Multi hop connections using 802.11

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Some animations may not be displayed correctly in PDF format.

Please see http://802wirelessworld.com for the original version in PowerPoint format.

Multi frequency Mesh

- Advantages of multi frequency mesh networks
  - Less interference
  - Exclusive channels
  - Reuse patterns
  - …
- Disadvantages of multi frequency mesh networks
  - Frequency planning
  - Frequency coordination
  - Power consumption
  - …
  - **COST (!)**

Single frequency Mesh

- E.g. Consumer Electronics (CE)
  - Mass production
  - Limited battery power
  - Limited computing power
  - Ease of use
  - …
  - **Cost sensitive (!)**
- Even 50¢ extra might be too much
  - Multi TRX not always possible
- Single transceiver solutions
  - Easy to implement
  - Available
  - Well known, …

→ Solutions for single frequency mesh needed

Introduction to multi hop

- What is Multi hop?
  - Relay connection
  - Used to forward packets/frames
  - Wireless Routers, L2 switches

The key element to mesh networks

- Next slides
  - Single frequency mesh networks
  - General assumptions
  - Introductive theoretical overview

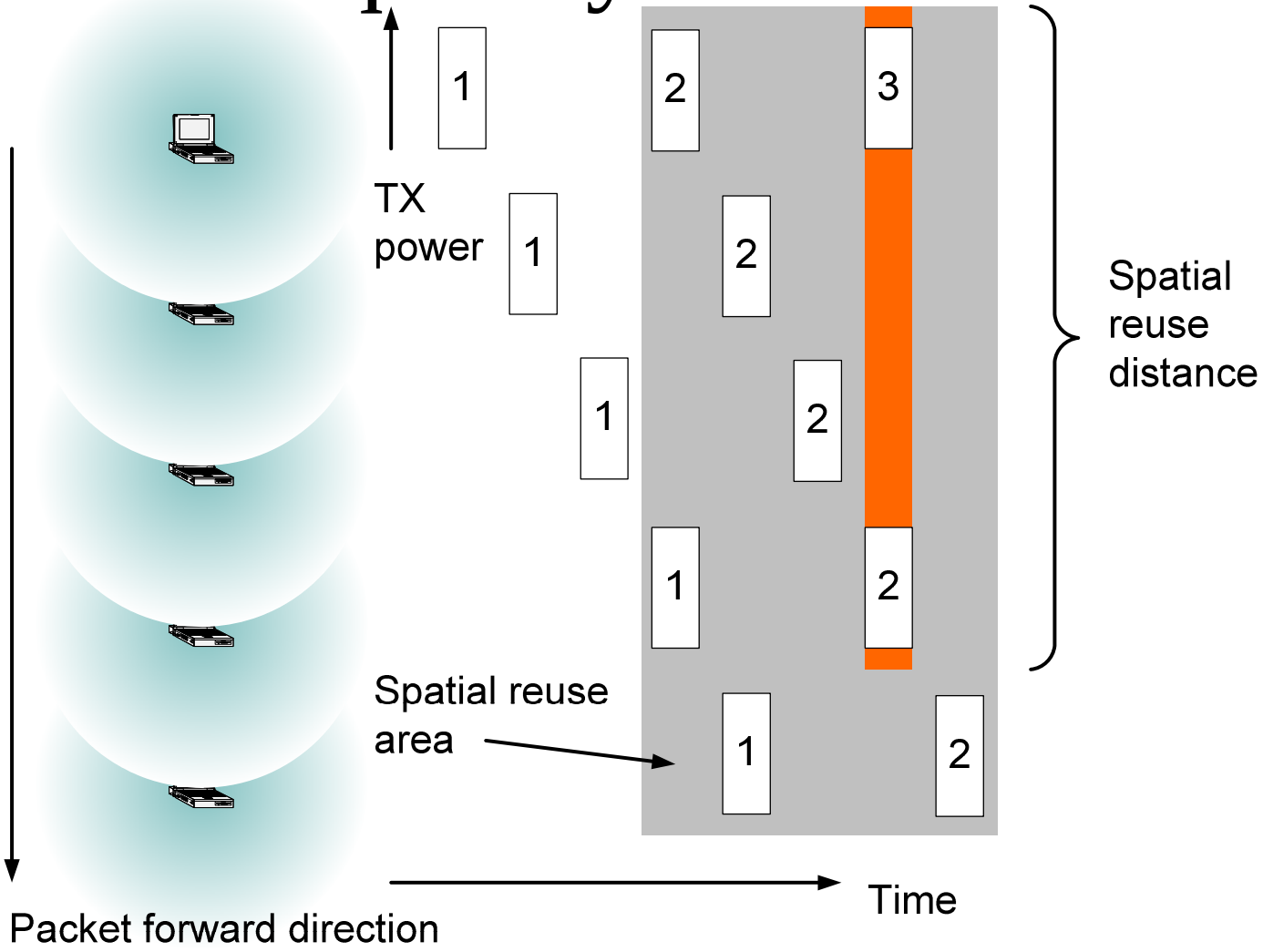
Spatial frequency reuse scenario

- Assumption
  - TDMA channel
  - Equal transmission duration
  - Equal transmission power
  - Equal distance between stations
  - No errors on wireless medium
  - Simplex connection
  - Interference range limited to neighboring station
  - Reception limited to neighboring station

→Best case

Spatial frequency reuse

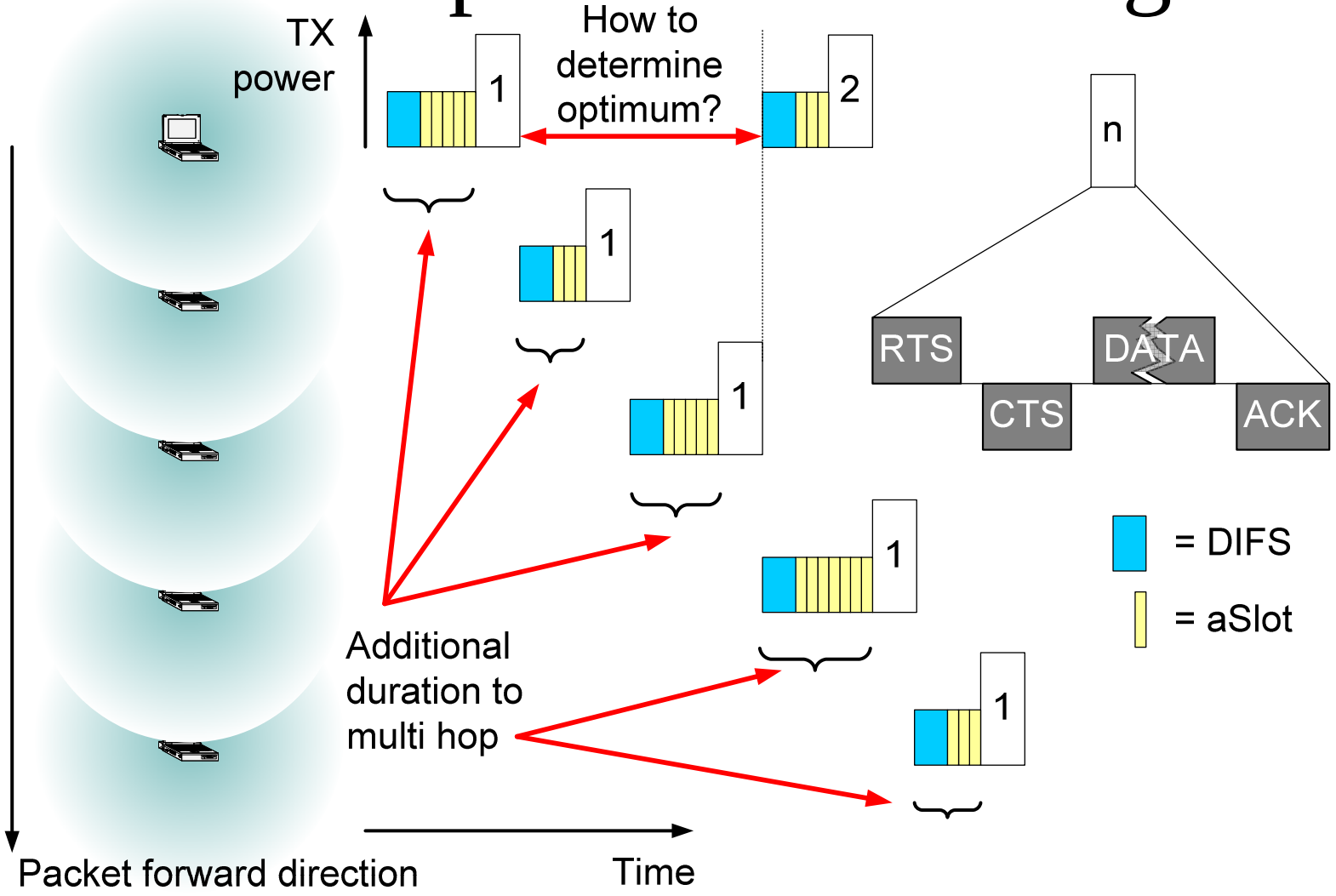
- Reuse limited by neighbor
- Reuse distance min. 4 hops



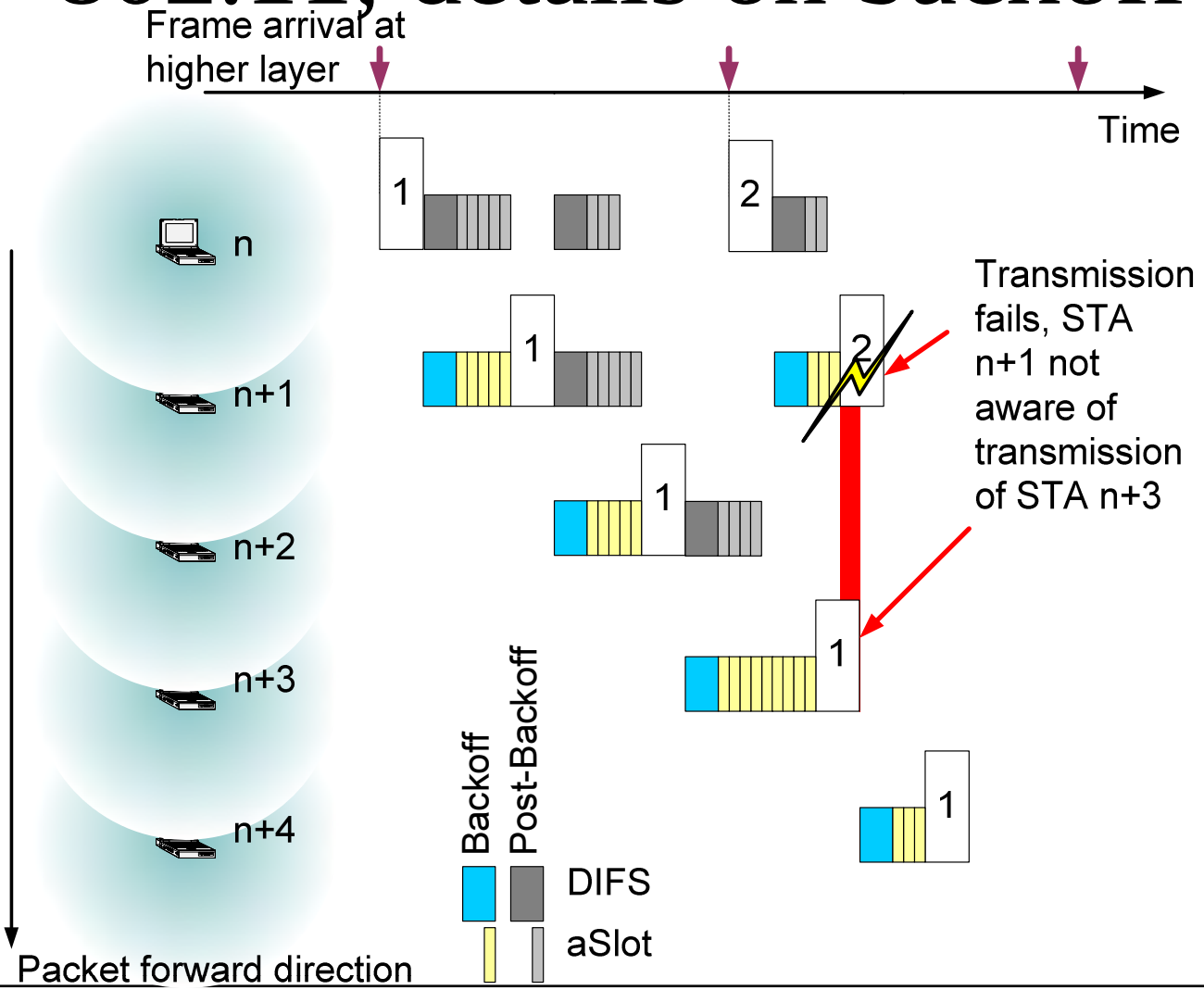
Real world, real 802.11

- Assumptions as before
  - Easy scenario
  - Stations placed on a line
  - Only neighboring in
    - Reception range
    - Interference range
  - No local interferers
    - No associated stations
  - Only Mesh Points
  - General overview

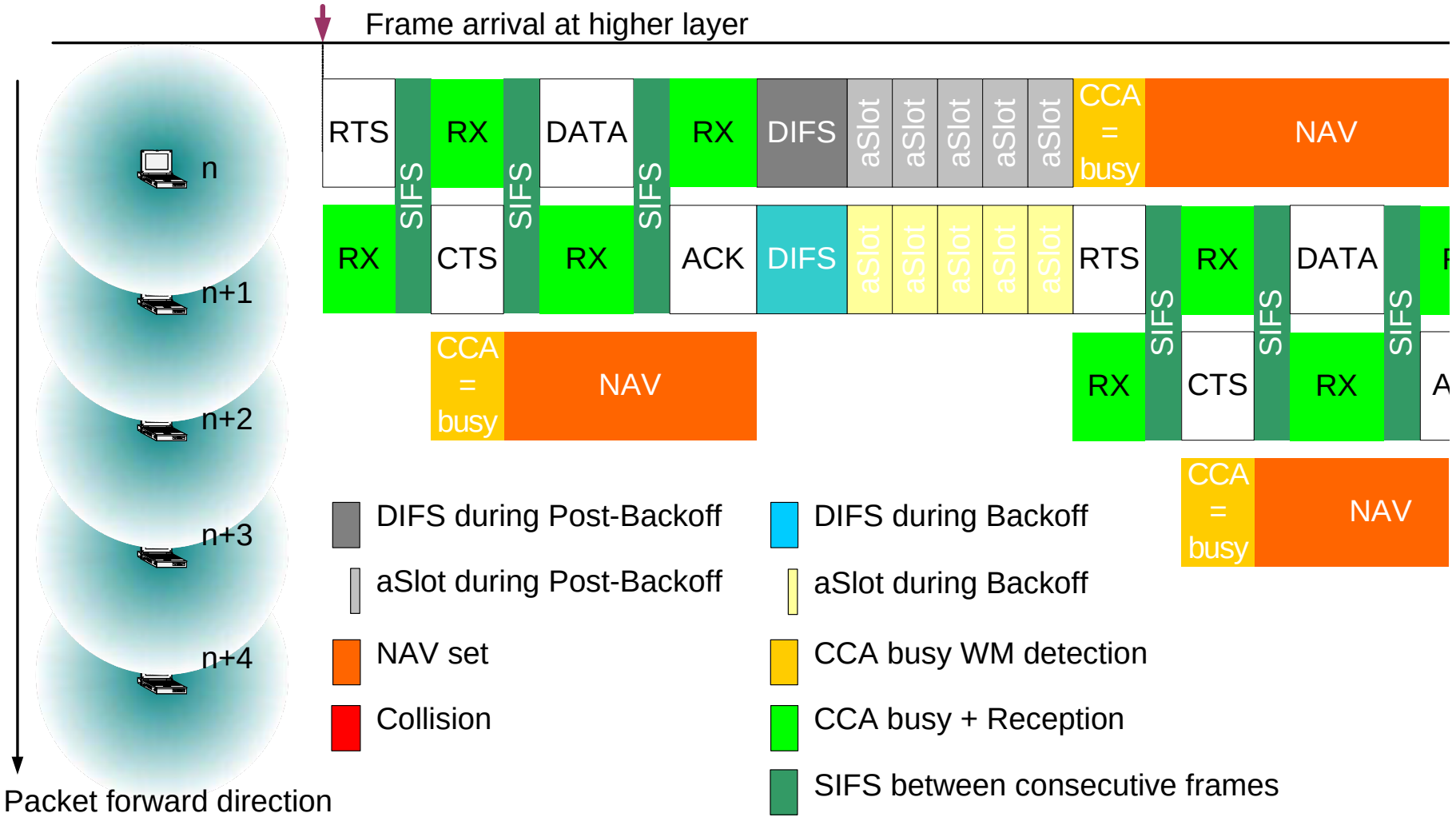
802.11 optimal forwarding



802.11, details on backoff



802.11 forwarding in detail



802.11 = Single hop MAC

- Distributed Coordination Function
  - Coordinates single hop
    - Local BSS only
  - No Coordination for Multi Hop
    - Independent process in each STA
  - Network Allocation Vector (NAV) reserves single only
    - No priority to forwarding

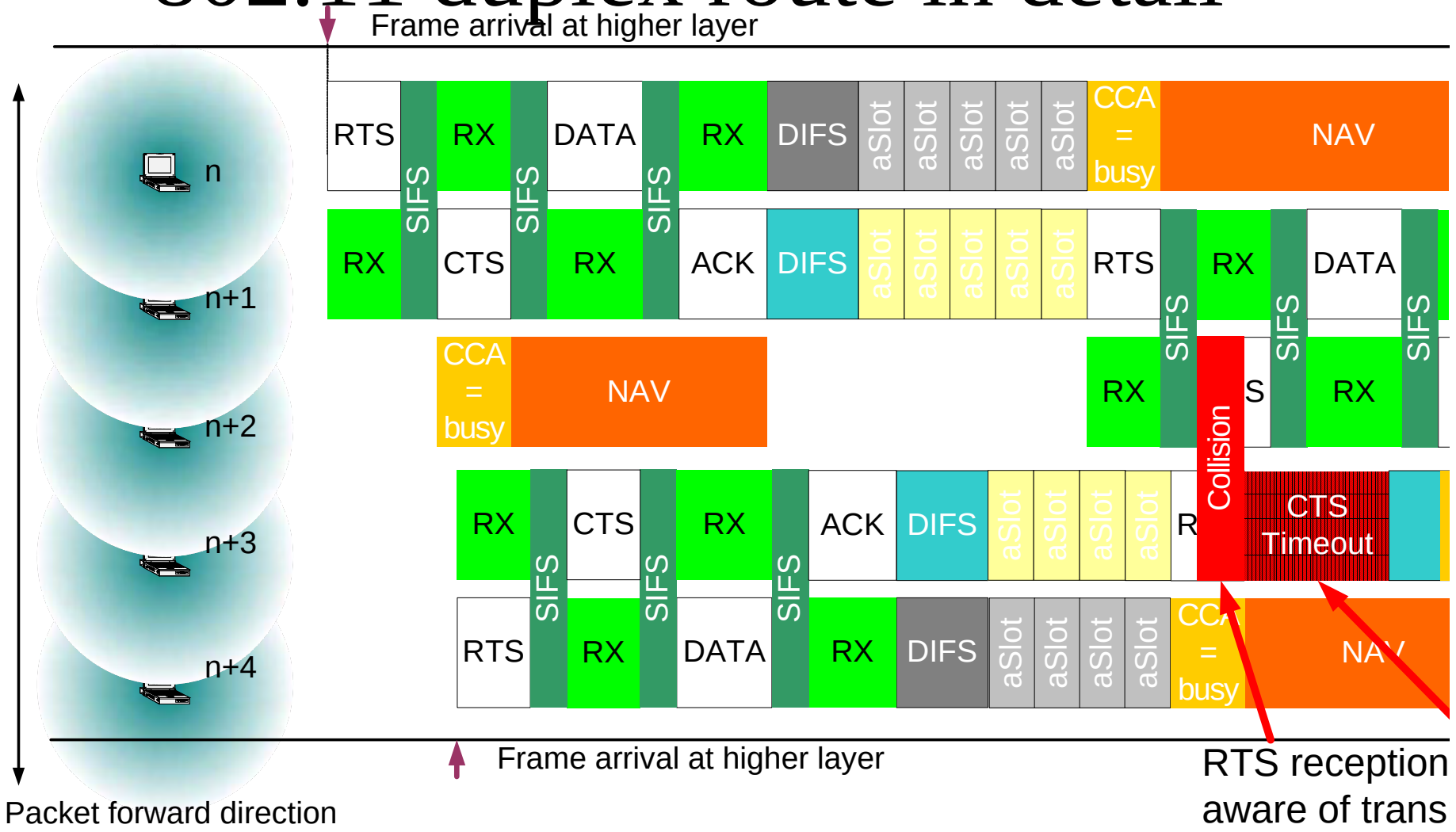
No Multi Hop concept in 802.11

- Infrastructure based BSS
  - Multi hop connection via AP
  - Hops to/from AP wireless
  - Wired backbone
  - Four address format
- Independent BSS
  - All stations in reception range
  - No forwarding procedure defined

Duplex route scenario

- One-way traffic hardly does not exist
- Same scenario as before
- Both endpoints generate/consume data
- Intermediate nodes forward only
  - No local traffic generation

802.11 duplex route in detail



Duplex multi hop

- Much worse than simplex connection
- Forwarding stations = Bottleneck
  - "Neighborhood capture" (11-01/596r1)
    - For system level, intra BSS
    - Here: For multi hop between stations
  - No equal channel access probability
    - Un-proportional reduced for forwarding nodes
  - Steady collisions with neighbors
  - No priority to forwarding
  - Uncoordinated access

Conclusion

- 802.11 MAC is **not** sufficient for multi hop
- 802.11 leaves information unused for multi hop
- **Multi hop is the key element to mesh networks**

Without useful protocol for multi hop in core network, mesh will fail

Thank you for your attention

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http://ieee.comnets.rwth-aachen.de/cgi-bin/wiki.pl?Mesh