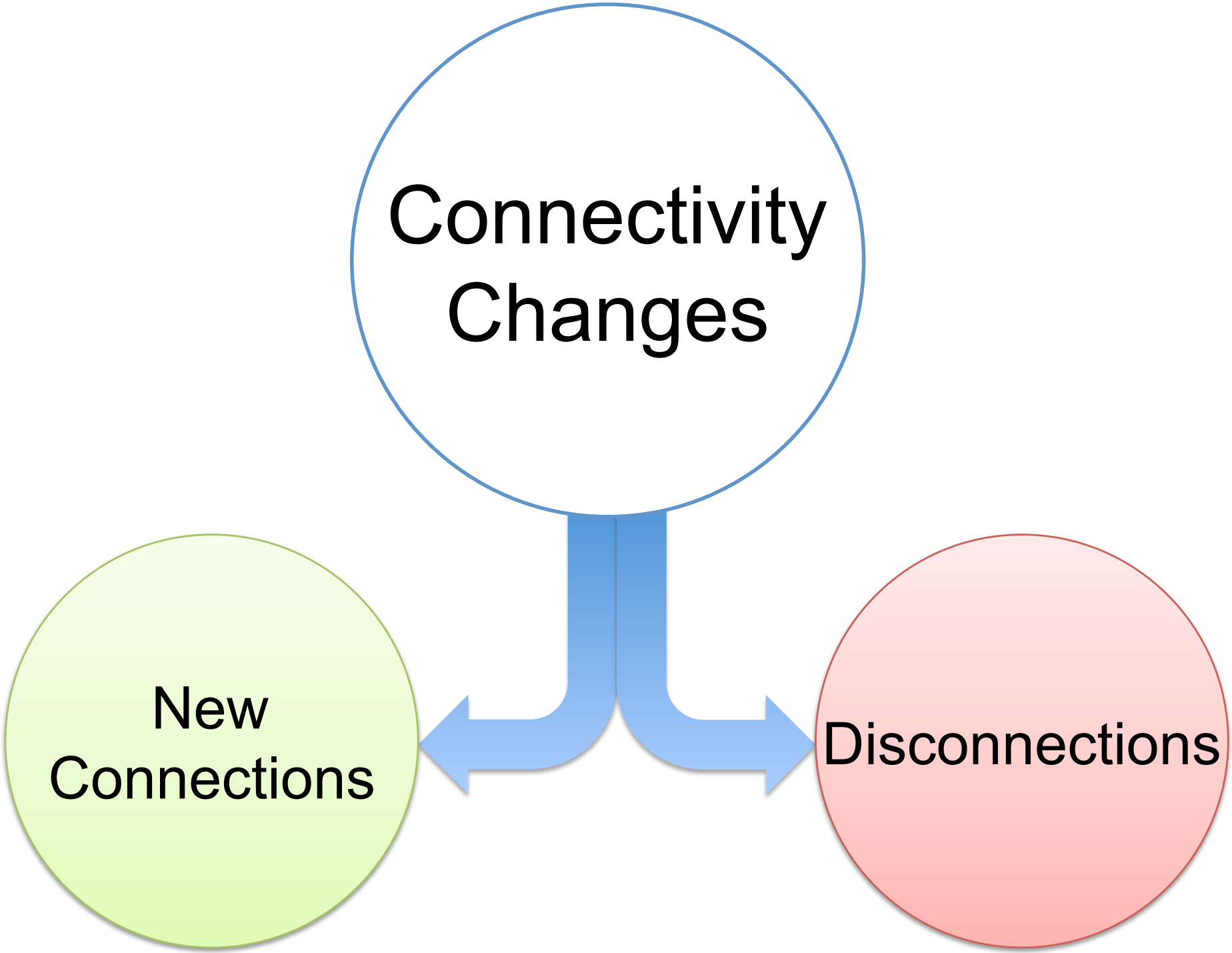

Path Discovery
R6
Path = (R4, R1)
R4
Path = (R4, R1)
R1
Path = (R1, R7)
R7
Path = (R1, R7)
R8
R9
Path = (R4, R1)
R5
R3
Path = (R1, R2)
R2
Path = (R1, R2)
Path = (R1, R2)
R10

Loop Filtering

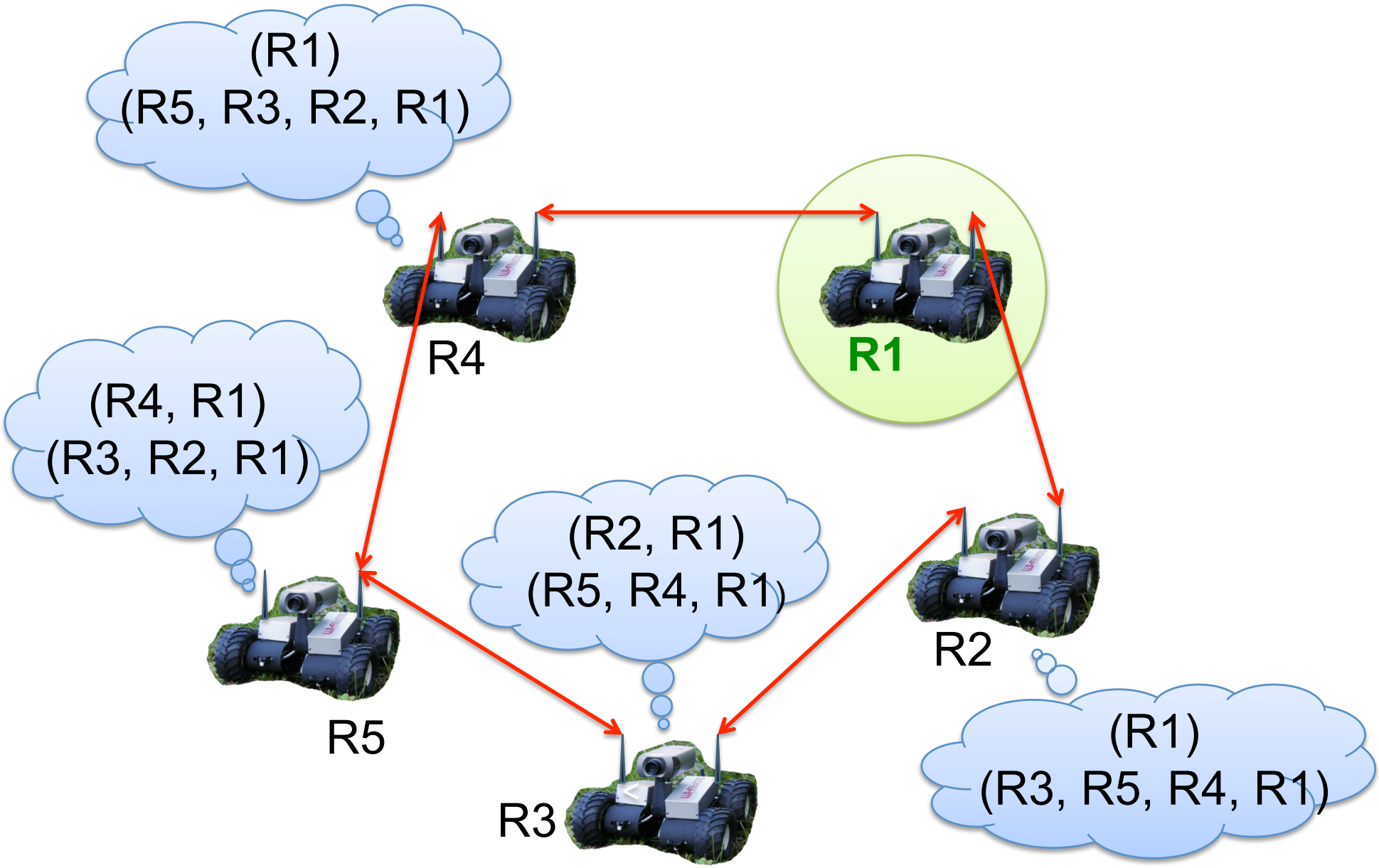



Loop Filtering
O(n!) messages
n= number of robots
Loop Filtering
+
Propagation
of Disjoint
Paths only
O(2nd) messages
d = density of robots
[ICRA2009]

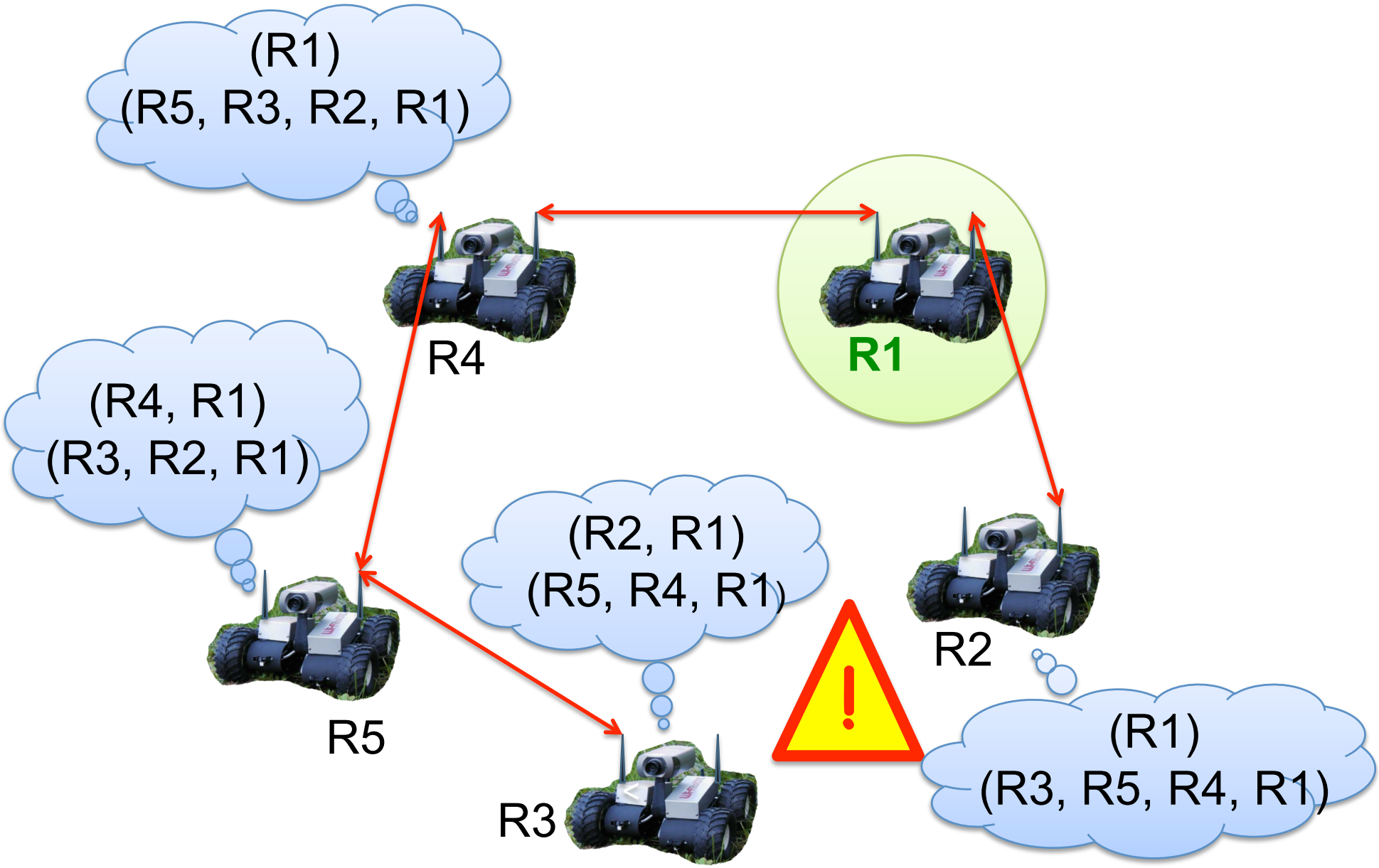

Robot Movementf
Obstacles
Connectivity Changes
Robot Failure
Update Robots Knowledge ?


Connectivity Changes
New Connections
Disconnections

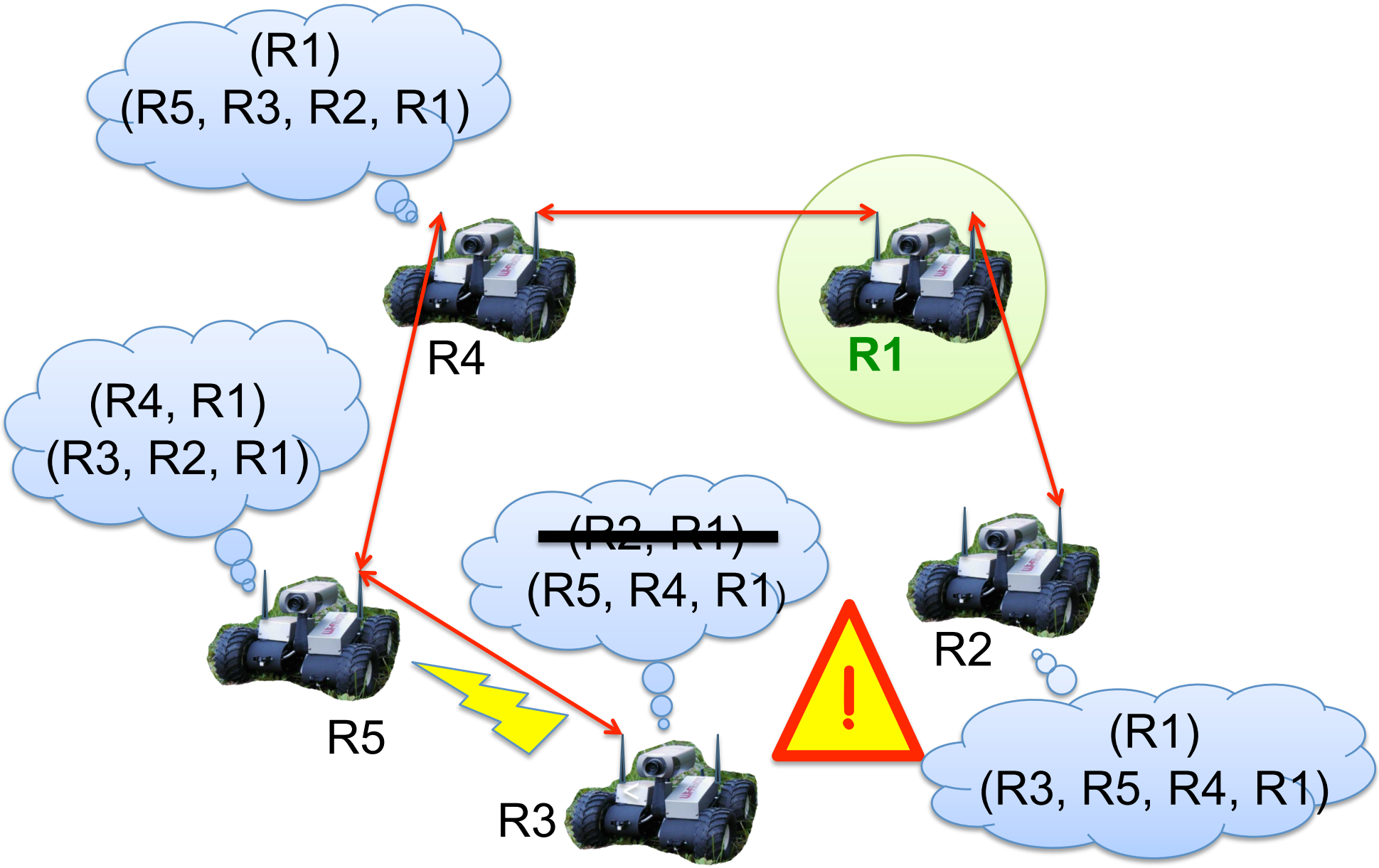
Disconnection



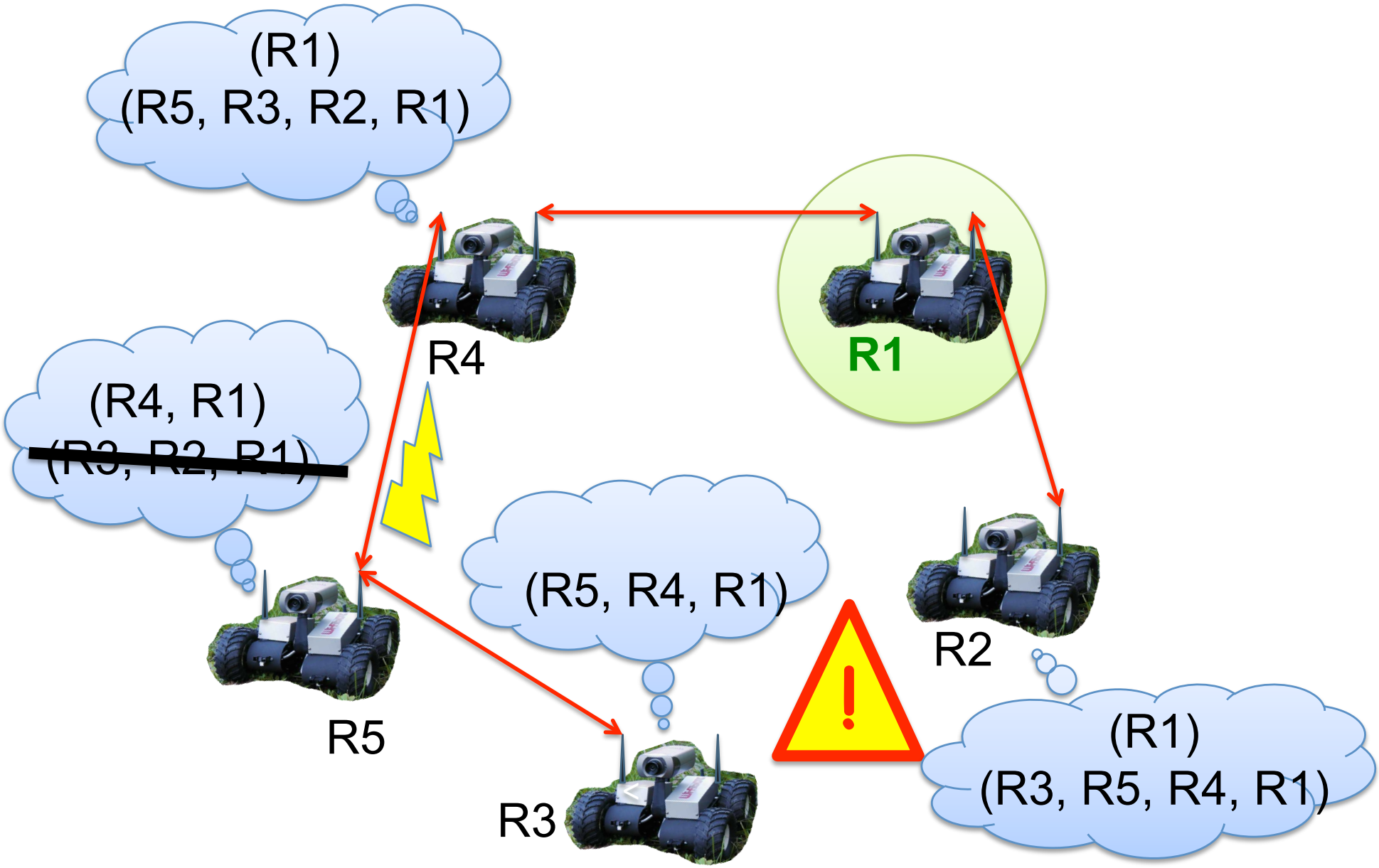
Disconnection



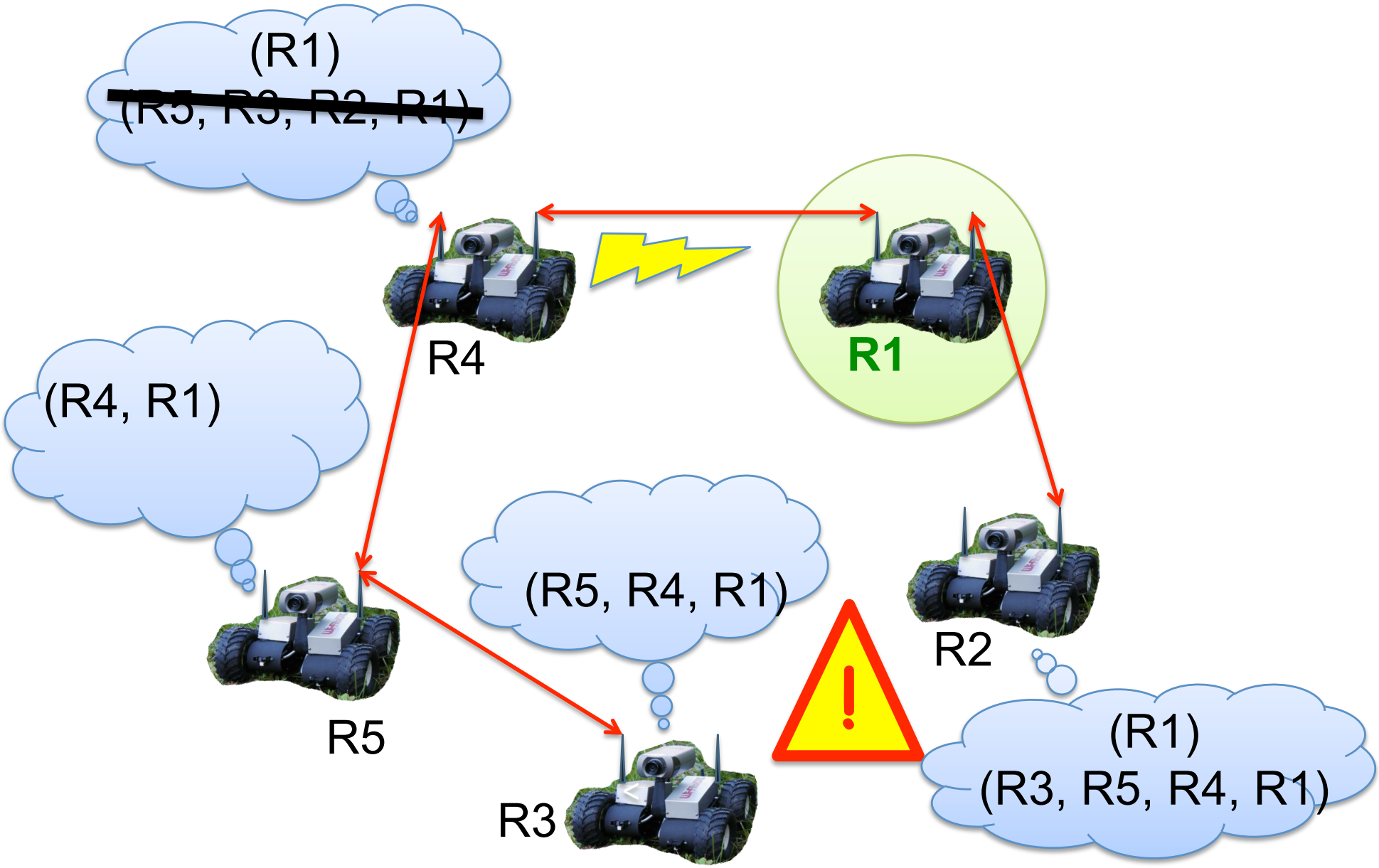
Disconnection



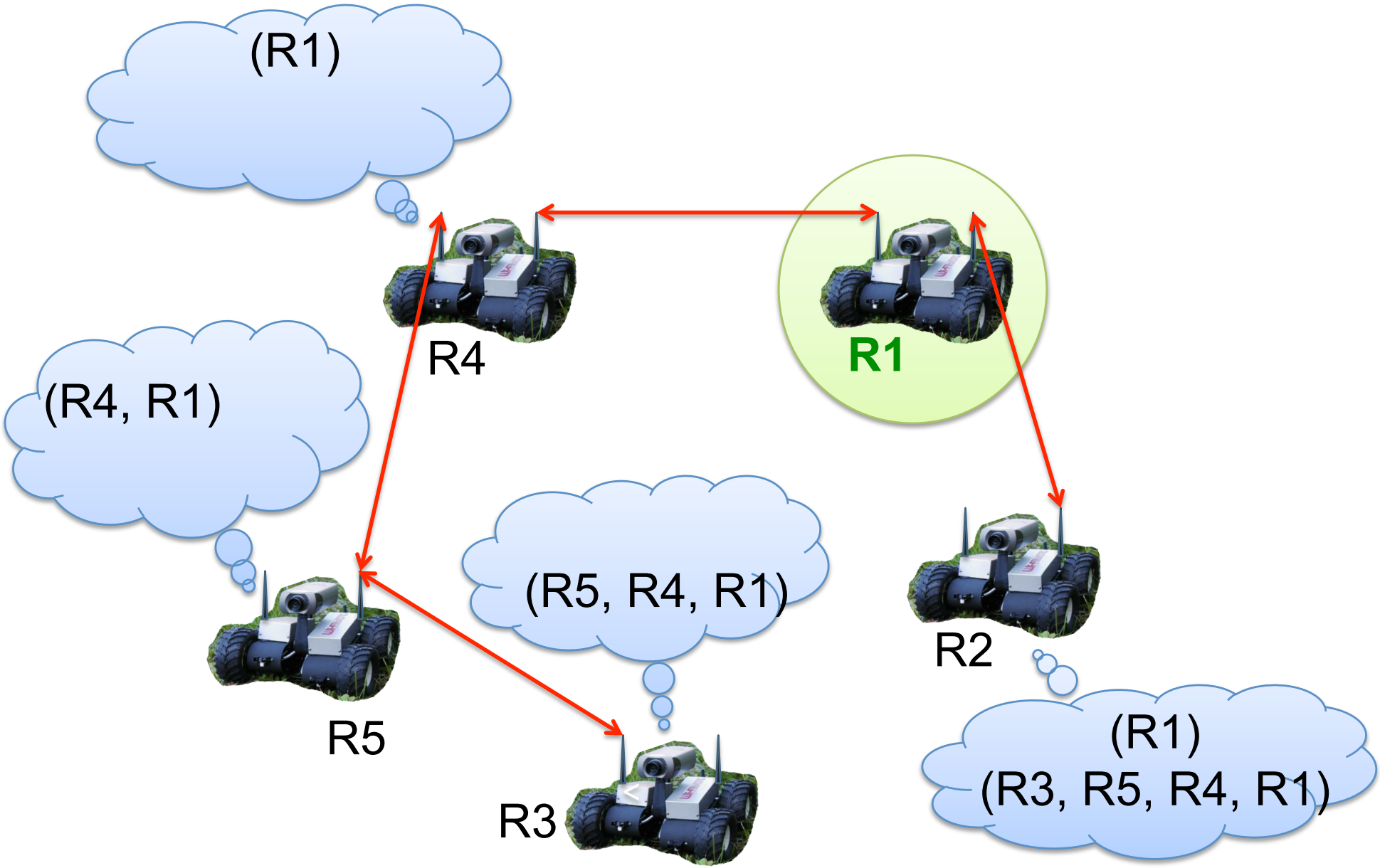
Disconnection



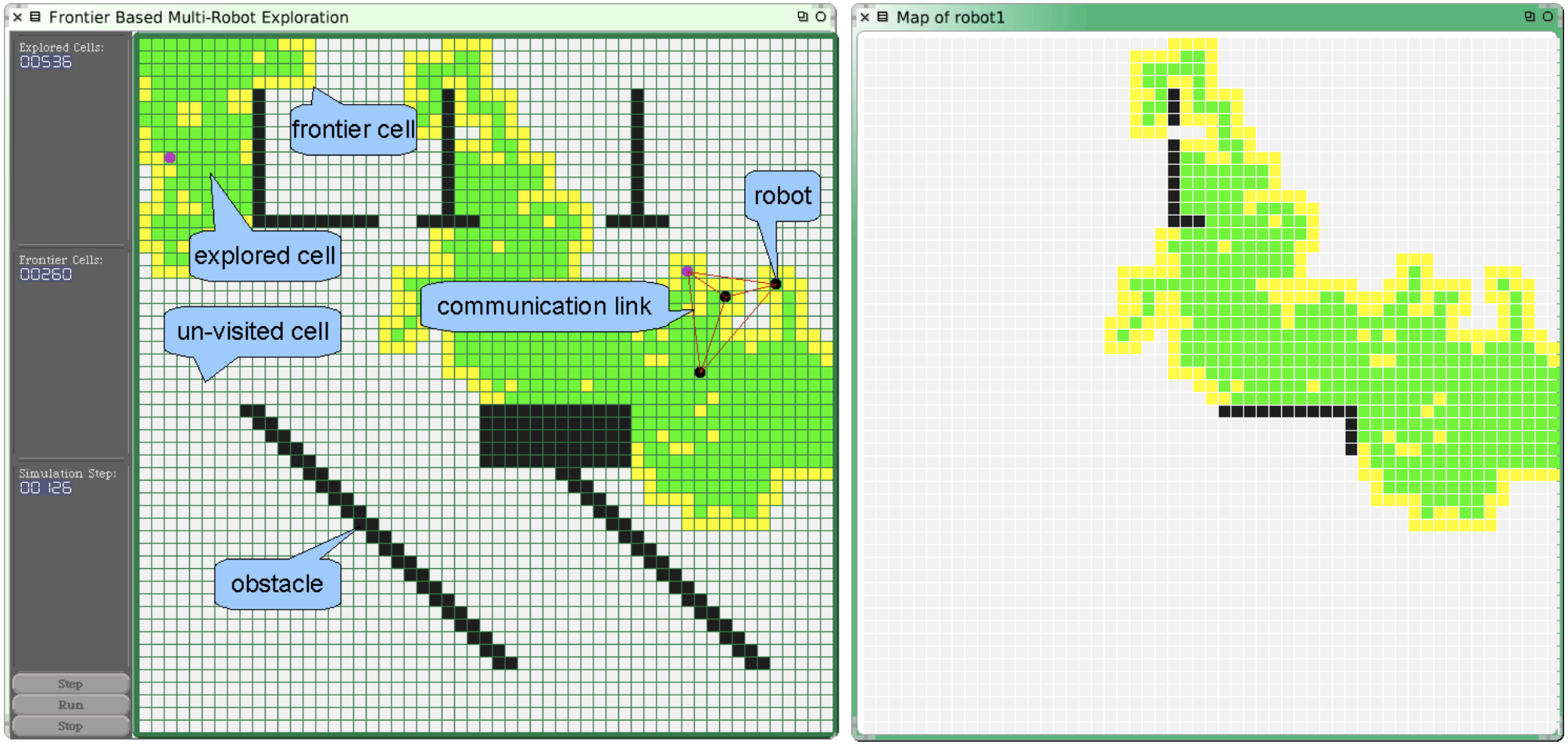
Disconnection



Disconnection



Validation through Simulation



Frontier-Based Exploration

Awarness for Bi-Connectivity

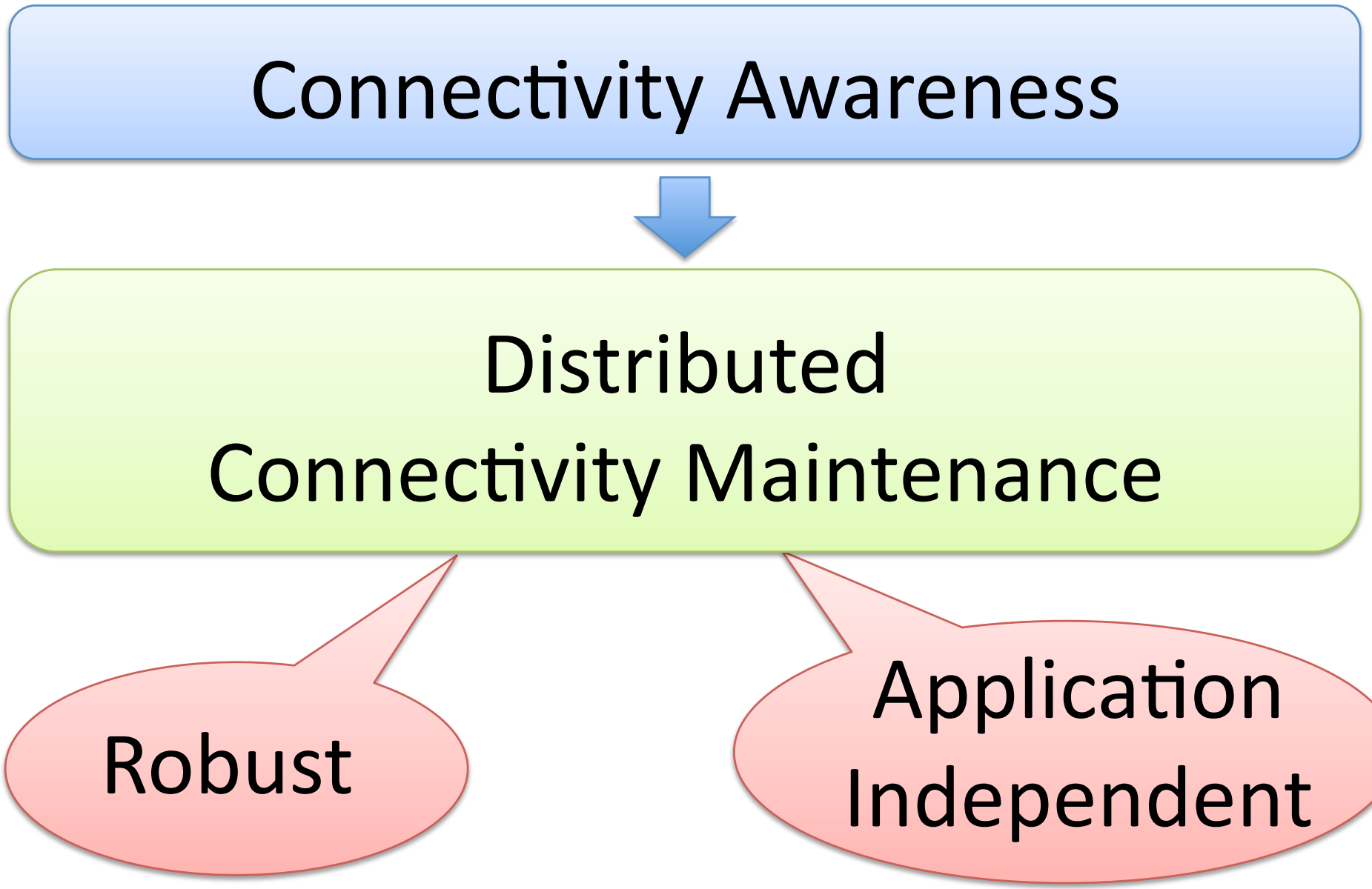
Bi-Connectivity = Robust connectivity

2 disjoint connections per-robot

Biconnectivity =

- Awarness with 2 reference Robots
- 2 communication paths between reference Robots

Conclusion


Connectivity Awareness
Distributed
Connectivity Maintenance
Robust
Application
Independent