Method for integration of cooperative relaying into the 802.16 standard

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Purpose:

Accelerate integration of cooperative relaying into the 802.16 standard

Cooperative relaying system

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Problem description

- Strong competition with networks based on other technologies that operate at different frequencies
- Limitations of 802.16 aimed frequencies
  - Bypass obstacles and penetrate into buildings
  - Uncertain and fast changing channel conditions
- Allowing shortly significant benefits to accelerate market penetration of 802.16 based networks
  - Larger cell size, coverage and throughput

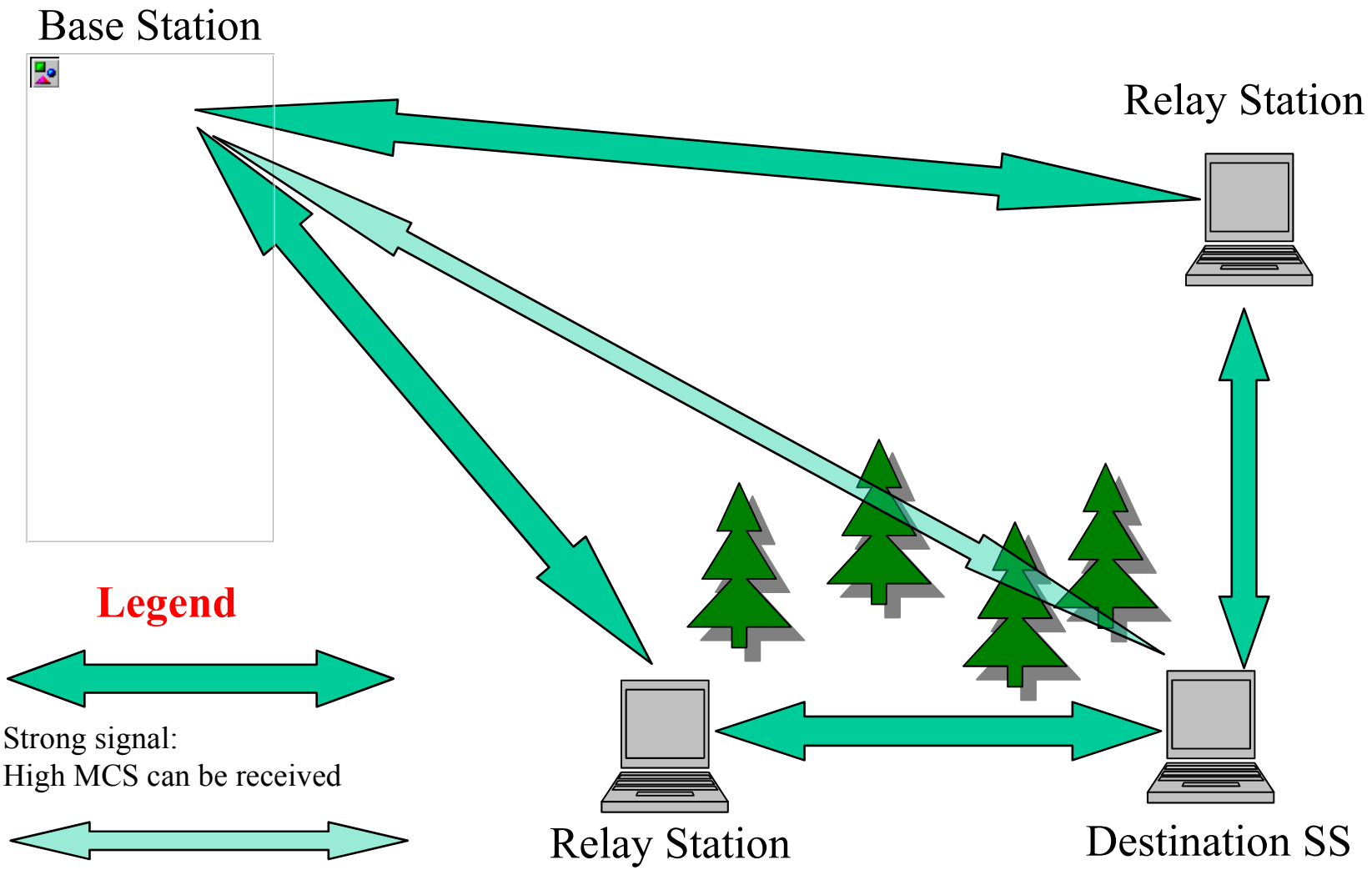
Suggested solution – cooperative relaying based

- Cooperative relaying means multiple synchronized transmissions from spatially distributed relaying stations of bursts originated at BS or SS
- Cooperative relaying methods are known to combat effectively wireless channel conditions
- Simple decode-and-forward method that can be implemented shortly and at low cost seems to be significantly beneficial
- The BS indicates all relaying transmissions for relayed bursts
- Each relaying station relays information according to the reliability of its reception
- The relaying stations may be SS with relaying capability or dedicated relay stations (RS)

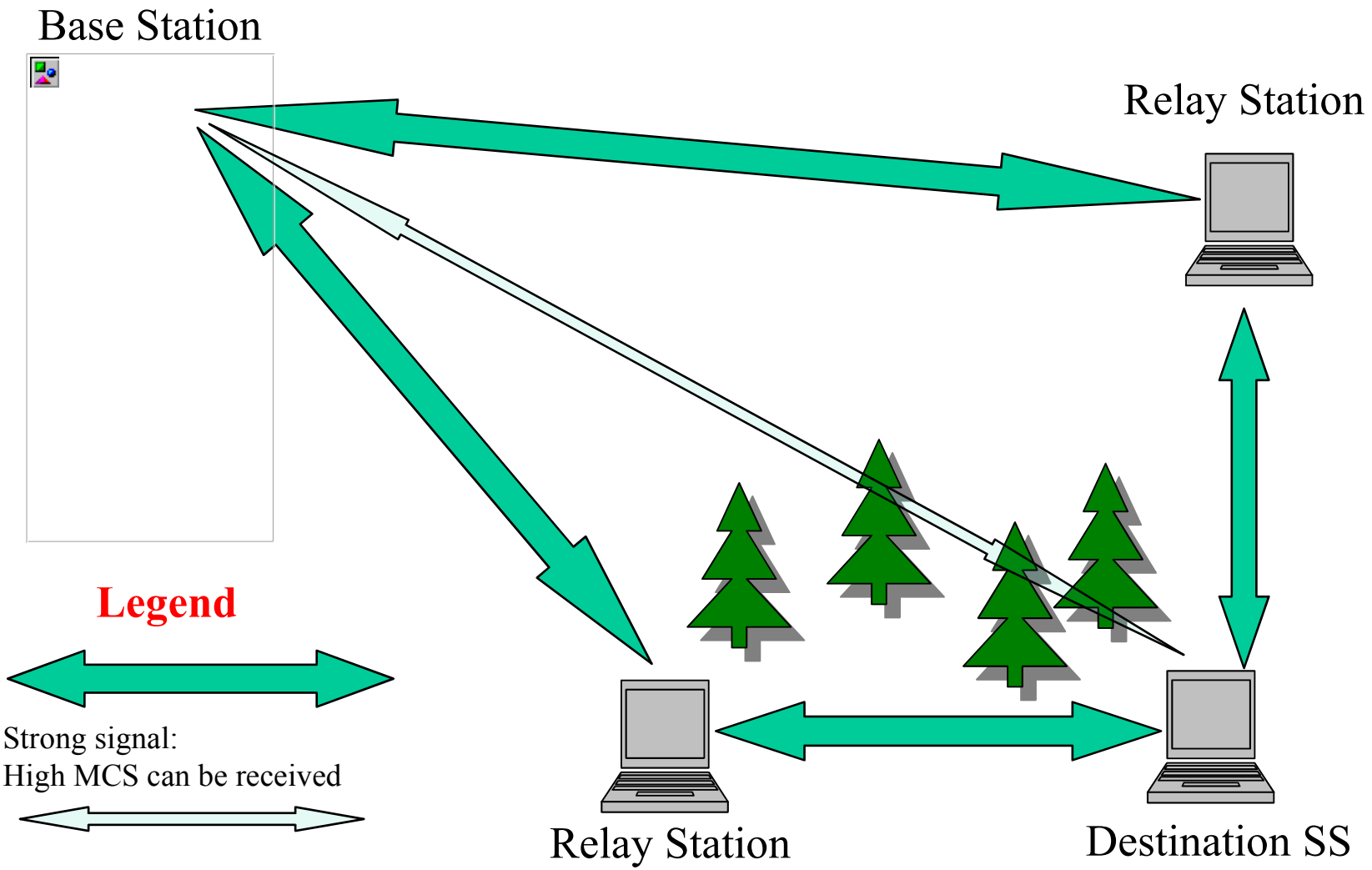
Contribution overview

- Multiple synchronized transmissions of reliable information from dedicated relaying stations (RS) or from SS with relaying capability
  - Reliability of each bit in received bursts can be determined with several indicators (e.g. CRC, code block decoding quality and Symbol quality)
  - No MAC activities are required from dedicated RS
- All relaying transmissions indicated by the BS
- Backwards compatible with 802.16
- Supports two distinct methods
  - Simple relaying
    - Destination SS receives properly BS preamble and maps transmissions
    - BS receives well SS CDMA, FFB and HARQ ACK/NACK
  - Advanced relaying
    - Preamble and maps transmissions or some of them should be relayed to the destination SS
    - CDMA for ranging and for bandwidth request, FFB and HARQ ACK/NACK or some of them should be relayed to the BS

Example: two RS serving a SS with simple relaying



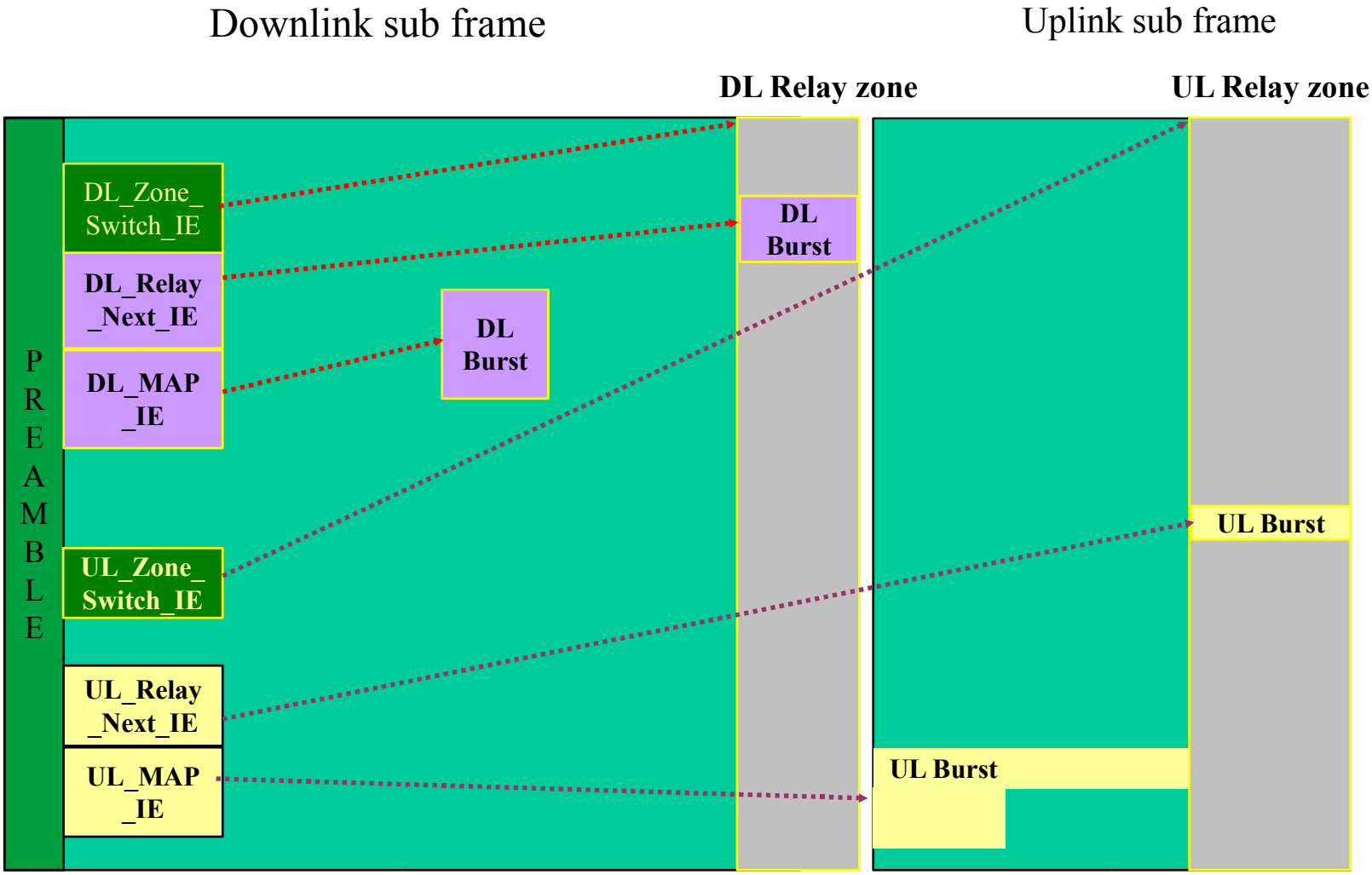
Example: two RS serving a SS with advanced relaying



Simple relaying

- Can be implemented shortly with low cost and labor
  - Accelerates market penetration of 802.16 based networks
- Aims SS that communicates directly with BS
  - Preamble and maps from BS and ranging from SS are received
  - Only bursts are relayed
- Relaying transmission and receptions are in dedicated zones
- BS transmits in maps all the allocations of relay transmissions for each relayed burst.
- Relay indication IEs contain:
  - Relaying allocations
  - Source and destination of the burst
  - Timing, sub-channels, boosting and xIUC
  - Total hops number of the burst and current hop index
    - Hops index indicate hops distance from the source of the burst for MCS.
    - Making relay transmissions may consider remaining hops number.

Example of simple relaying usage



Advanced relaying

- Aims SS with direct channel to BS that prevents usage of simple relaying
- In addition to the bursts, advanced DL relaying transmissions may contain mid-amble, FCH and maps or some of them
- In addition to the bursts, advanced UL relaying transmissions may contain ranging, bandwidth request, HARQ response and FFB or some of them.

Simple relaying benefits

- Low cost relays
  - Dedicated relays may cost less than SS since MAC is not handled
  - SS can support simple or advanced relaying with small additions
- Flexibility to implement diverse cooperative relaying methods
- Increased cell size
- Higher coverage inside the cell
- Higher throughput with higher MCS
- Suitability for higher RF frequencies
  - Bypassing obstacles is improved by far
- Allows direct SS transmissions to other SS without reception at base station
  - If the destination of a SS is a SS the BS can indicate relaying transmissions of the UL burst in the DL relay zone
  - Security should be considered

Advanced relaying with respect to simple relaying

- More labor is required for implementing
- Higher coverage inside the cell
  - For example outdoor and indoor penetration
- Increased cell size
  - Limited by efficiency of protocol and not by physical channel
- Consumes more power from relaying stations
  - Additional relaying transmissions (mid-amble, maps, FCH, CDMA for ranging and for bandwidth request, FFB and HARQ ACK/NAK or some of them)

Considerations

- Inter-cell Interference from multiple transmissions
  - Relays identify from the hop number of the received uplink relay transmissions, their updated hop distance from SS
    - Relaying to a destination SS only if remaining number of burst hops is sufficient thus decreasing the number of transmissions allows saving power and diminishing inter-cell interference
- Inter Symbol Interference (ISI) from the spatially diverse cooperating relays
  - Relays transmissions power is low and controlled, therefore the ISI is low and controlled
- Limitations on deployment of relay stations
  - Relays transmission power may be similar to SS's thus enabling large amounts of relays