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Comments on Relay Nodes for LTE-Advanced Systems

Agenda Item: 12
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Document for: Discussion

Introduction

- Relay Nodes (RNs) for LTE-Advanced systems
  - Expectations of introducing RNs are listed as follows [1-5]
    - Coverage extension
    - Improvement of throughput (especially of cell-edge UEs)
  - The above items are attractive, but not enough.
  - Deployment of RNs should be cost effective compared to pico-cells
    - Necessity of considering the cost vs. effectiveness!
    - In other words, we should try to minimize functions in RN and to maximize performance gain
- Detail discussions have just started in 3GPP
  - Topics
    1. Types of RNs
    2. No. of hops
    3. In- or out-band operation for the link between eNB and RN
    4. Division duplex modes between the link of eNB-RN and the link of RN-UE
    5. Frame structures
    6. …
- This contribution presents a view on (1)~(2) in the above topics

Type of RNs

- Type of RNs are summarized in [1]
- Another point from operator: "RNs should be cost effective!"
  - ⇨ i.e. "High performance gain should be obtained at the expense of deploying RNs (in terms of both CAPEX and OPEX)"
- Additional comments of [1]
  - L1 RN (Repeater)
    - (Pros.) Expected to be low cost (compared to the other types of RNs) and short delay
    - (Cons.) Concerns about necessity of longer CP length due to the processing delay inside of L1 RN ⇨ Less spectral efficiency
  - L2 RN (MAC with scheduler)
    - (Pros.) Higher link quality due to the regeneration of received signals and performance gain from sub-band scheduling, AMC, power control, etc.
    - (Cons.) Concerns about high cost and longer delay and less improvement in terms of end-to-end (i.e. between eNB and UE) throughput

      ⇨ In addition to the ordinal throughput analysis at PHY/MAC-layer, it will be better to evaluate throughput and delay at IP-layer
  - L3' RN (RRC)
    - (Pros.) Mobility management including session set-up & handover procedure will be available
    - (Cons.) Concerns about much overhead due to mobility management and handover in addition to the same concern as in L2 RN

Necessity of Study on L2 RN

- Expected to provide
  - Frequency scheduling gain
  - Interference management
  - Power control
  - AMC
  - …
- Need to evaluate performance gains on the above functions in a realistic system parameters as follows
  - Overhead caused by L2 RN
  - CQI report interval
  - Sub-band size for frequency scheduling
  - …

- Unnecessary functions should be removed
  - e.g. L1.5 RN = “L2 RN w/o a part of the scheduling function”

No. of Hops

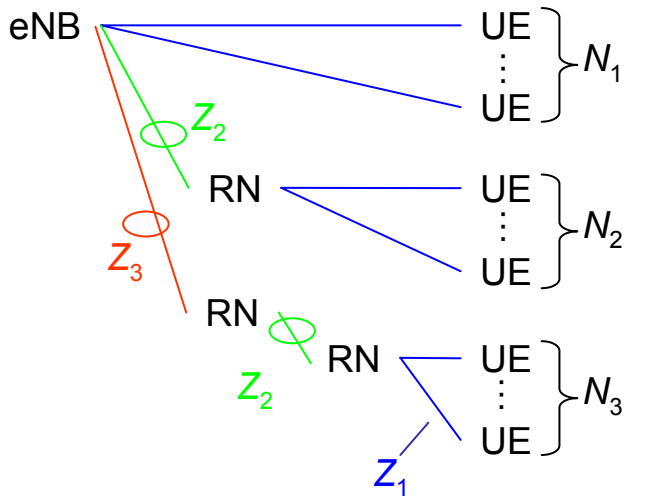
- Most contributions suggest at most two hops
- KDDI currently supports the above suggestion
  - Reasons
    - Less expectation of capacity (throughput) improvements in a system with more than two hops considering increment of overhead and interference
    - Concern about increase of end-to-end latency, which is not suitable for real-time applications
    - Complexity in terms of operations will tremendously increase in a system with more than two hops ⇨ increases OPEX

An Overhead Estimation in Multi-hop System

- Notations
  - N_i: No. of UEs with i-hop connection to eNB/RN
  - N_{all} : Total No. of UEs
  - Z_i : Overhead at i-th hop link from UEs
    - Assumption that header compression and AMC are used
      ⇨ Differ the overhead
  - M: Max no. of hops supported by system
- Assumption
  - Overhead of the 1st hop from UE is identical regardless of no. of hops
- Ratio of overhead in multi-hop to <u>single-hop only</u> LTE

$$\frac{\sum_{i=1}^{M} N_i \sum_{k=1}^{i} Z_k}{N_{all} Z_1} = \sum_{i=1}^{M} R_i \sum_{k=1}^{i} A_k$$

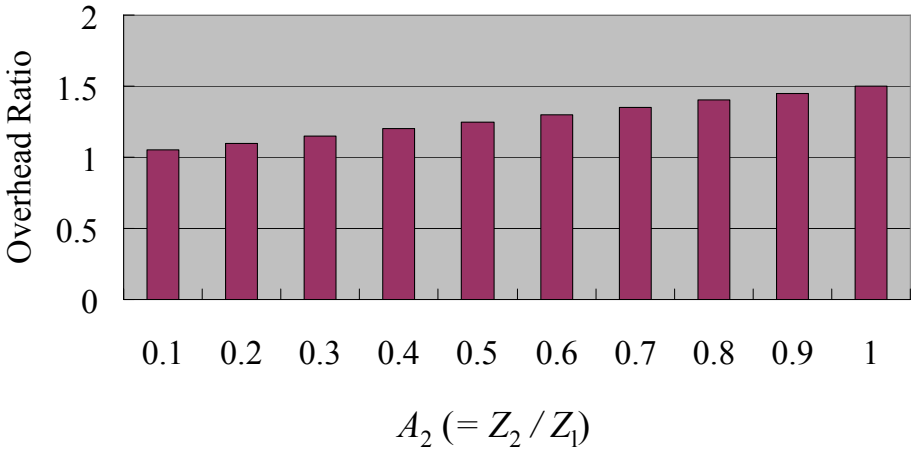
  - Where, $R_i = N_i / N_{all}$ and $A_i = Z_i / Z_1$
  - Note that $A_1 = 1$



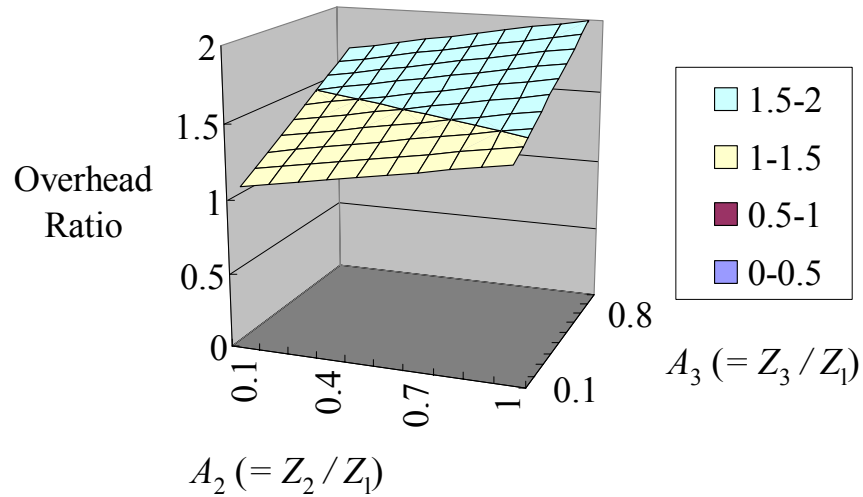
In the case of M=3

Examples of Overhead Ratio

2-hop scenario



3-hop scenario



- Parameter setting
  - R_i is identical regardless of the value M (e.g. in 2-hop scenario, R_1 and R_2 are 0.5)
- Observations
  - 2-hop scenario: even if the overhead between eNB and RS is half of that between RS and UE (i.e. A_2=0.5), the total overhead increases 25% compared to single-hop system
  - 3-hop scenario: even if A_2=A_3=0.5, the total overhead increases 50% compared to single-hop system

Conclusion

- Comments on RN from one operator
  - Necessity of
    - Evaluation of performance gain per function and finding effectiveness per function
    - Performance evaluation at IP-level
    - Conscious about cost

⇩

- Optimum RN (e.g. L1.5 RN, which implements necessary functions only out of all functions in L2 RN) will come from the above considerations and evaluations
- No. of hops
  - Seems better to select up to 2 hops, although further studies are encouraged

References

1. R1-082397, “Discussion on the various types of Relays,” Panasonic.
2. R1-082327, “Application of network coding in LTE-advanced relay,” Samsung.
3. R1-082380, “Technical scope for LTE-Advanced evolution,” ZTE.
4. R1-082470, “Self backhauling and lower layer relaying,” Ericsson.
5. R1-082517, “Relay Frame Structures for FDD,” Nortel.