Wireless networks

Routing: DYMO

AODV-DSR: Comparison

- Many studies in the literature
- DSR
  - Allows multiple routes
  - Supports unidirectional links
  - Overheards and caches routing info
- AODV
  - Does not require long hop lists
  - Supports multicast
  - Hallo messages to check connectivity

AODV-DSR: Comparison (2)

- With low traffic and low mobility
  - Both have an acceptable end-to-end delay, and small routing overhead (control packets)
- With high mobility, high traffic
  - AODV has an higher routing due to control packets:
    - routes become congested and need to be rediscovered
    - Hallo messages create collisions and interfere with slow start protocols (eg TCP)
  - DSR pays for multiple routes
    - With high mobility it is difficult to make sensible choices
    - Promiscuous overheard, aggressive caching and quick reaction to changes can make routes unstable

AODV-DSR: Comparison (bib)

- Johnson et al
  - Broch, Maltz, Johnson, Hu, Jetcheva. *A Performance Comparison of Multi-Hop Wireless Ad Hoc Routing Protocols*. Mobile computing and Networking 1998
- Nordstrom et al
  - Nordstrom, Gunningberg, Rohner, Wibling. *Evaluating Wireless Multi-Hop Networks Using a combination of Simulation, emulation amd Real World Experiments*. ACM MobiEval 2007 pp 29--34

Dynamic MANET On Demand Routing (DYMO)

- Draft RFC Feb 2011 IETF-MANET working group
- Proposed by Perkins & Chackeres
- Merges features of DSR and AODV
- Goals:
  - Simplify AODV
  - Use more information (accumulates routes as DSR)

DYMO: assumptions

- Same as AODV
- Cooperative nodes:
  - All nodes want to participate fully in the network protocol and ***will forward packets for other nodes***
- Bidirectional symmetric links
  - A node which has received a packet from a neighbor is able to route it back to the sender using the same link

DYMO: assumptions (2)

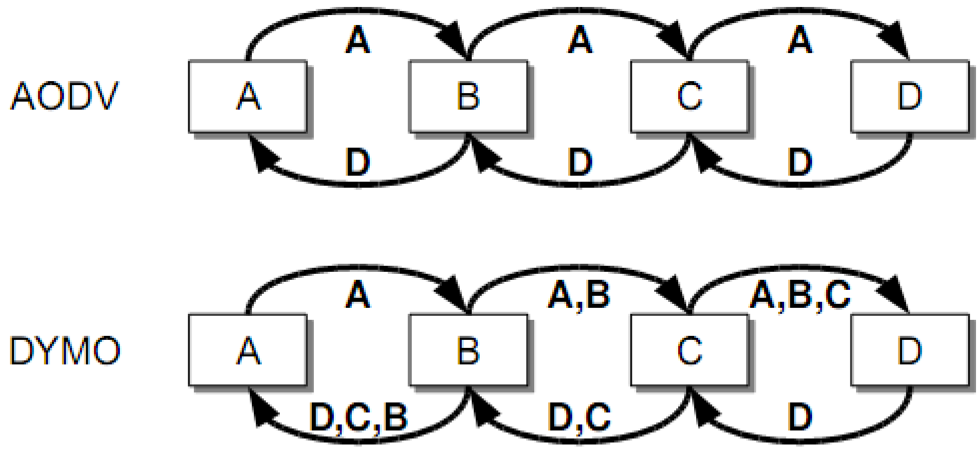
- Corrupted packets
  - A corrupted packet can be recognized and discarded by its destination
- Mobile nodes
  - Nodes in the network may move at any time without notice.

DYMO

- Similar to AODV
  - Route Discovery and Route Maintainance work in similar way
  - Uses same sequence numbers to prevent loops
  - Do NOT use Hallo packets
- Takes some ideas from DSR
  - RREQ and RREP messages carry information on all intermediate nodes
  - They are used to create Routing Table entries for all intermediate nodes (not only for Source and Destination as in AODV)

DYMO: RREQ RREP

- include informations about traversed nodes
  - Each node: (1) appends itself to the route
  - and (2) updates its RT with the route collected so far creating/updating entries for all intermediate nodes



DYMO: Routing Table

- An entry in RT includes
  - Destination address and sequence number: IP address and sequence number of the destination associated with this entry
  - Prefix: Indicates that the associated address is a network address, rathen than a network address
  - Next-hop address and interface: IP address of next hop in route and interface used to send packets

DYMO: Routing Table (2)

- An entry in RT includes (contd.)
  - Route forwarding: set to TRUE if the route can be used for forwarding messages
  - Route broken : set to TRUE if the next-hop becomes ureacheable or in respose to an RERR packet
  - Route Dist : number of hops to the destination along this route (optional field)

DYMO: RT timers

- Every RT entry can have a number of timers
  - ROUTE_AGE_MIN: minimum time a RT entry should be kept
  - ROUTE_SEQNUM_AGE_MAX: time after which sequence number in the RT entry should be discarded (to avoid too old info)
  - ROUTE_USED: every time a route is used this timer is set to ROUTE_USED_TIMEOUT
  - ROUTE_DELETE: this is set to ROUTE_DELETE_TIMEOUT for a broken route, after it expires the route entry is removed

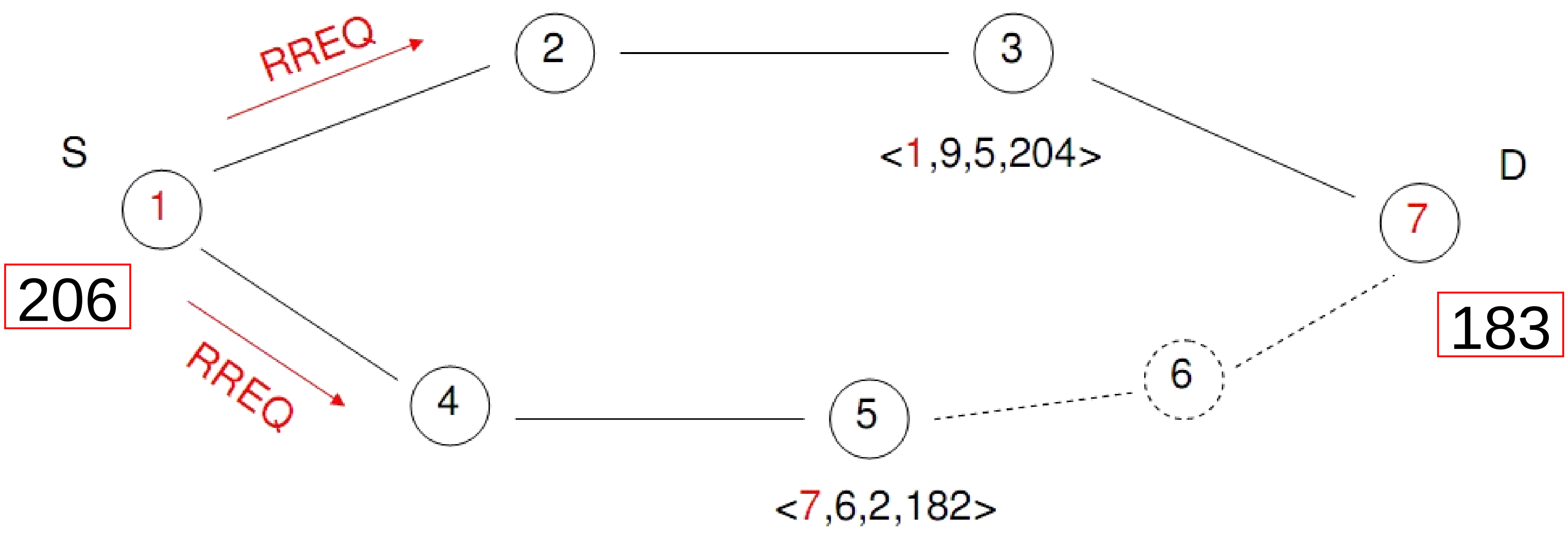
DYMO: Sequence numbers

- Used as in AODV
- Incremented when :
  - A source node generates a new RREQ
  - A destination node answers to an RREQ with a RREP
  - An intermediate node adds its information in an routing packet
- Complex interactions with timers and Route.dist and Route.broken to avoid loops in routing

DYMO: Sequence numbers (2)

- When a node is rebooted it must not set its sequence number to 0
  - This could produce loops due to old RT entry with positive sequence numbers
- Thus sequence numbers should be kept in persistent memory (if possible)
  - If a sequence number is lost node should wait for ROUTE_DELETE_TIMEOUT before fully participating to DYMO. In this period the node can only handle control messages but it cannot forward packets (it generates only RERR packets)

AODV: RREQ Example

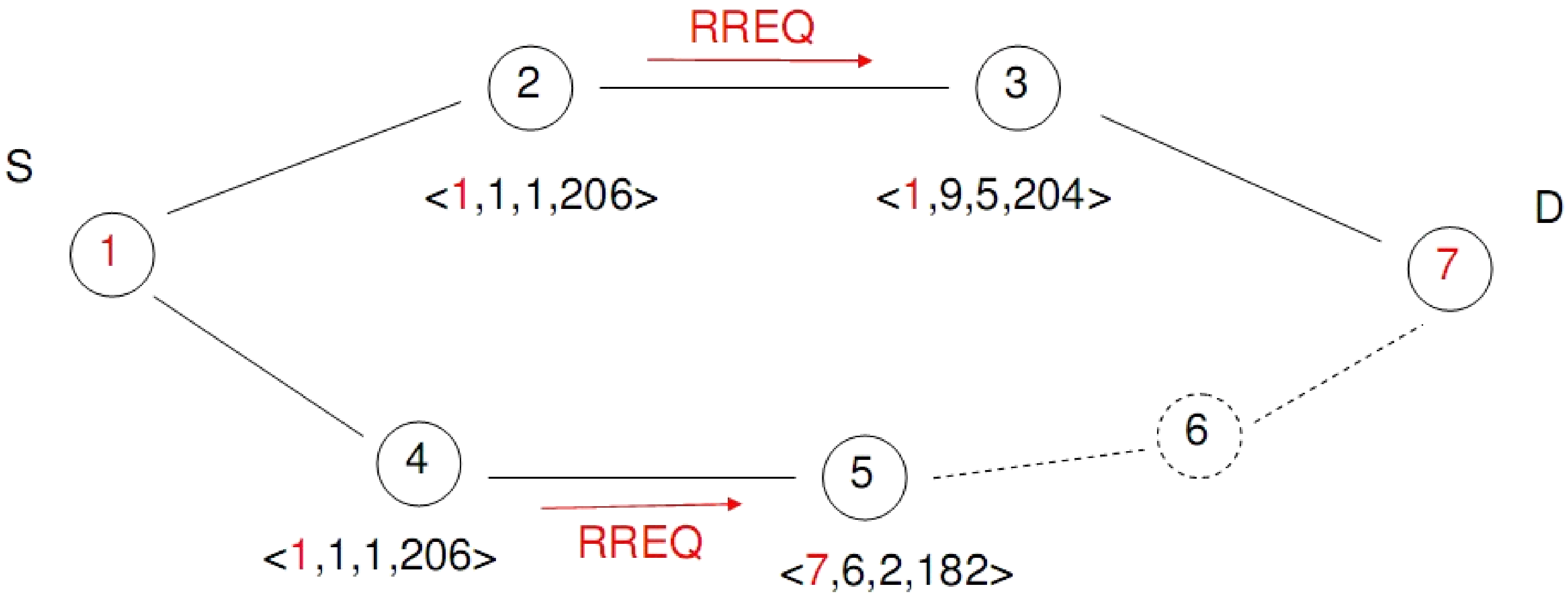


RREQ =

Dest : **7**
Dest Seq Num : **180**
Orig : **1**
Orig Seq Num : **206**
Hop Count : **0**

Table entry = <Dest,Next,Metric,Seq>

AODV: RREQ Example (2)

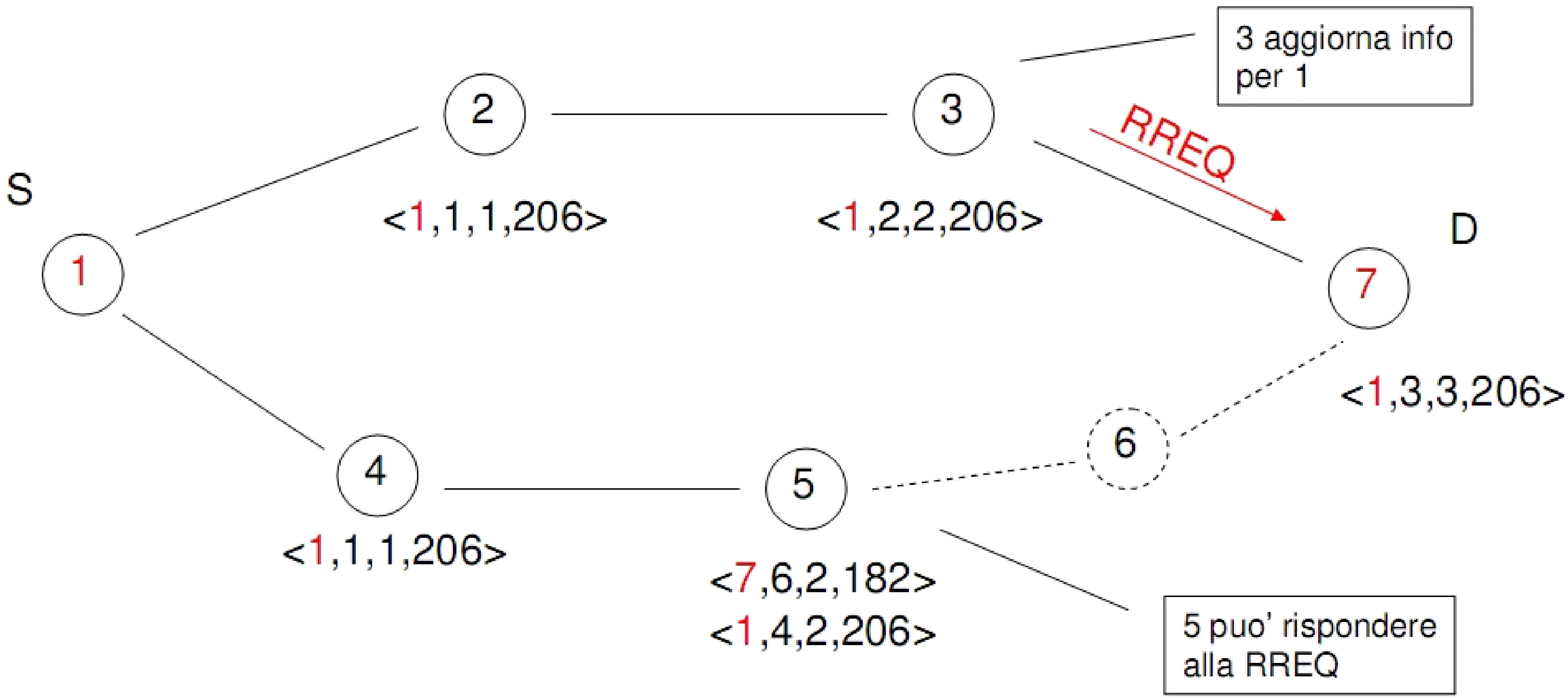


RREQ =

Dest : **7**
Dest Seq Num : **180**
Orig : **1**
Orig Seq Num : **206**
Hop Count : **1**

Table entry = <Dest,Next,Metric,Seq>

AODV: RREQ Example (3)

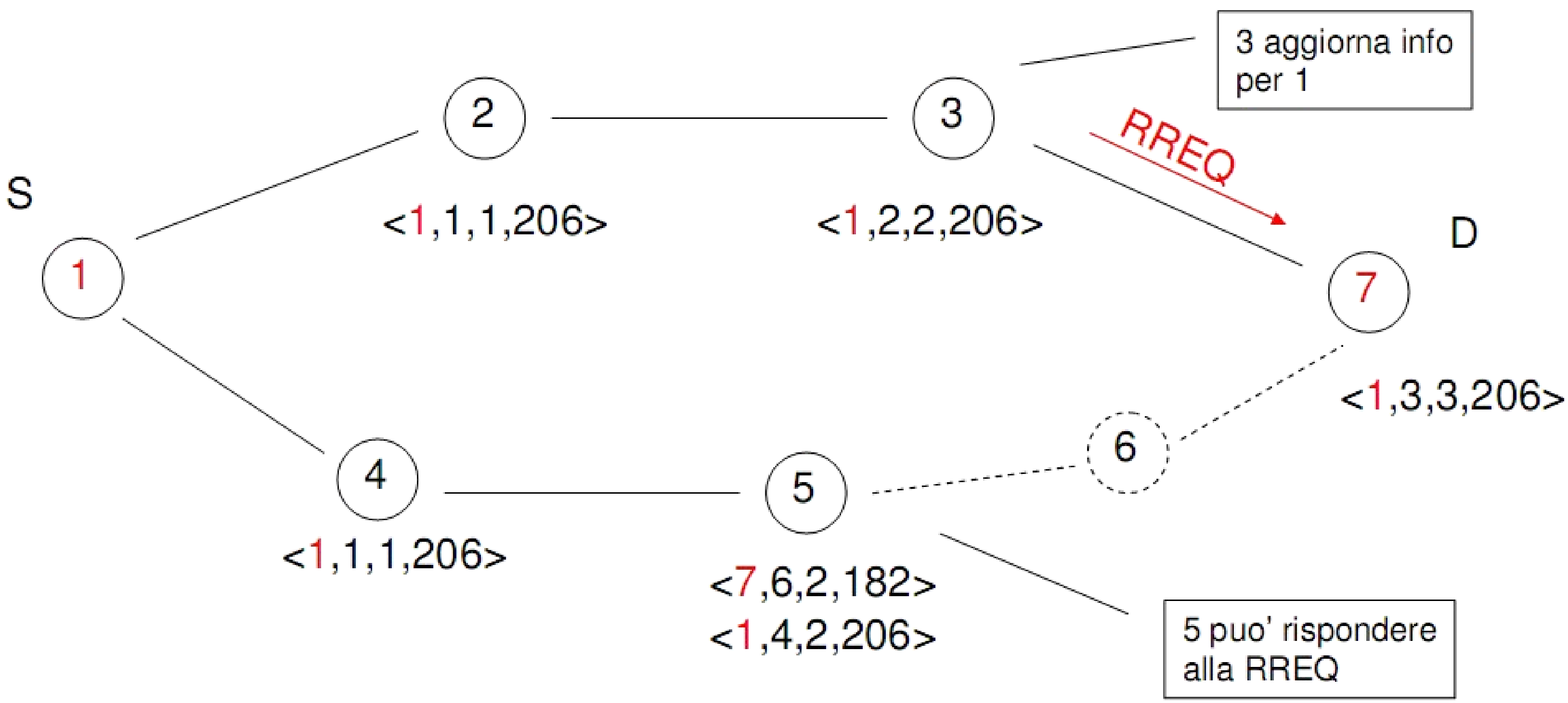


RREQ =

Dest : **7**
Dest Seq Num : **180**
Orig : **1**
Orig Seq Num : **206**
Hop Count : **2**

Table entry = <Dest,Next,Metric,Seq>

AODV: RREQ Example (4)

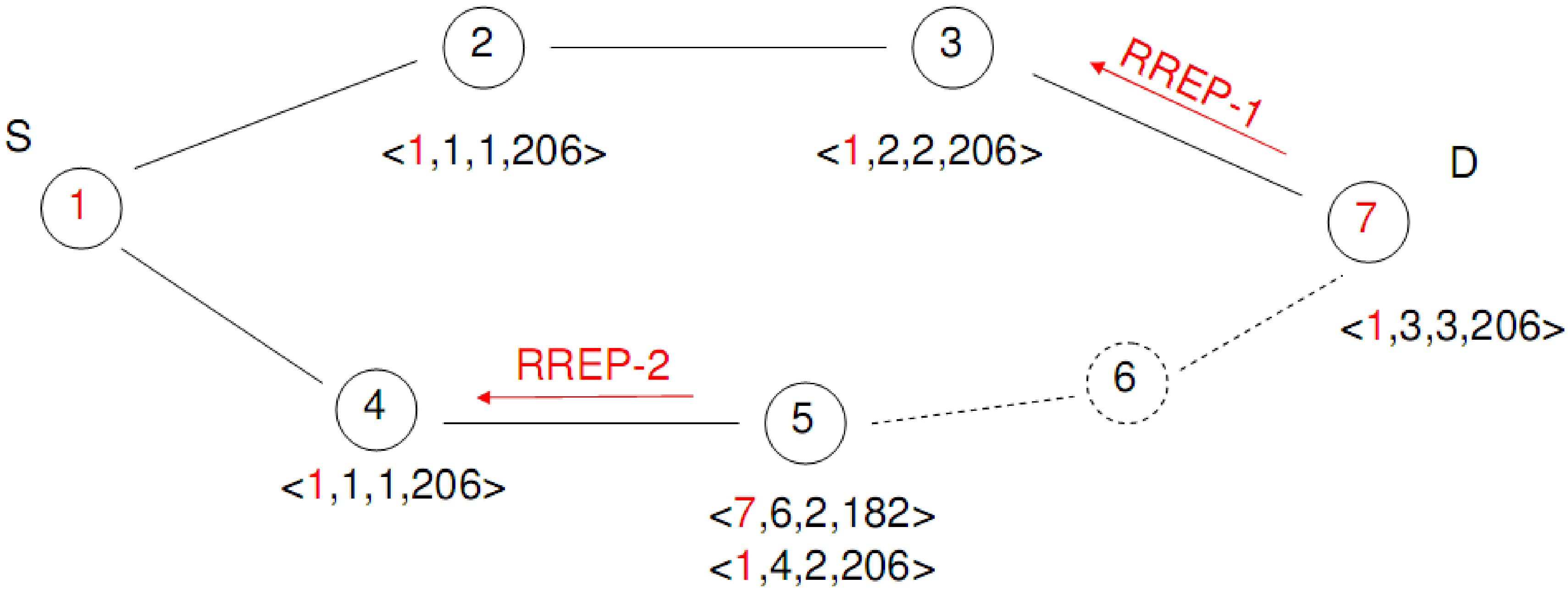


RREQ =

Dest : **7**
Dest Seq Num : **180**
Orig : **1**
Orig Seq Num : **206**
Hop Count : **2**

Table entry = <Dest,Next,Metric,Seq>

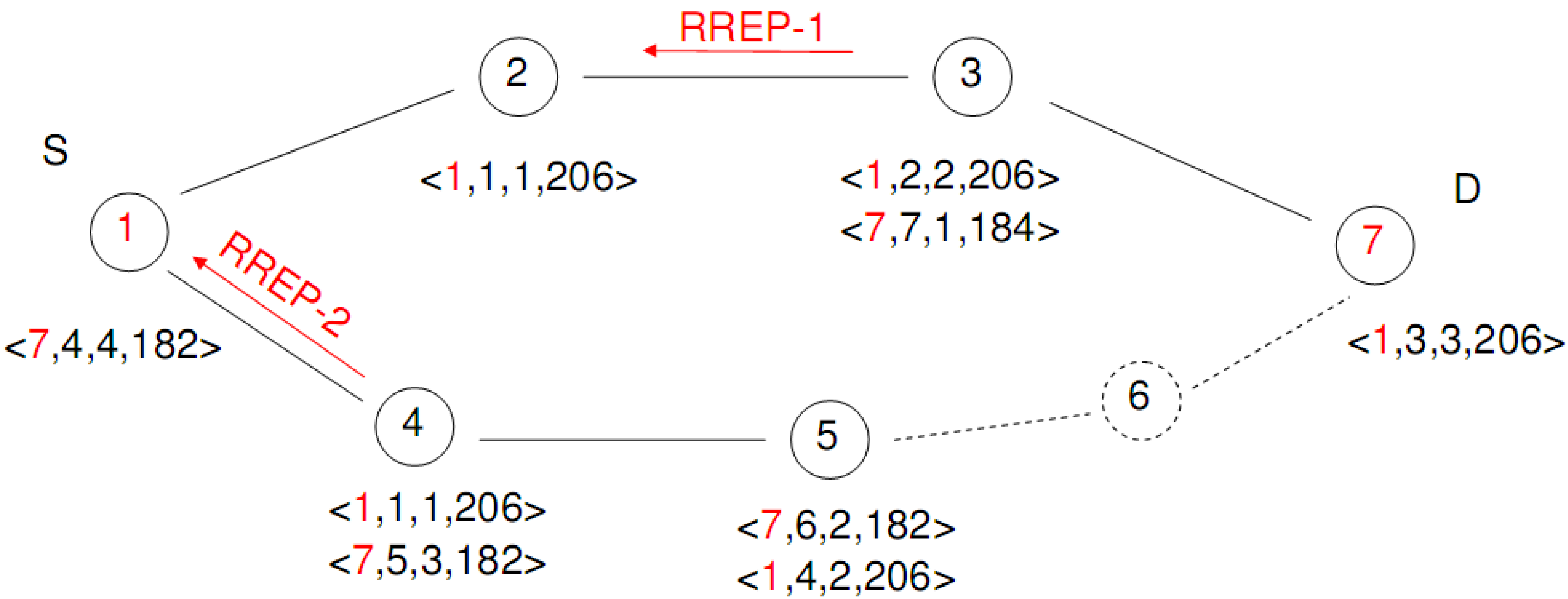
AODV: RREP Example



RREP-1 =
Dest : **7**
Dest Seq Num : **184**
Orig : **1**
Hop Count : **0**

RREP-2 =
Dest : **7**
Dest Seq Num : **182**
Orig : **1**
Hop Count : **2**

AODV: RREP Example (2)



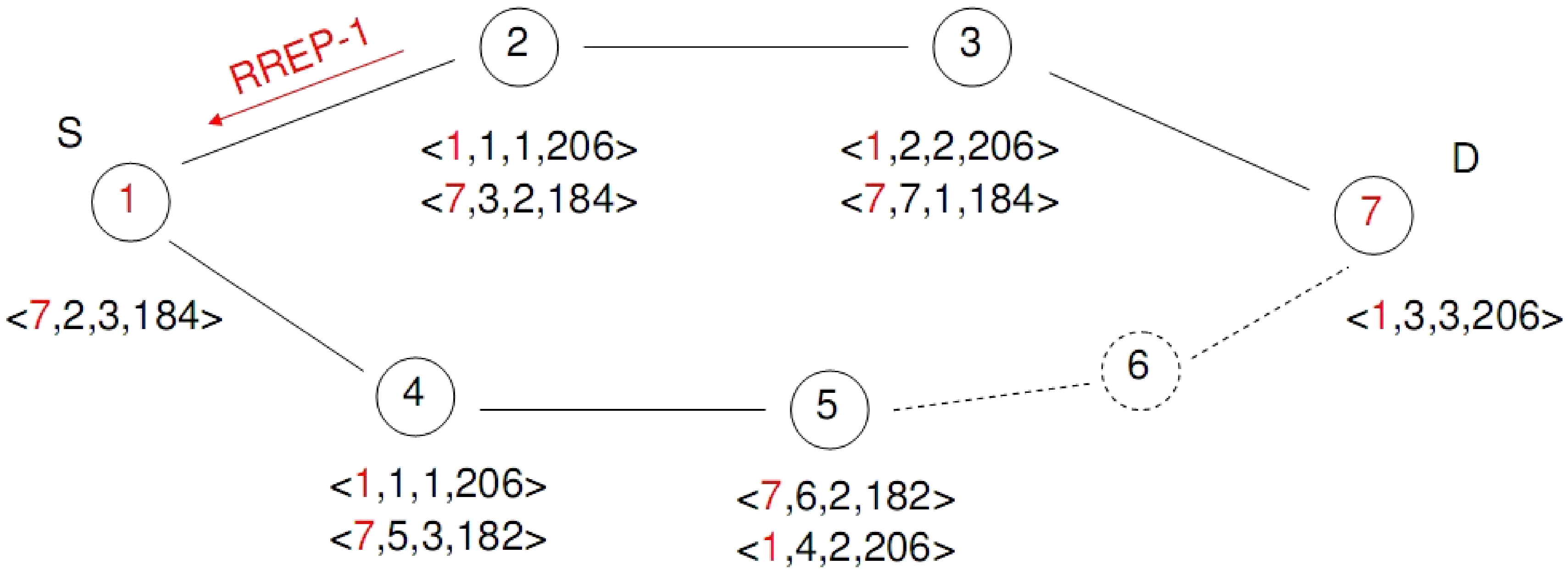
RREP-1 =

Dest : **7**
Dest Seq Num : **184**
Orig : **1**
Hop Count : **1**

RREP-2 =

Dest : **7**
Dest Seq Num : **182**
Orig : **1**
Hop Count : **3**

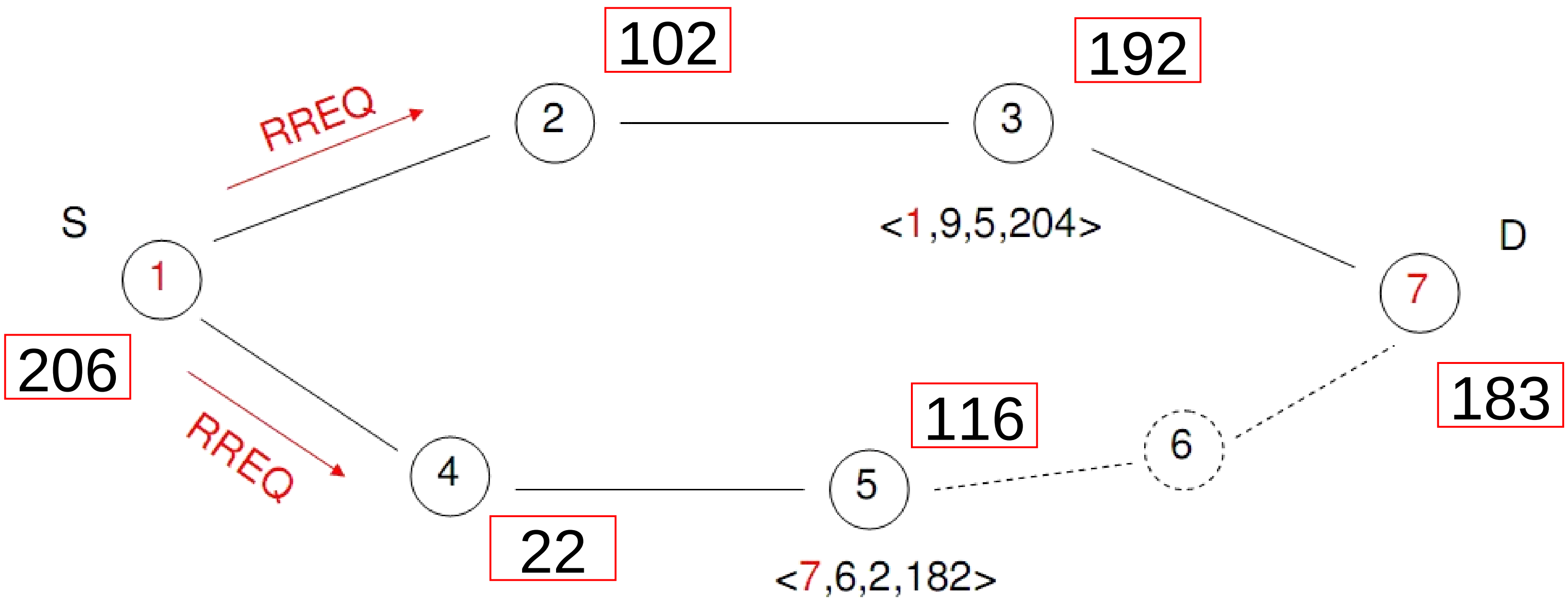
AODV: RREP Example (3)



RREP-1 =

Dest : **7**
Dest Seq Num : **184**
Orig : **1**
Hop Count : **2**

DYMO: RREQ Example

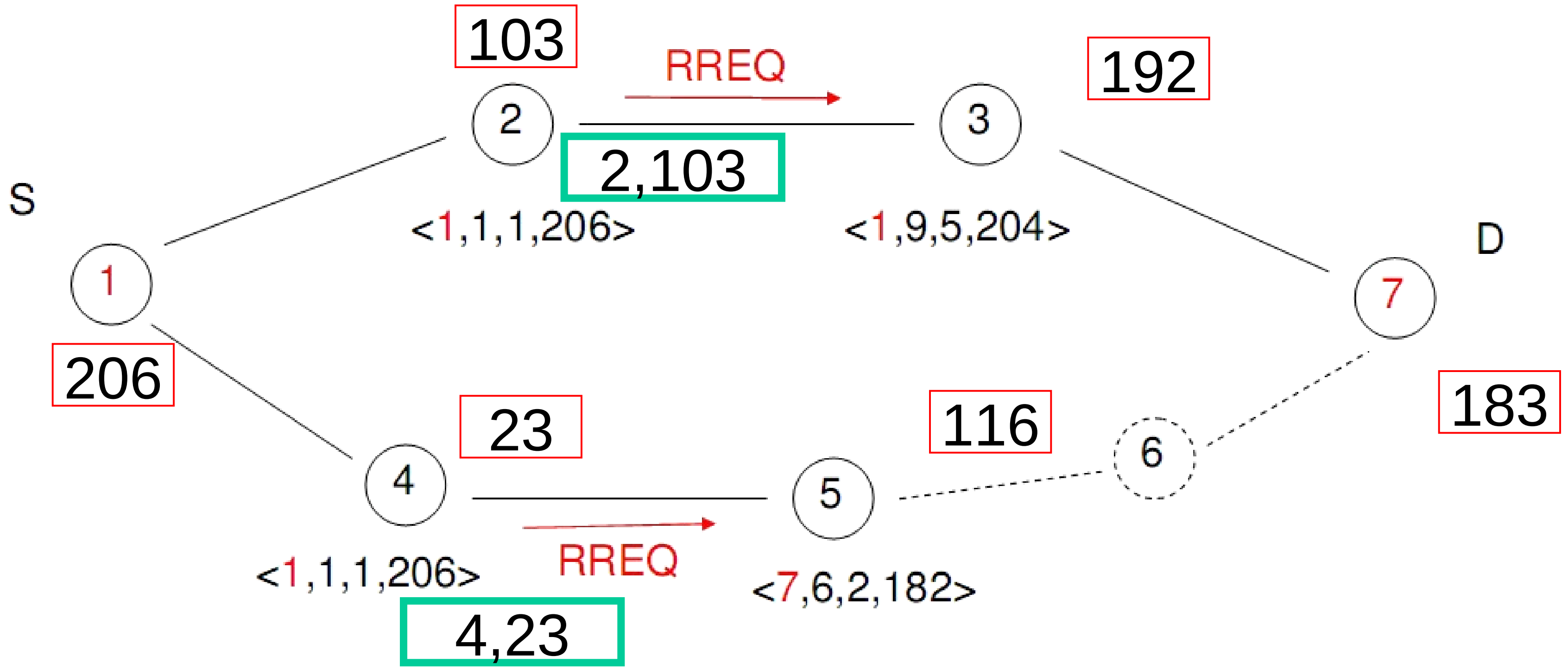


RREQ =

Dest : **7**
Dest Seq Num : **180**
Orig : **1**
Orig Seq Num : **206**
Hop Count : **0**

Table entry = <Dest,Next,Metric,Seq>

DYMO: RREQ Example (2)



RREQ =

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Dest Seq Num : **180**
Orig : **1**
Orig Seq Num : **206**
Hop Count : **1**

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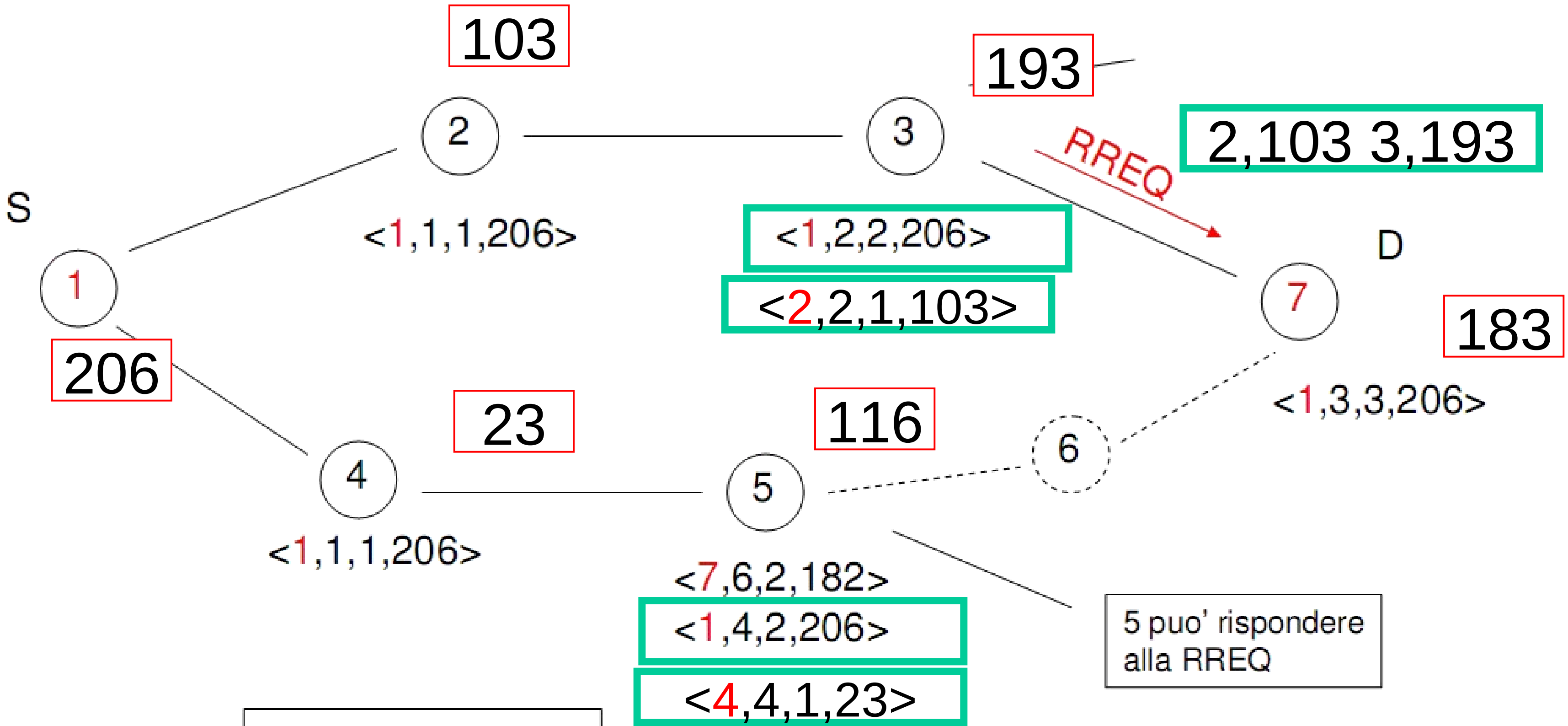
DYMO: RREQ Example (3)



RREQ =

Dest : **7**
Dest Seq Num : **180**
Orig : **1**
Orig Seq Num : **206**
Hop Count : **2**

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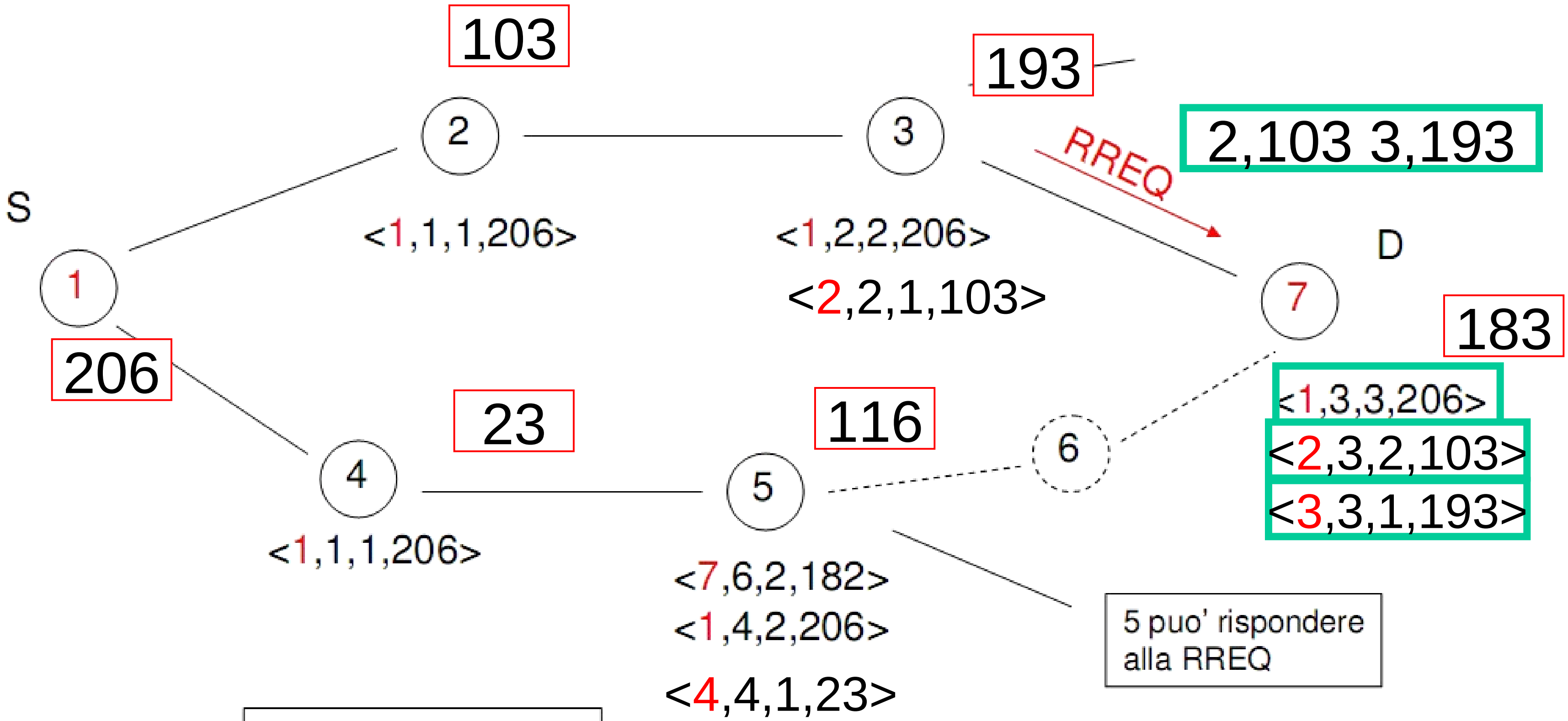
DYMO: RREQ Example (4)

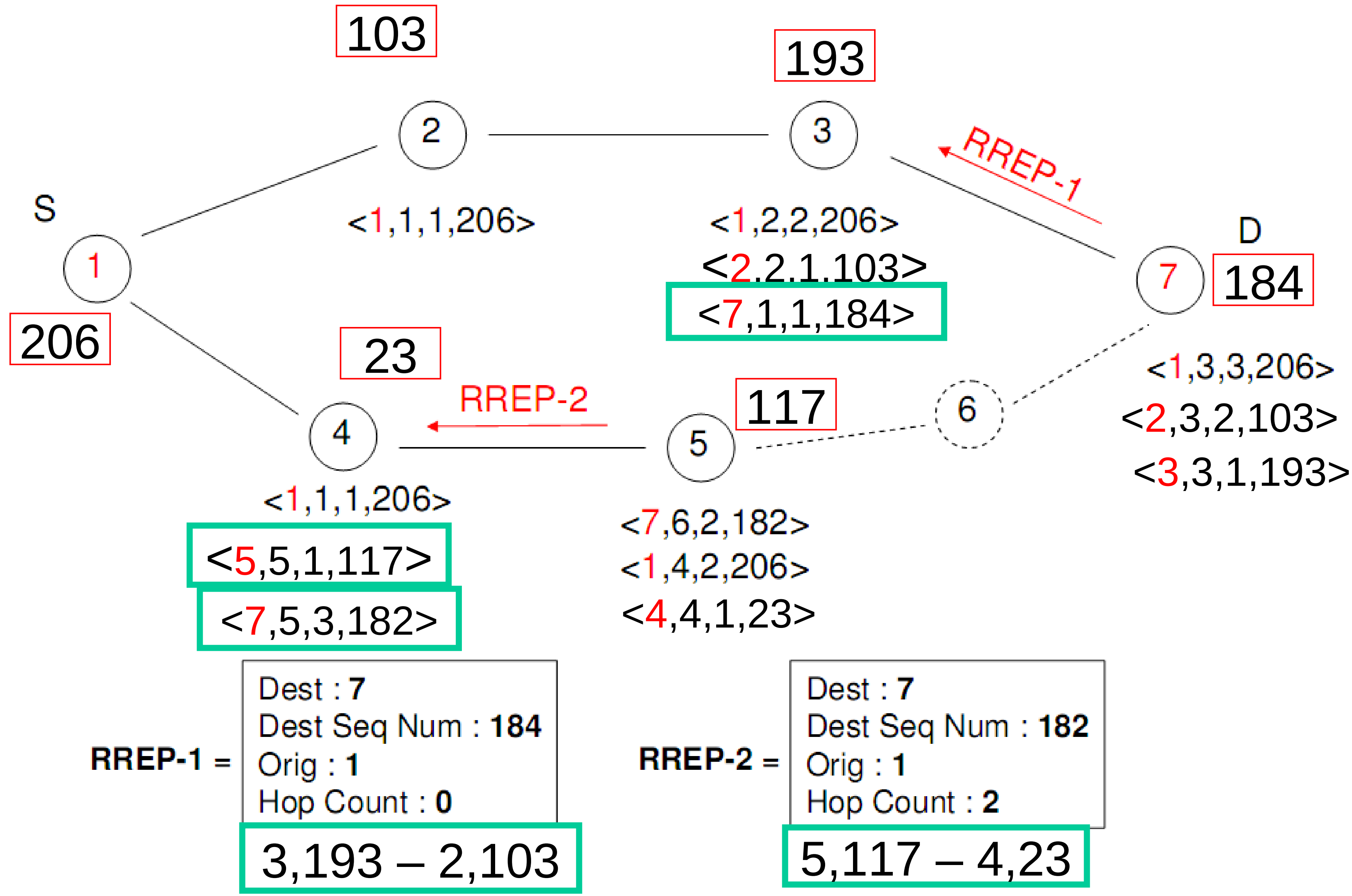


RREQ =

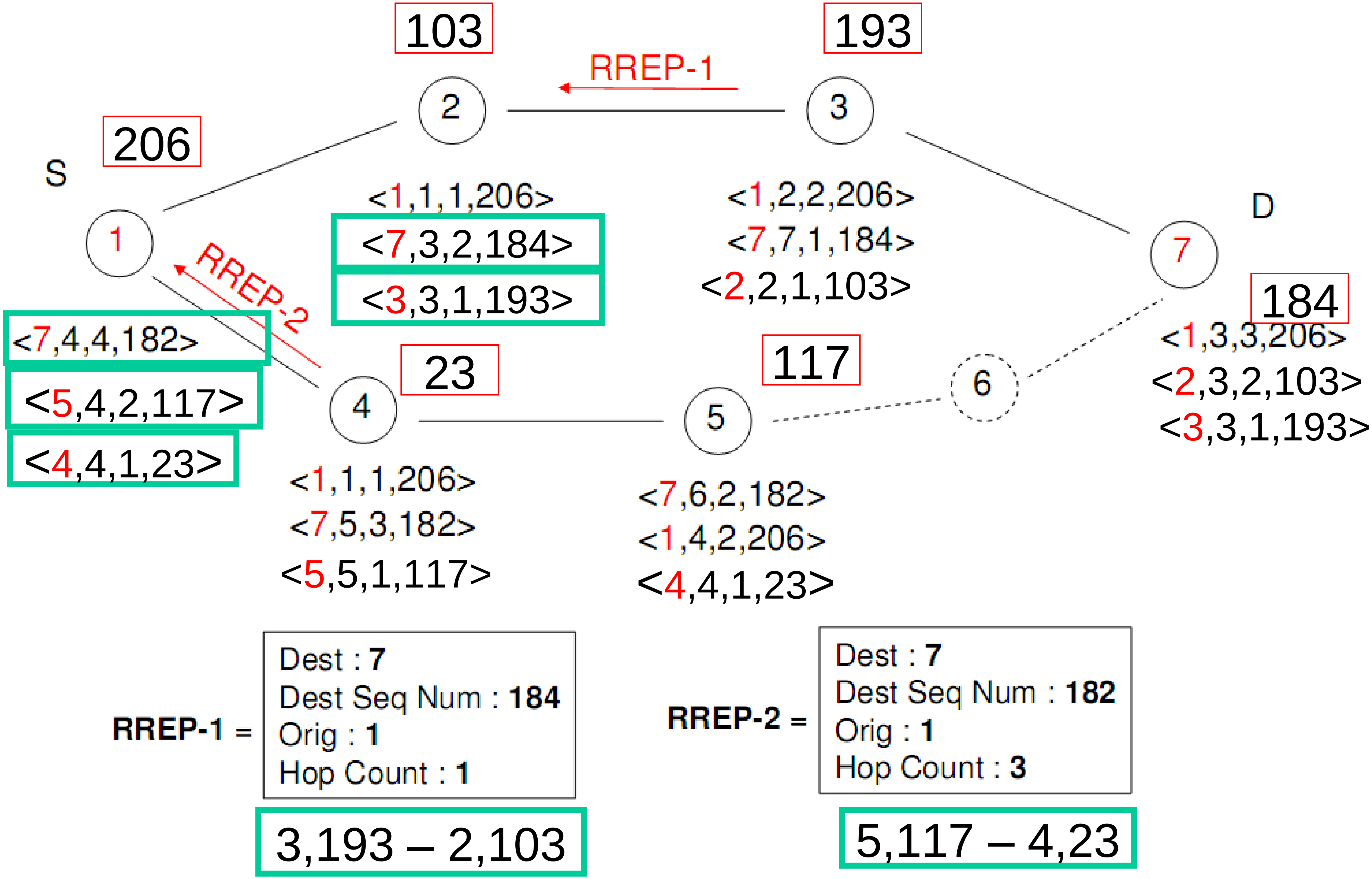
Dest : **7**
Dest Seq Num : **180**
Orig : **1**
Orig Seq Num : **206**
Hop Count : **2**

Table entry = <Dest,Next,Metric,Seq>

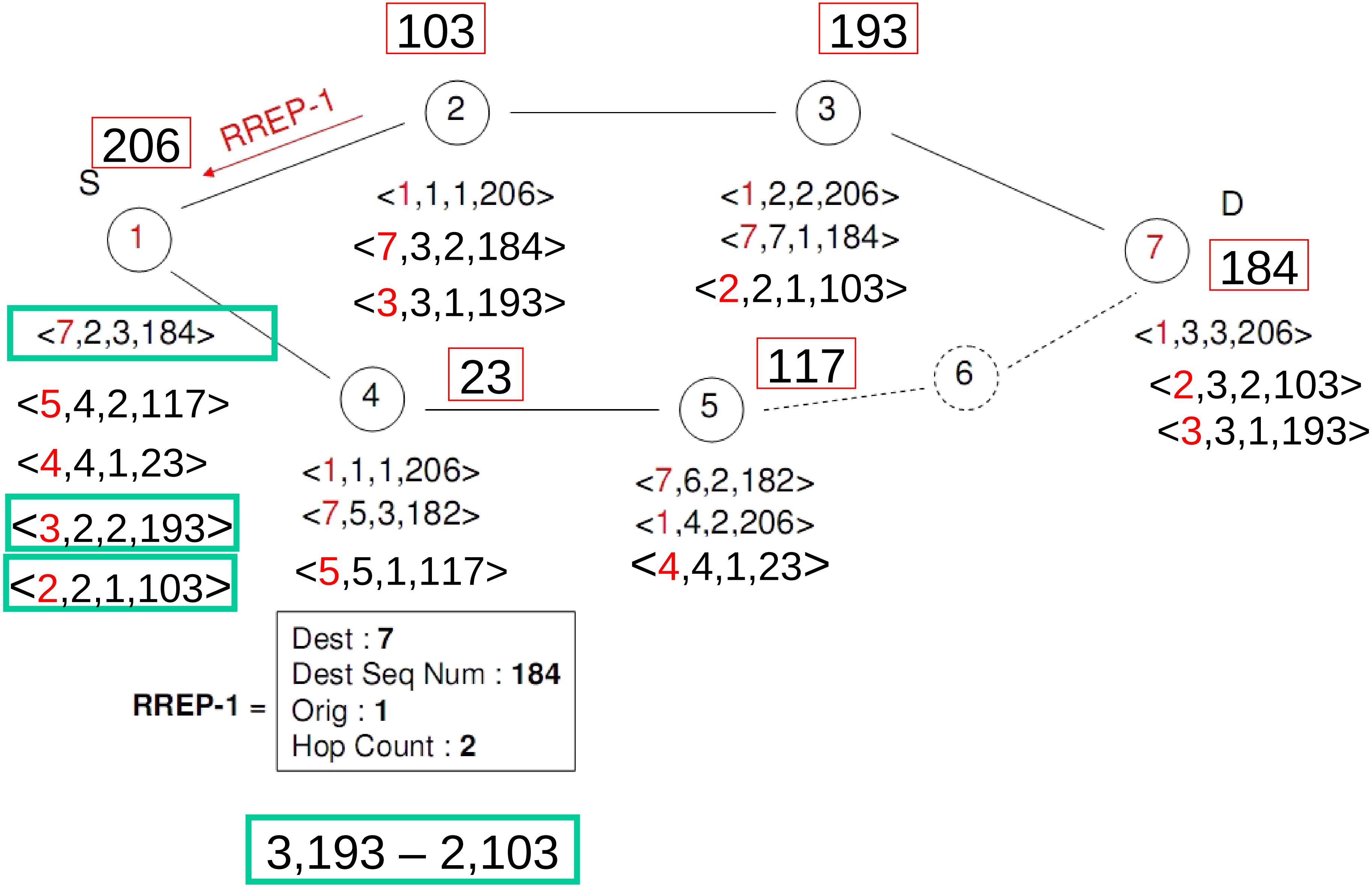
DYMO: RREP Example



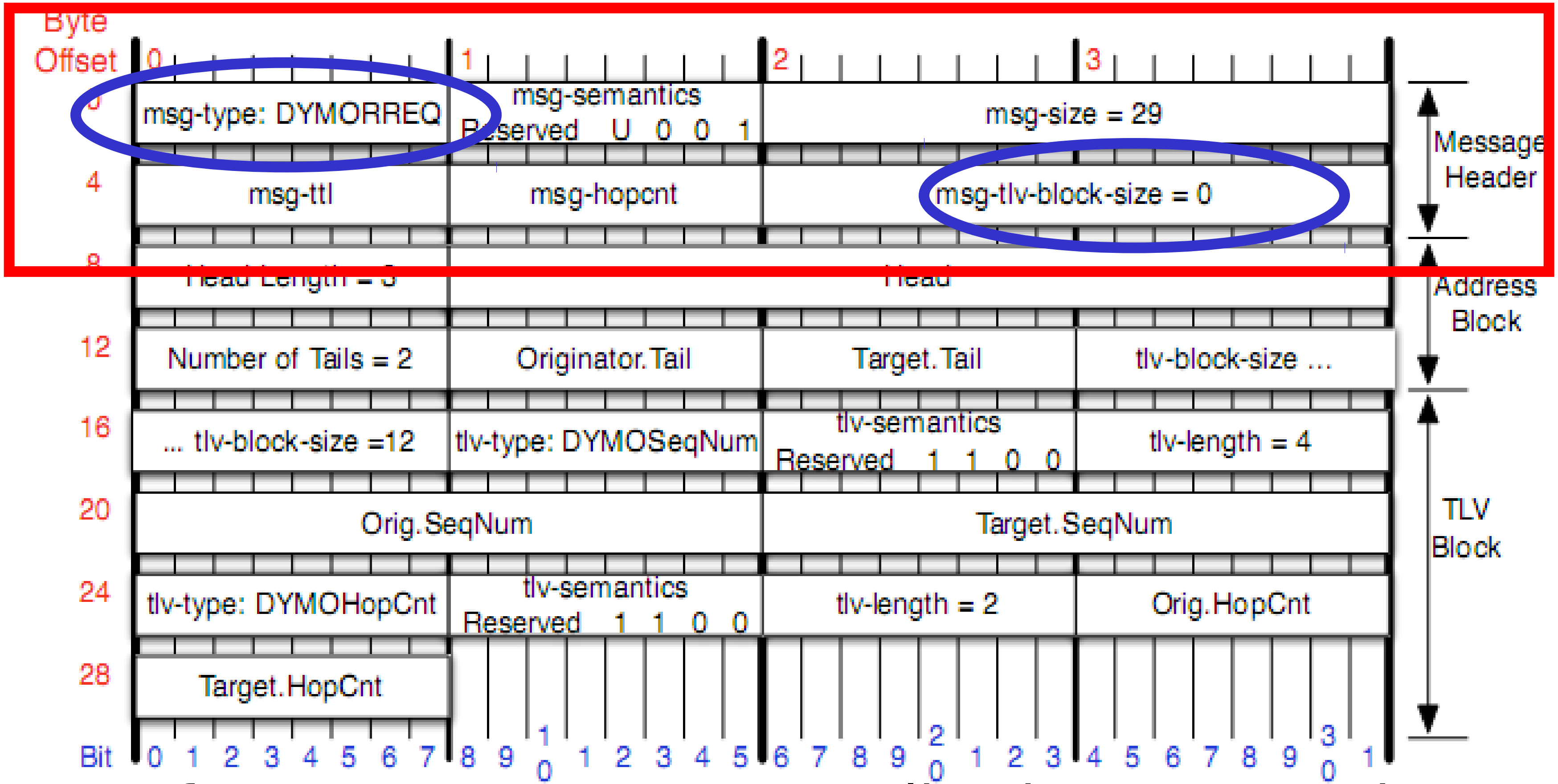
DYMO: RREP Example (2)



DYMO: RREP Example (3)

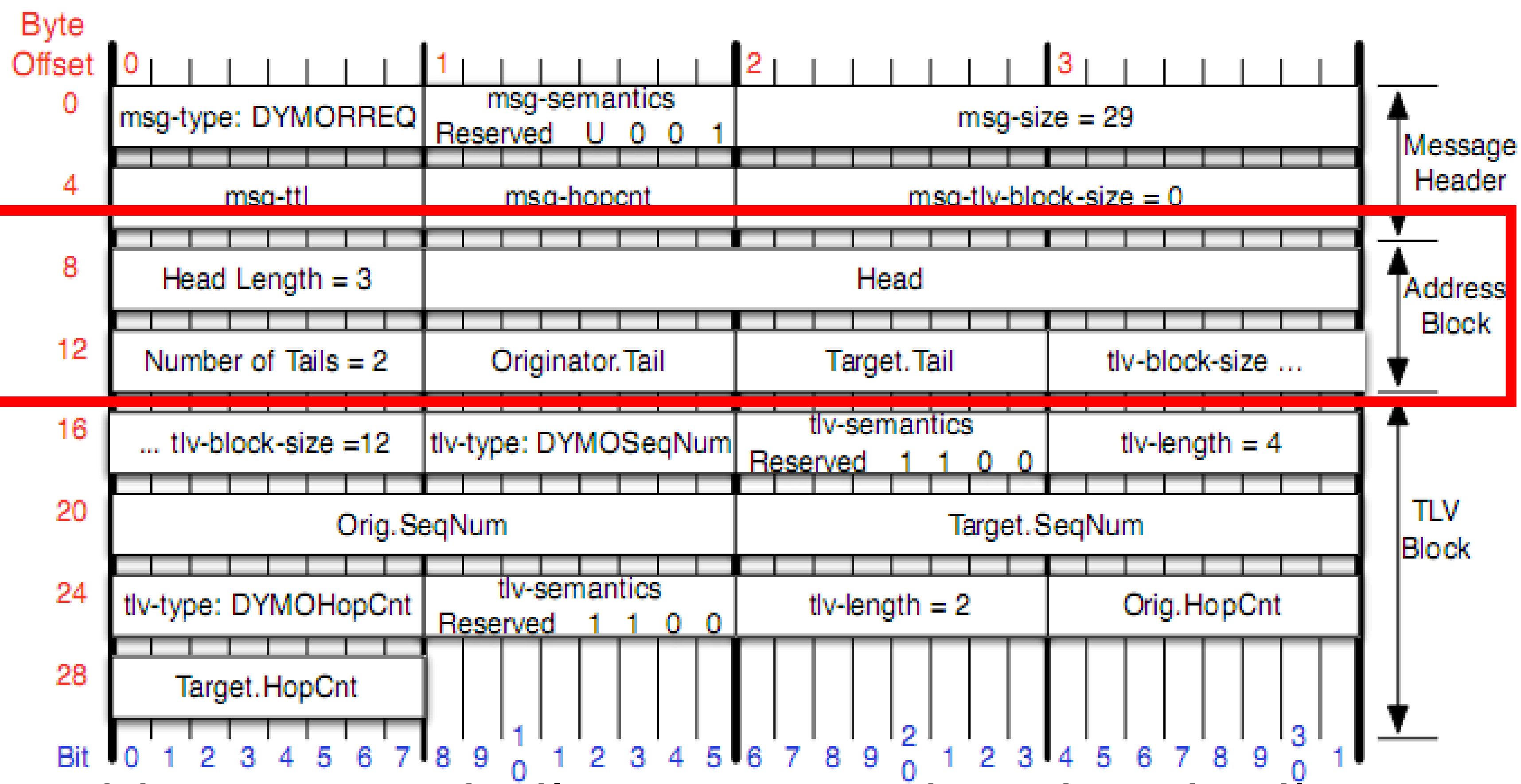


DYMO: message header



- Conform to RFC 5444 Generalized MANET Packet Message Format
- Format still under discussion

DYMO: address block



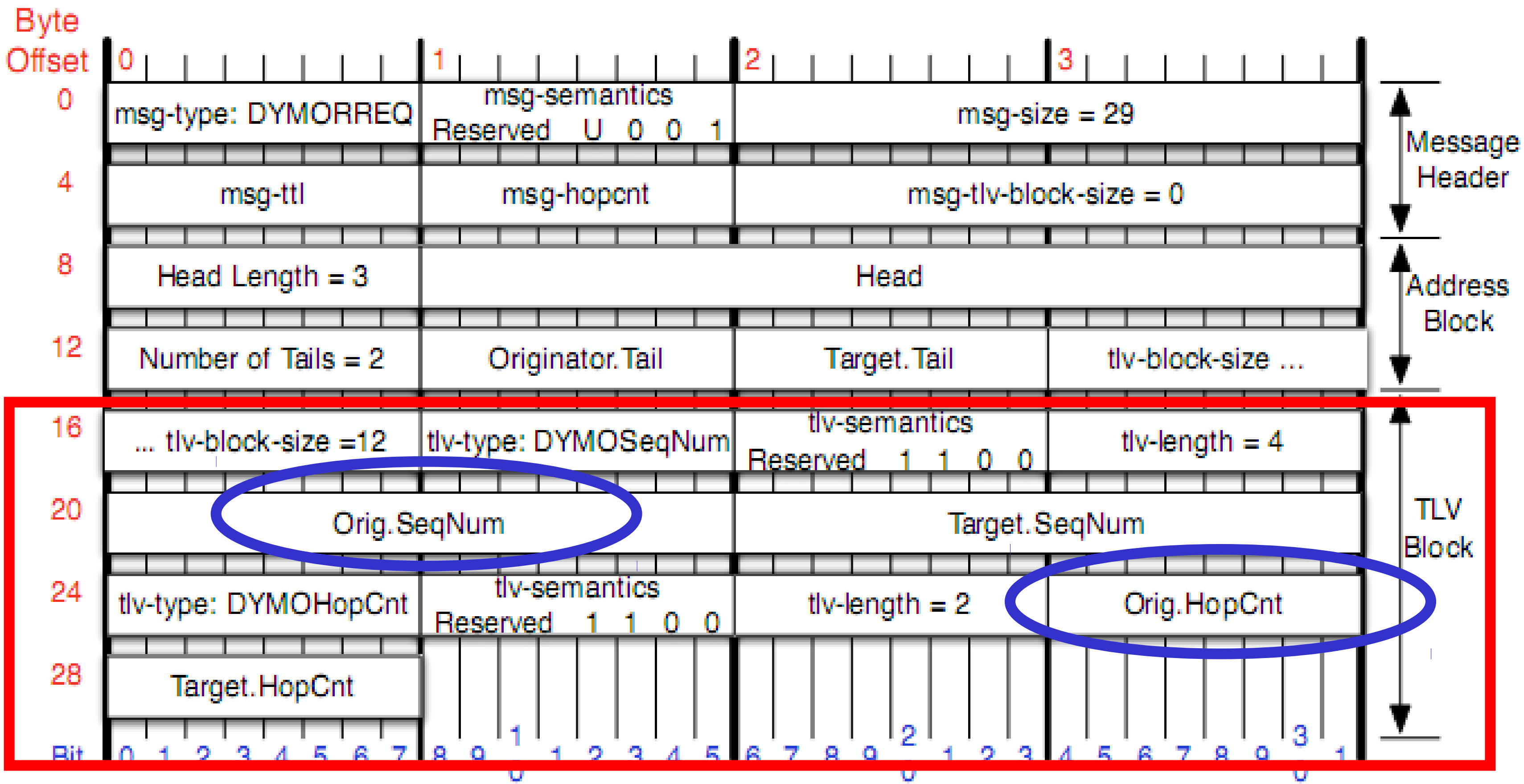
• Addresses are built concatenating “head:tail”

Es. Head: 192, 168, 42 Originator Tail: 50

Target Tail: 51

IP Originator: 192.168.42.50 IP Target:

DYMO: TLV block

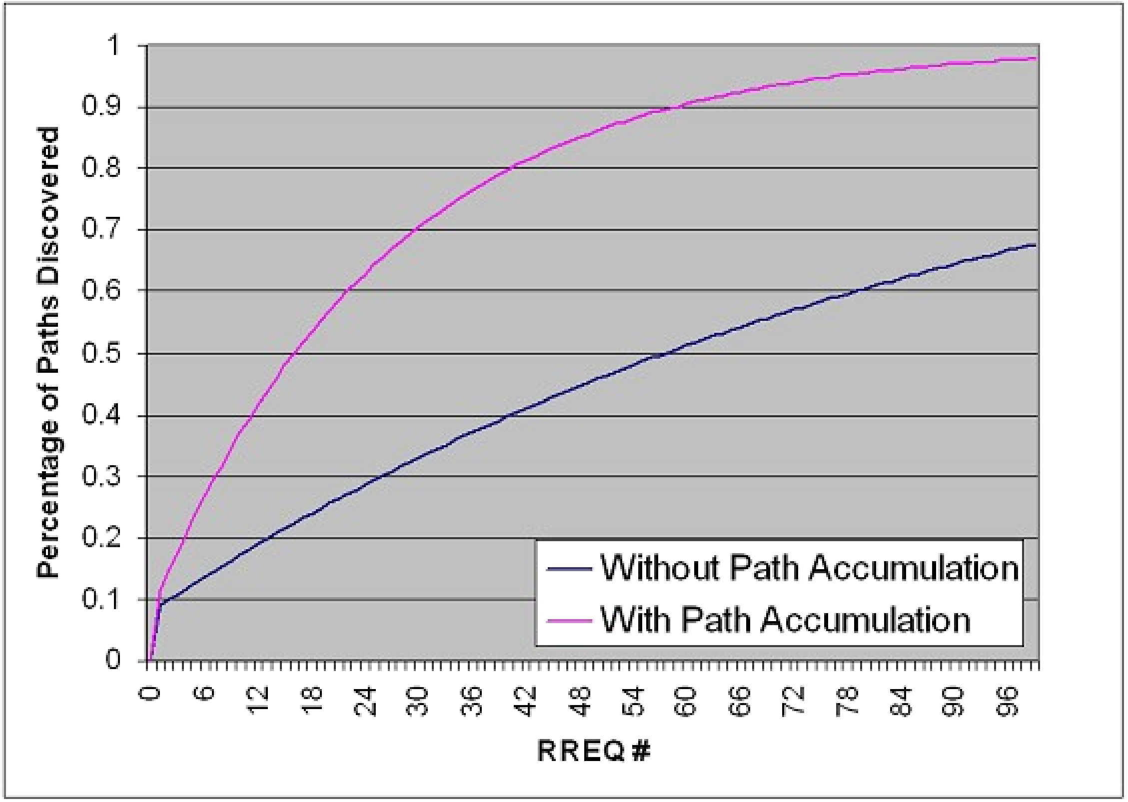


- associates attributes with addresses (seq numbers, hop counts etc

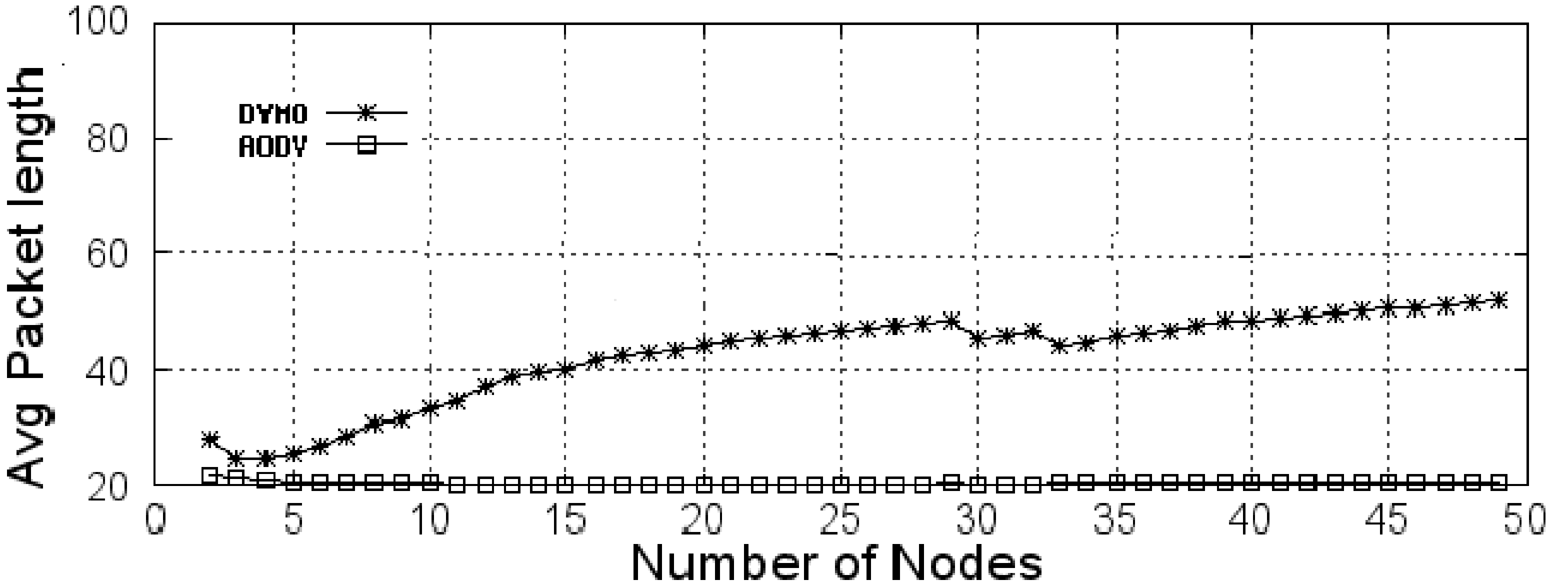
AODV/DSR vs DYMO

PARAMETERS	DYMO	AODV	DSR
Number of generated packets	3757	3700	3777
Number of sent packets	3619	3561	3605
Number of forwarded packets	470	482	509
Number of dropped packets	140	148	220
Number of lost packets	610	781	776
Minimal packet size	24	28	28
Maximal packet size	1072	1072	1104
Average packet size	282.8582	297.8778	288.7804
Packets dropping nodes	0 1 2 3 4 5	0 3 5	0 1 2 3 4 5
Minimal delay (CN, ON, PID)	0.000640471(0,1 ,340)	0.000640471 (0, -1,0)	0.000640472 (5,-1,0)
Maximal delay (CN, ON, PID)	1.001006484 (0, -1,0)	2.271632516 (0,5,62)	6.084161062 (0,5,98)
Average delay	0.02780103516	0.04171916814	0.04842961264

AODV/DYMO path discovery



AODV/DYMO packet lenght



DYMO: References

[Draft DYMO]

I.D. Chakeres C.E. Perkins. *Dynamic MANET On-Demand (DYMO) Routing*. Internet Draft Mobile Ad Hoc Networks Working Group

draft-ietf-manet-dymo-21 2011

[Perkins Royer Gwalani 2003]

S. Gwalani C.E. Perkins and E.M. Royer. *AODV-PA: AODV with path accumulation*. ICC 2003

[Kum et al 2010]

D-W Kum et al *Performance evaluation of AODV and DYMO routing protocols in MANET* IEEE CNCC 2010