A MAC and Routing Protocol in Ad Hoc Wireless Networks with Directional Antenna

2003/09/25

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Outline

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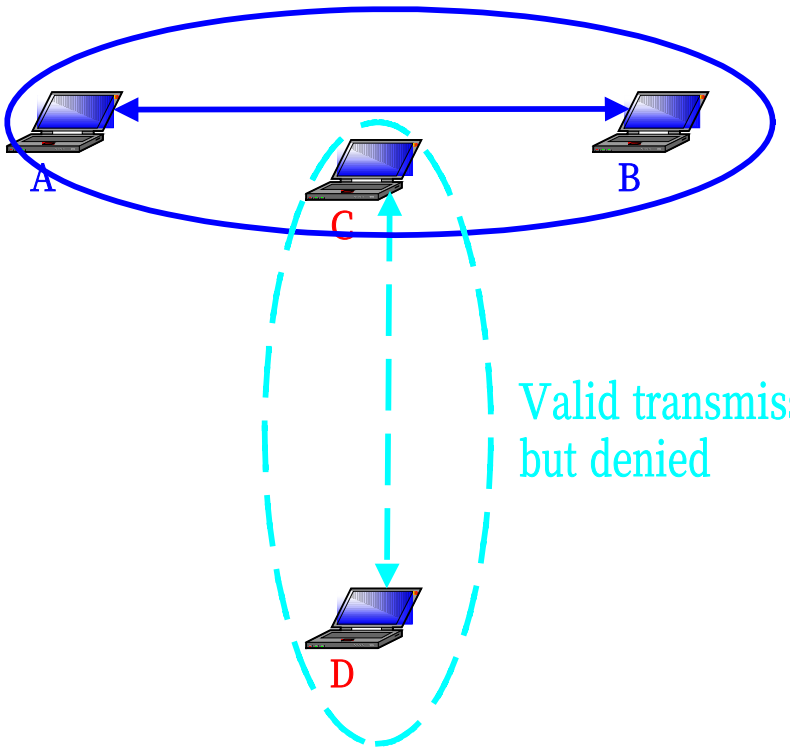
Introduction

- The goal of CSMA/CA is to have a node transmit a packet *if and only if* there will be *no collisions* [4].
  - Not only should it *be blocked* if there will *be a collision*, but it should *also not be blocked* if there will *be no collision* [4].
- CSMA/CA meets this goal admirably in ad hoc networks when omni-directional antennas are used. However, with directional transmissions, this is not true [4].

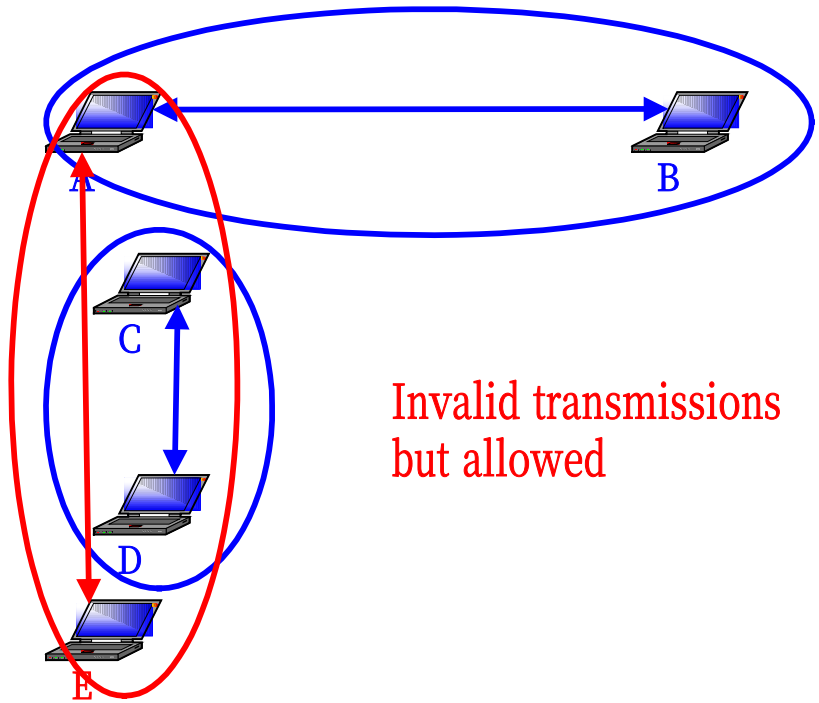
Problem Definition

- MAC Issues
  - The Deafness Problem [1][3]
  - The Hidden Terminal Problem [1][3]
- Routing Issues
  - Route Coupling Problem [4]

Problem Definition (MAC Issues)

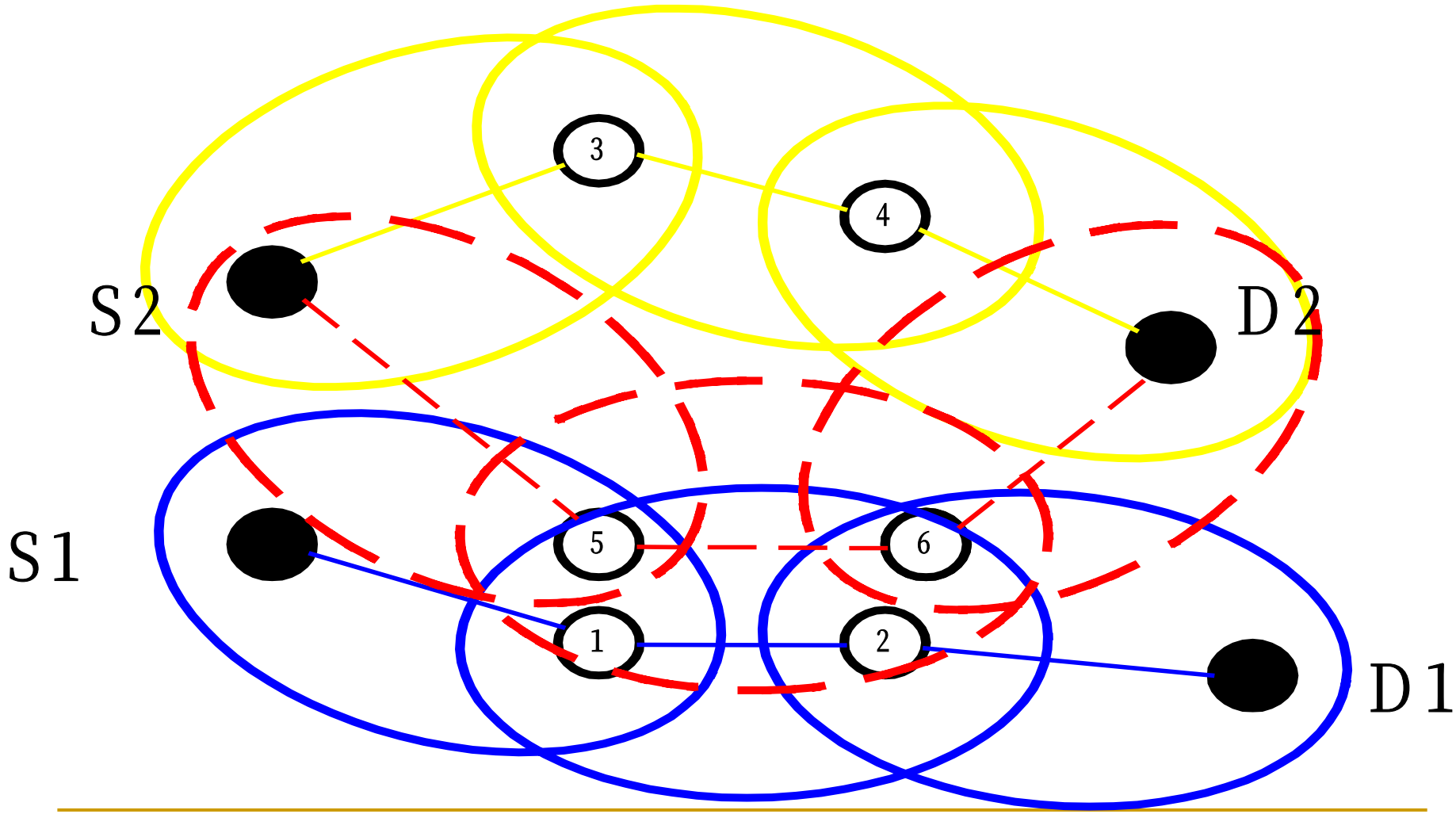


Valid transmissions but denied



Invalid transmissions but allowed

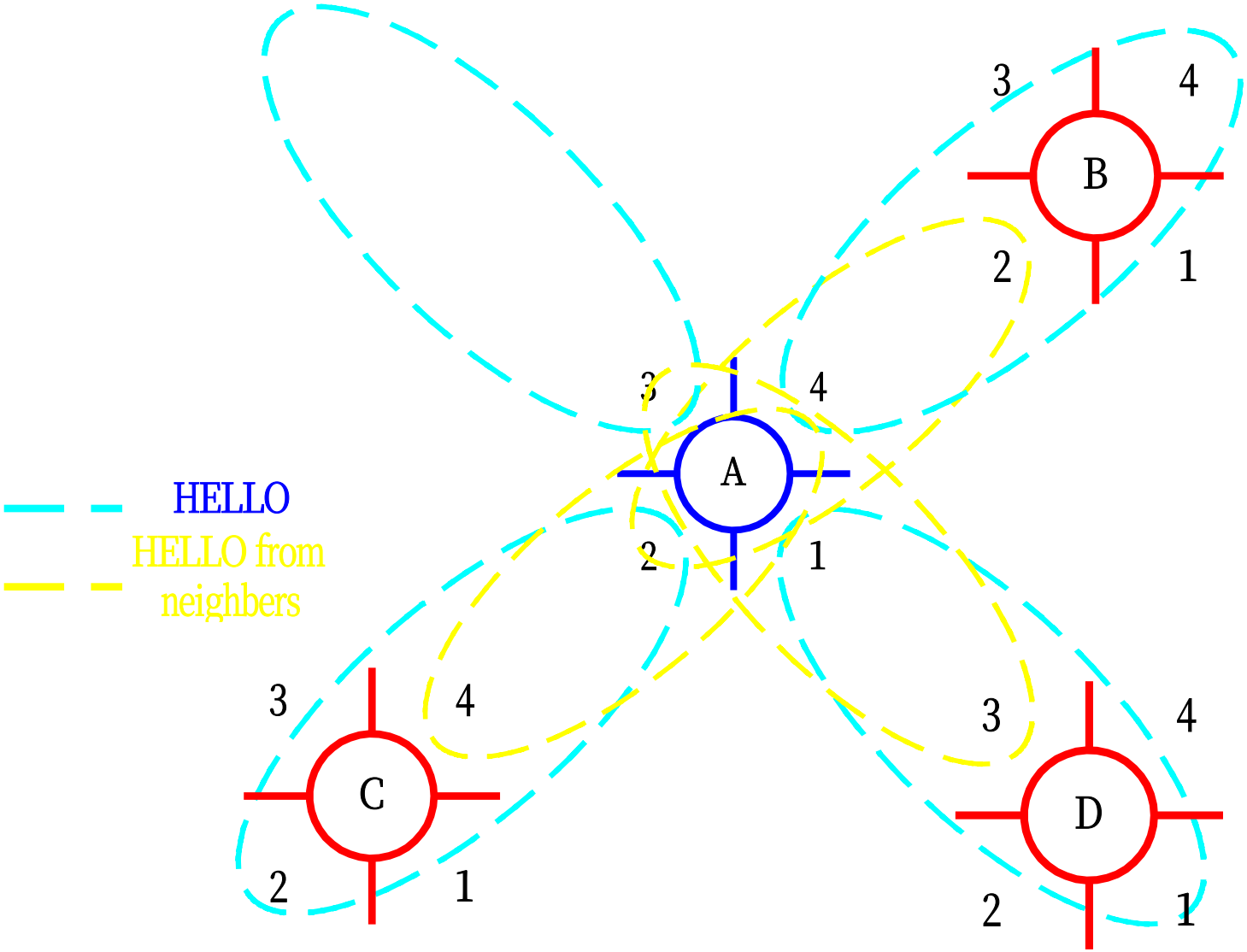
Problem Definition (Routing Issues)



The Control Messages Shared between Proposed MAC and Routing Protocol

- Circular Directional Control Message
  - Directional Link State Advertisement
  - *Location Table* [3]
  - Communication State Advertisement (which is combined with link state advertisement) [4]
  - *Active Node Table* [4]

Directional Link State Advertisement



Location Table

- All nodes should construct the location table which contains the location of its neighbors.

Me	Neighbor	My Beam	Neighbor's Beam
A	B	4	2
A	C	2	4
A	D	1	3

Communication State Advertisement

- The hello message of link state advertise-ment must contain the communication state of the node.
- The possible state of all the nodes in the network could be 0(inactive) or 1(active).

Active Node Table

- All node should construct the active node table which contains *the perception about communication activities* in the entire network.

Nodes	n_1	n_2	…	n_N
State	0(inactive)	1(active)	…	0(inactive)

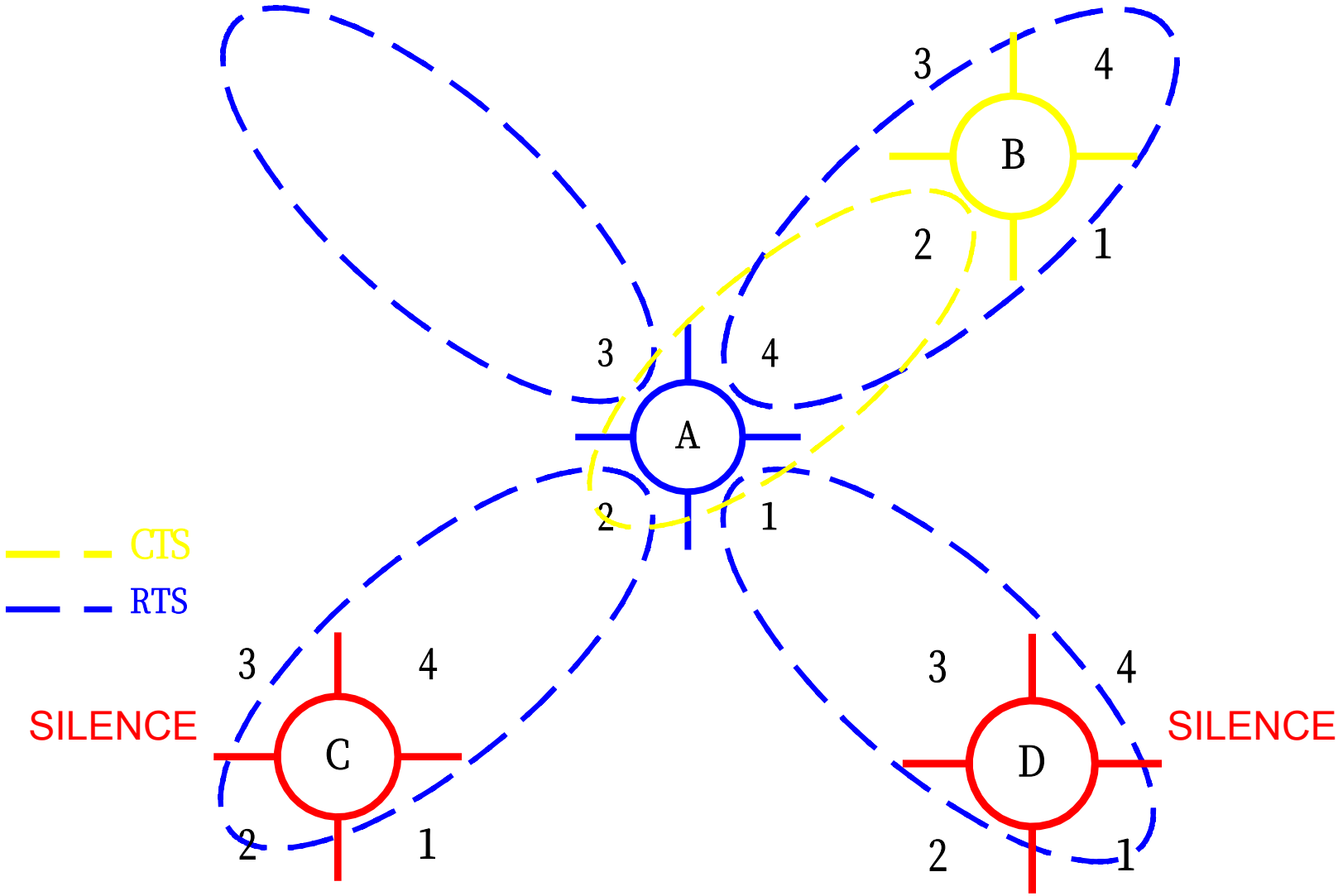
The Proposed MAC Protocol

- Preceding Tone [4]
- Circular Directional RTS [3] and CTS
- D-NAV [2][3][4]

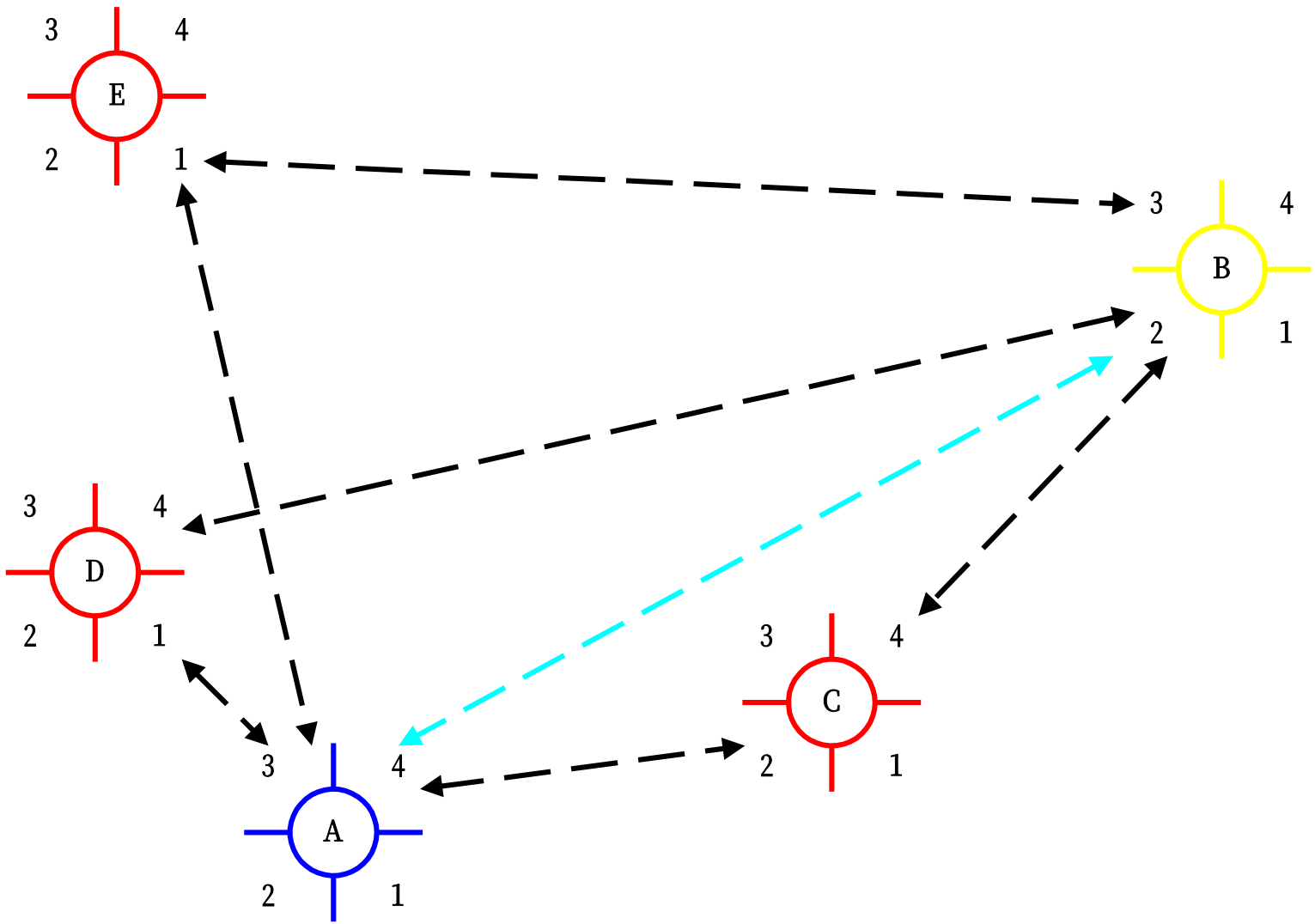
Preceding Tone

- In order to enable the receiver decoding the received signal correctly, each control packet is transmitted with a preceding tone with a duration such that *in this period the receiver can track the best possible direction of receiving the signal*.

Circular Directional RTS and CTS



D-NAV



The Proposed Routing Protocol

- Routing Protocol with Maximally Zone Disjoint Shortest Path [4]
  - Step 1: Find out all paths between s-d pair with numbers of hop less than H_{max}.
  - Step 2: Consult the active node table for finding out the nodes involved in ongoing communications at that point of time for computing route correlation factor η.
  - Step 3: Choose the lowest η path as routing path.

Conclusions

- *Preceding tone* help the receiver quickly track the correct direction of the transmitter.
- *Circular directional RTS and CTS* fully exploit the coverage of smart antenna, at the same time, it solves the problem of hidden terminal.
- *D-NAV* refines the spacial reuse of WLAN, for this reason, it can improve the capacity of WLAN drastically. D-NAV also solves the deafness problem.
- *Maximally Zone Disjoint Shortest Path Routing* can resolve the route coupling problem which degenerate the end-to-end delay of route.

References

- [1] Ram Ramanathan, “On the Performance of Ad Hoc Networks with Beamforming Antennas”, ACM MobiHoc, 2001.
- [2] Mineo Takai, Jay Martin, Aifeng Ren and Rajive Bagrodia, “Directional Virtual Carrier Sensing for Directional Antennas in Mobile Ad Hoc Networks”, ACM MobiHoc, 2002.
- [3] Thanasis Korakis, Gentian Jakllari and Leandros Tassiulas, “A MAC Protocol for Full Exploitation of Directional Antennas in Ad-hoc Wireless Networks”, ACM MobiHoc, 2003.
- [4] Siuli Roy, Dola Saha, S. Bandyopadhyay, Tetsuro Ueda and Shinsuke Tanaka, “A Network-Aware MAC and Routing Protocol for Effective Load Balancing in Ad Hoc Wireless Networks with Directional Antenna”, ACM MobiHoc, 2003.