

Verification and Extension of Selection Diversity Forwarding in an End-to-End Scenario and Incorporation of Multi User Detection

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Introduction - Motivation & Background

Motivation





-  MUD has been shown to enhance performance in scheduled multihop networks [Shr02].
-  Of interest to examine MUD in the context of contention based protocols and multihopping. ([Cho92], [Rod00] only single hop)
-  One interesting example of a contention based protocol aimed for multihop networks is SDF [Lar01] that has been shown to exhibit good performance.
 - ? Study MUD enhancements of SDF.
 - ? Also, of interest to extend study in [Lar01] to include ETE aspects.

Previous work





-  SDF related: [Nel84], [Jub87], [Pur94], [Lar01], [Val03]
-  MUD related: [Cho92], [Rod00], [Shr02]

SDF Characteristics

Exploited observations

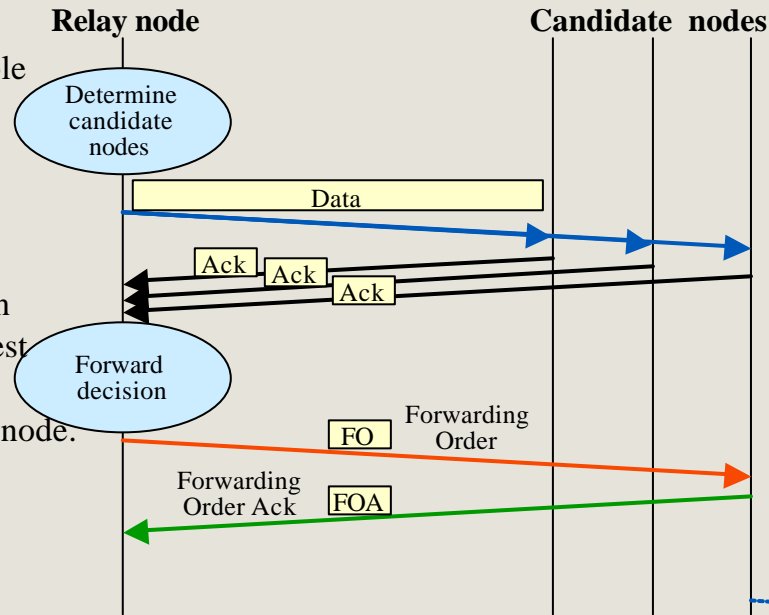
-  Inherent broadcast characteristic of radio channel.
-  Radio channel fluctuations.
-  Traffic (interference) fluctuations.
-  Multiple relay stations.

SDF concept

-  Incorporate concept of diversity into framework of routing.
-  Fast forwarding algorithm on top of a slow route cost determination protocol.
-  Perform forwarding decision (Selection Diversity) after data transmission and based on feedback.
-  Ensure forward progress towards destination for each packet transmission.

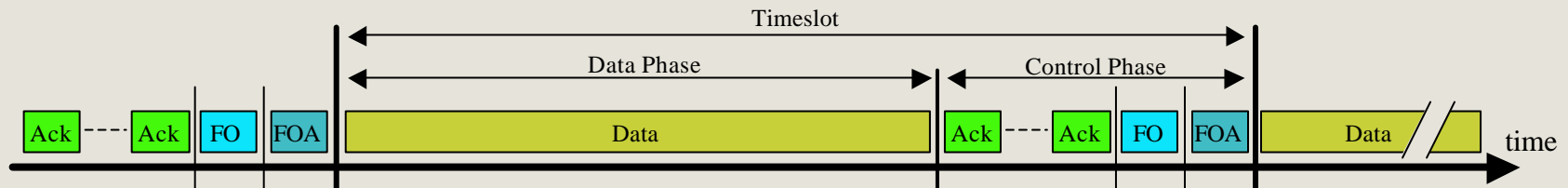
SDF Message Exchange Scheme

- When data packet is received, determine set of nodes that are suitable next hop candidates.
- Broadcast data packet to candidate nodes.
- Determine forwarding node based on returned Acks. Select node with lowest remaining cost.
- Issue a forwarding order to selected node.
- Receive a forwarding order Ack.

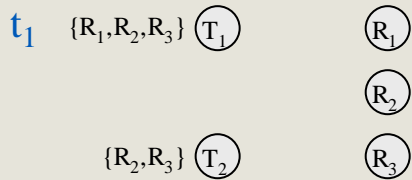


N.B. Small and low energy control packets relative data packet.

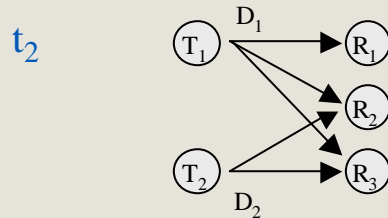
- Return Ack. (e.g. in order as addressed, i.e. no collisions). Indicate cost to destination.
- Return forwarding order Ack.
- Send Data to next set of candidate nodes.



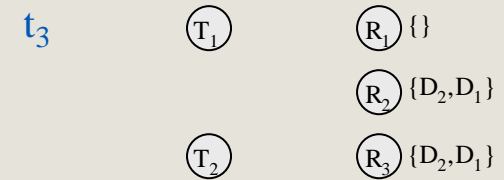
Message Exchange Scheme for “MUD-SDF”



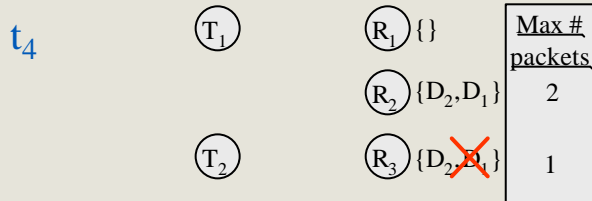
Select candidate nodes. {and optionally select and adjust TX parameters}



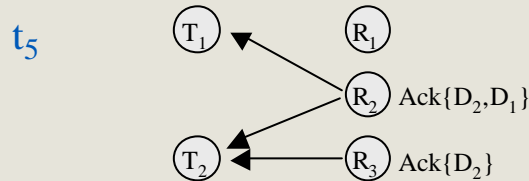
Transmit data packets D₁ and D₂.



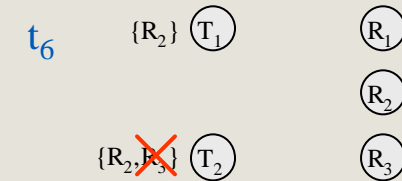
Decode received signals with MUD.



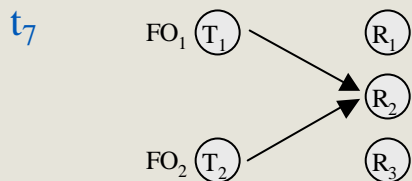
Prioritize and, if needed, limit the number of correctly decoded data packets. {Discard irrelevant packets}



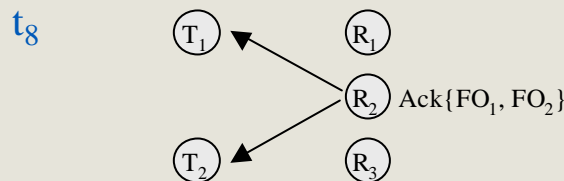
Transmit Acknowledgements {and optionally provide feedback information}.



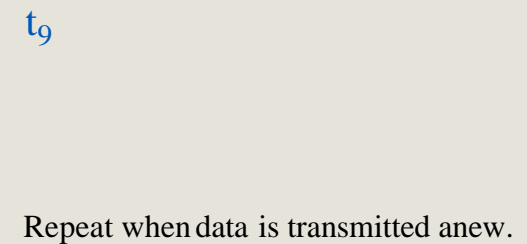
Prioritize among the successful transmissions to candidate nodes.



Transmit forwarding order to prioritized nodes. Prioritize and insert packets in transmit queue.








Acknowledge forwarding orders. {Discard irrelevant packets}.







Simulation Scenario & Models



System model

-  Shortest path based routing with path loss based metric.
-  Slotted ALOHA.
-  SDF with MUD/SUD.
-  Error free feedback with negligible control packet size.
-  “Information theoretical optimal” MUD/SUD detector.







Simulation scenario

-  Topology: Grid with wrap around.
-  Propagation model: $G? D^{-?}$.
-  Traffic pattern: all-to-all.
-  “Closed queuing network” (ETE flow control).



Simulation variables

-  Transmit probability.
-  Rate (Spectrum efficiency in [b/Hz/s]).

Simulation parameters

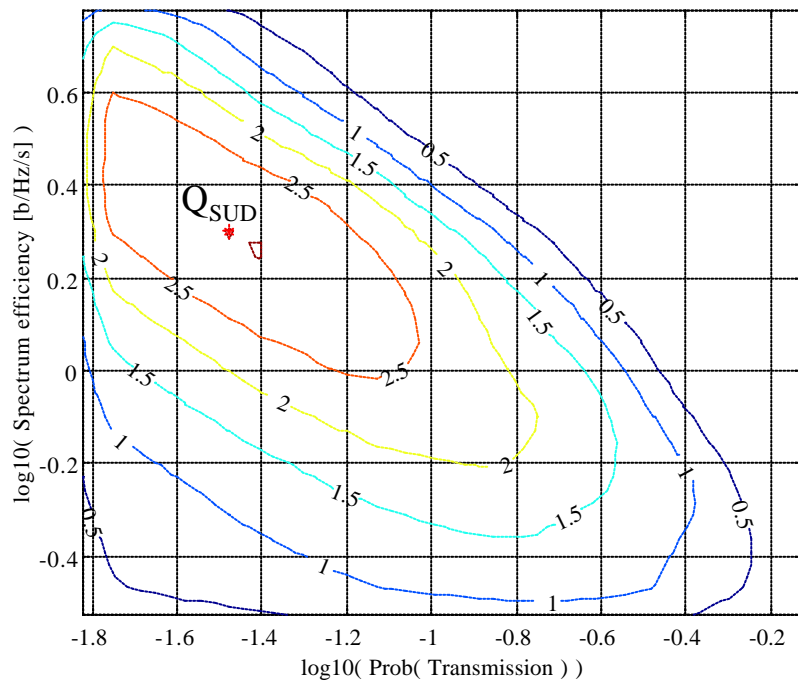
-  # of nodes= 121
-  $? = 3$
-  $R_{max} = 6$ b/Hz/s
-  Transmit power set to reach two hops @ highest rate.
-  Average # of packets per queue= 4.
-  Buffer packet size limit= 10.

Performance measure

-  Mean aggregate throughput [b/Hz/s].
-  Packet latency [Timeslots].

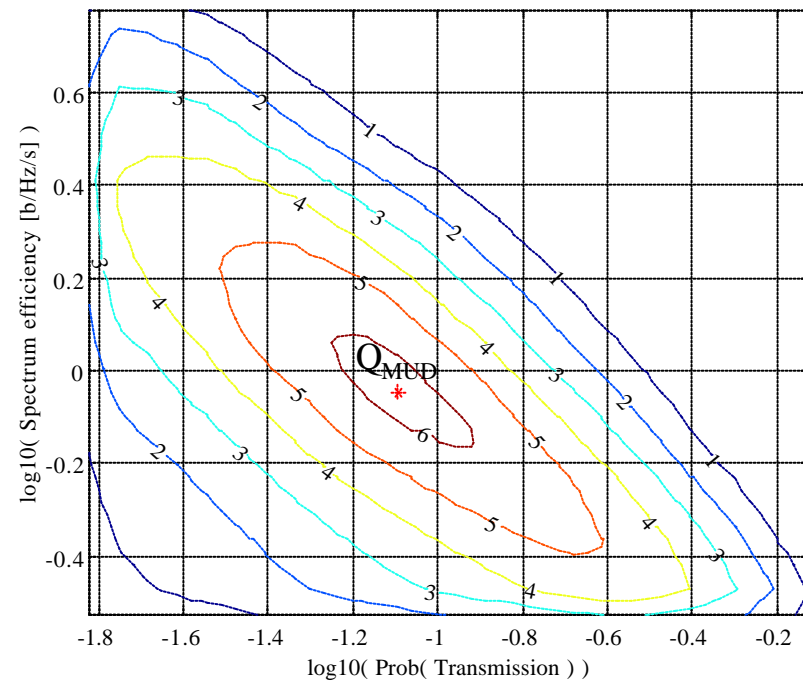
Simulation Results (1) – Throughput [b/Hz/s]

Single User Detection - SDF



$T_{\max} = 3.00$ [b/Hz/s]
 Rate = 2.0 [b/Hz/s] @ T_{\max}
 Prob (TX) = 0.033 @ T_{\max}

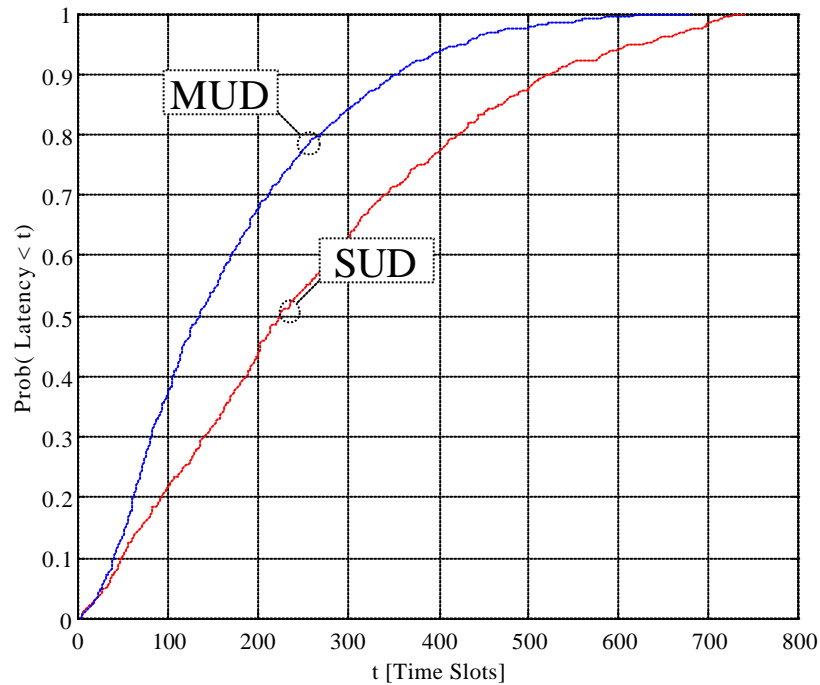
Multi User Detection - SDF



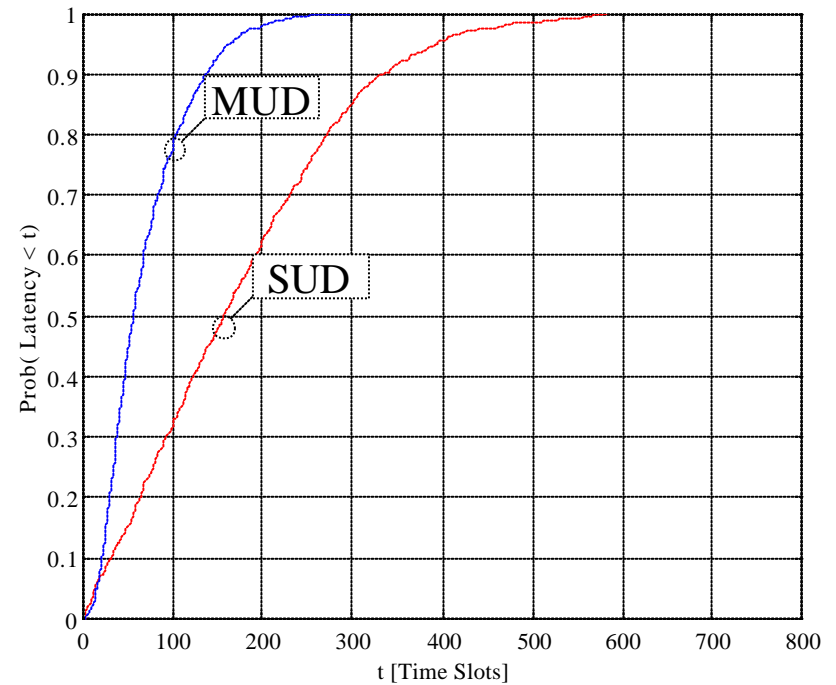
$T_{\max} = 6.25$ [b/Hz/s]
 Rate = 0.90 [b/Hz/s] @ T_{\max}
 Prob (TX) = 0.08 @ T_{\max}

Simulation Results (2) – ETE Latency

Latency CDF @ Q_{SUD}





Latency CDF @ Q_{MUD}




Summary and Conclusions

Summary

-  Simulation of ETE performance of SDF w.r.t. throughput and latency.
-  SDF extended with MUD capability.

Conclusions (for the simulated scenario)

-  MUD relative SUD in SDF provides:
 - » a throughput gain of roughly a factor two, and
 - » a significant reduction in latency.

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