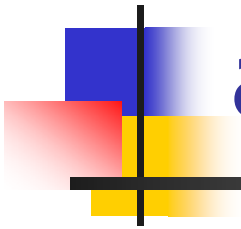

Voluntary Forwarding in Wireless ad-hoc networks

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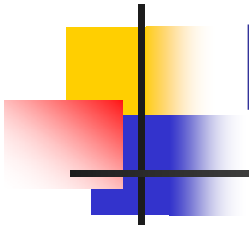
Hang Liu

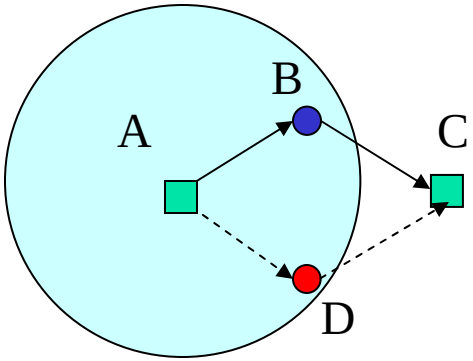
Dipankar Raychaudhuri



Motivation

- Unreliable links in Wireless Networks
  - Nodal Mobility and Failure; Fading channel; Interference and Collision etc.
  - Unreliable Routes : Packet Loss
- Spatial Diversity: Using Multiple routes
  - Redundancy increases reliability
  - Utilize inherent redundancy

Redundancy in Wireless Broadcast



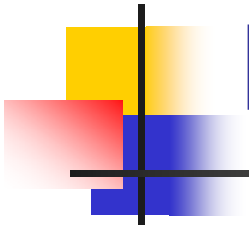
- Link Reliability of each link is *p*
- Stop-and-Wait ARQ in each hop
- Acknowledgements always be received

$$E(N) = \frac{2}{p}$$

- Redundancy already exists
  - Unicast to B is a broadcast
  - A stops retry if either B or D ACKs

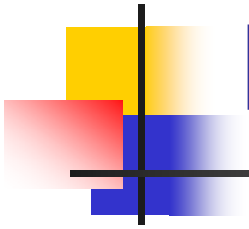
$$E(N') = \frac{1}{2p - p^2} + \frac{1}{p}$$

- Exploit wireless broadcast → Fewer transmissions
- To utilize the redundancy, more nodes involved



Problems

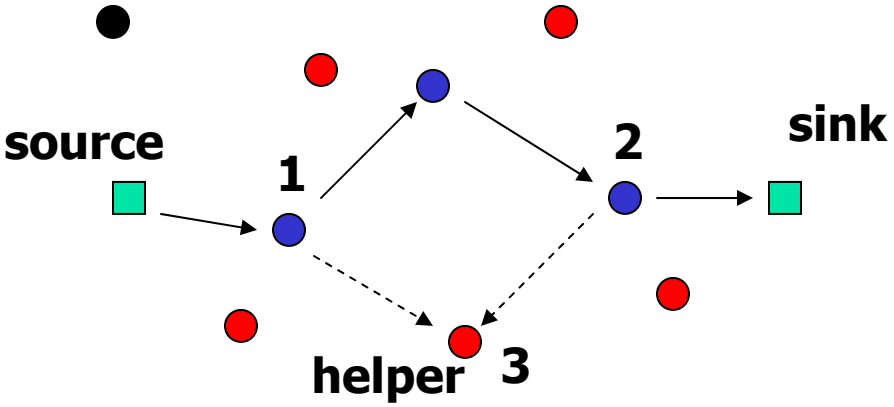
- Is it good to involve more nodes?
  - End-to-end disjoint path (> 2 hops) might have worse efficiency.
  - Link reliability distribution is the key
- How to discover good forwarders?
  - Some to forward, some to drop
- How to coordinate in a distributed manner?
  - Who send to whom? Who sends first?
  - When to start and how to stop?

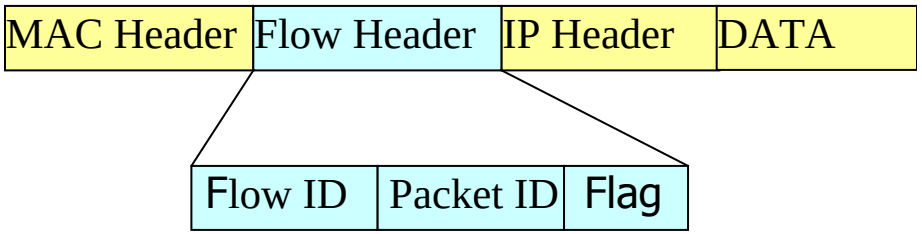


Related Work

- Cross-layer MAC routing design
  - Multipath-Routing + Packet Cache *A. Valera et. al. '03*
  - Opportunistic Routing *S. Biswas et. al. '04*
  - Hop by Hop Broadcast *B. Deb et. al. '03*
  - Need some modifications on MAC or routing
- Our approach ---- Voluntary Forwarding
  - No change to MAC and Routing protocols
  - Modified header format without new control messages

Voluntary Forwarding Design

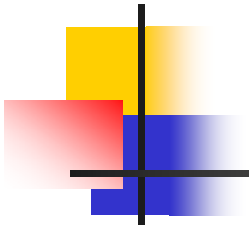




Helper

- Self-identify its own role as "helper"
  - Overhears two forwarder's transmissions
  - Use flow state information
- Does "voluntary forwarding"

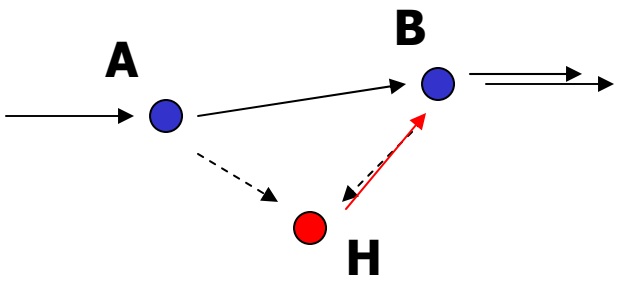
* Flag: A 1-bit to indicate "voluntary forwarding".



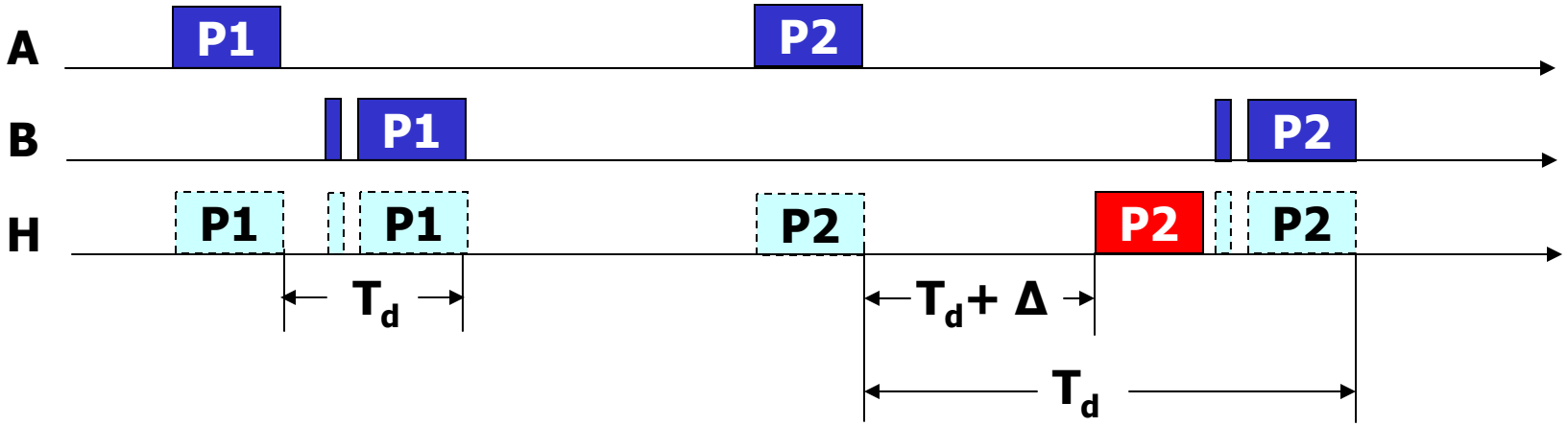
Voluntary Forwarding

- With perfect knowledge of link reliability.
  - Trigger: helper's route reliability is better than primary route
- Observation of reliability (Partial info)
  - Monitoring Delay in primary route
    - Trigger: Large delay indicates a bad link reliability
  - RSSI (Receive Signal Strength) estimate of Helper
    - Trigger: Strong signal shows a good helper's route
- Control Rules:
  - "Voluntary forwarding" not cached by any helpers
  - At most cache one packet for each flow
  - Acknowledgements also be sniffed

Delay-Triggered Forwarding



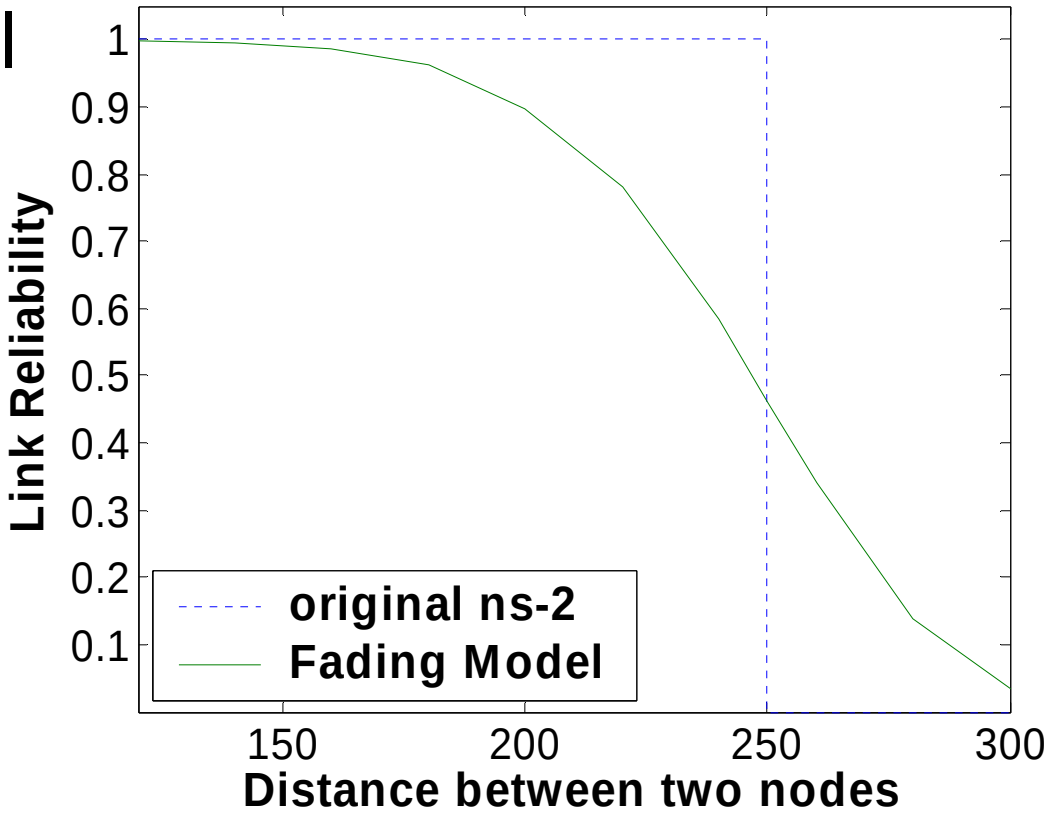
- H monitors A and B for Packet 1
- H records T_d of Packet 1
- H set $T_{thr} = T_d + \Delta$
- H cache A's Packet 2
  - If ACK or DATA from B heard, stop
  - If beyond $T_{thr,}$ forward
- Set new T_d



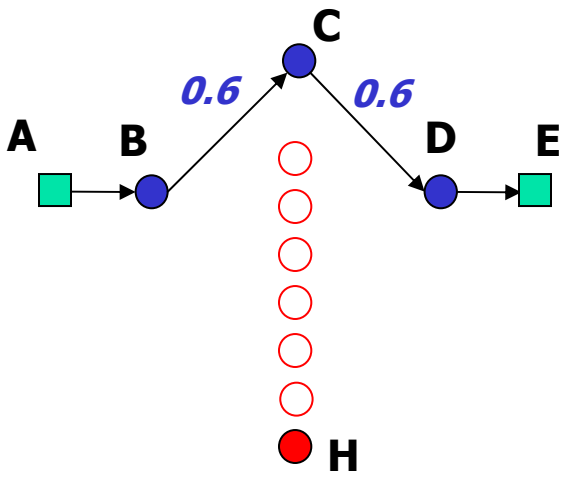
Fading Model

Varying Link Reliability

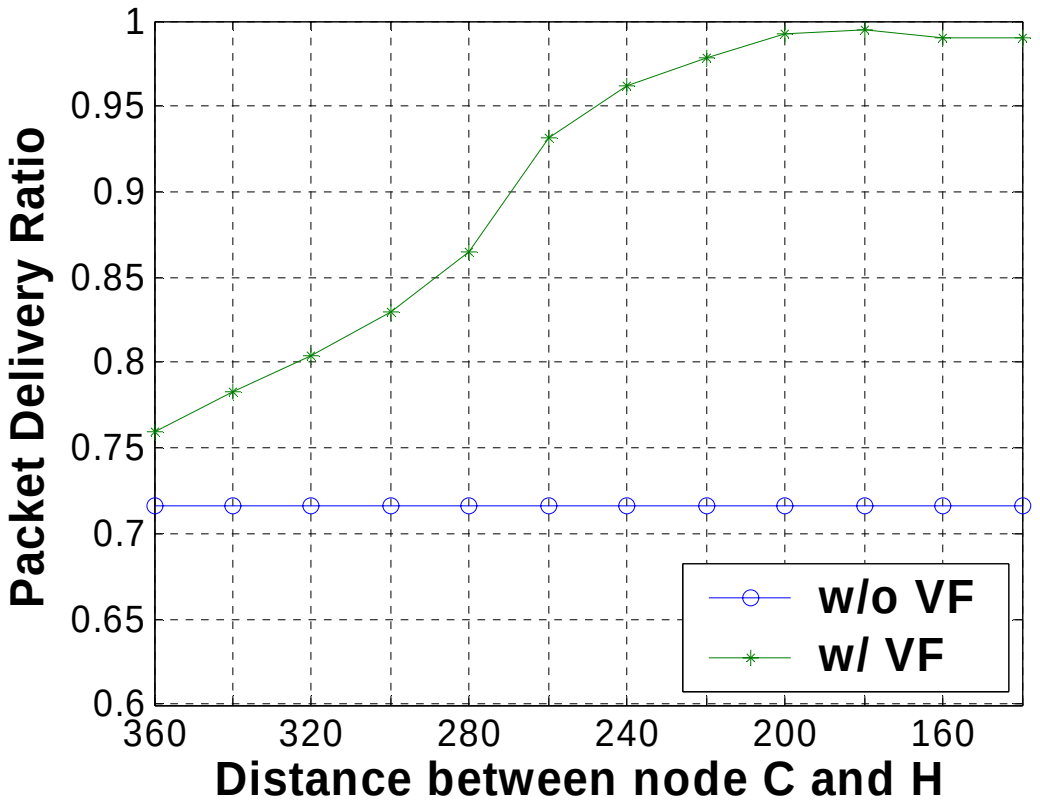
- Ricean Fading Model [*Punoose in VTC'00*]



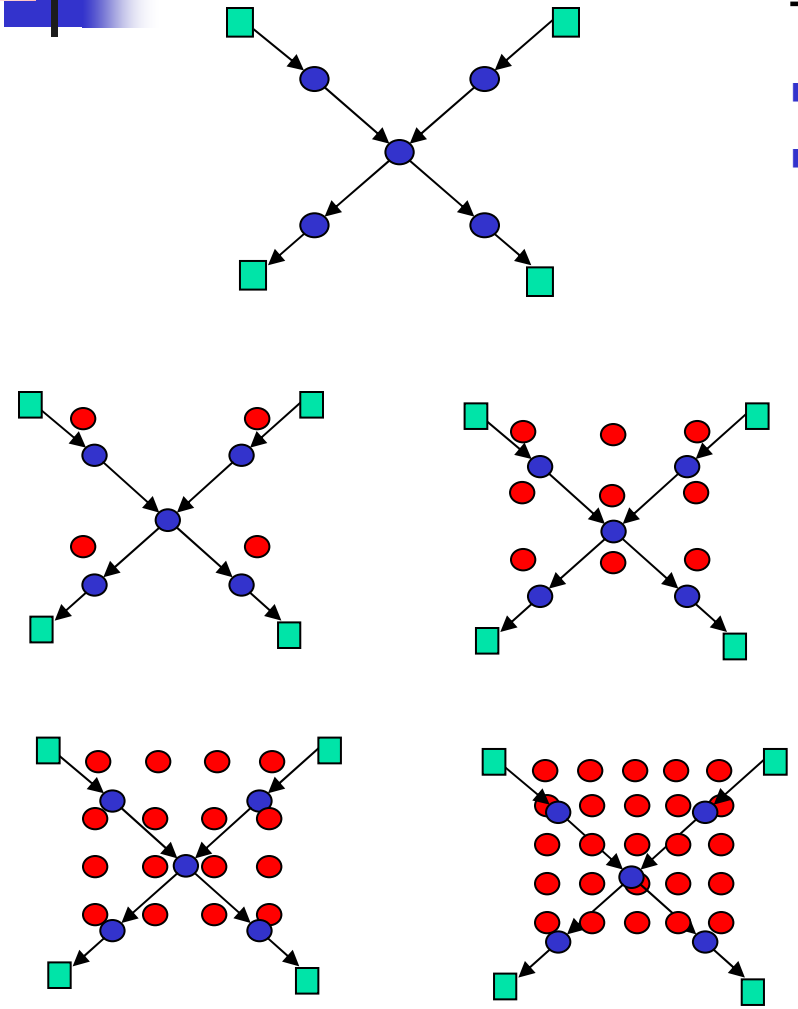
A Proof-of-Concept Exp.



- 802.11 MAC, Maximum MAC Retries: 4
- Measure Packet delivery Ratio

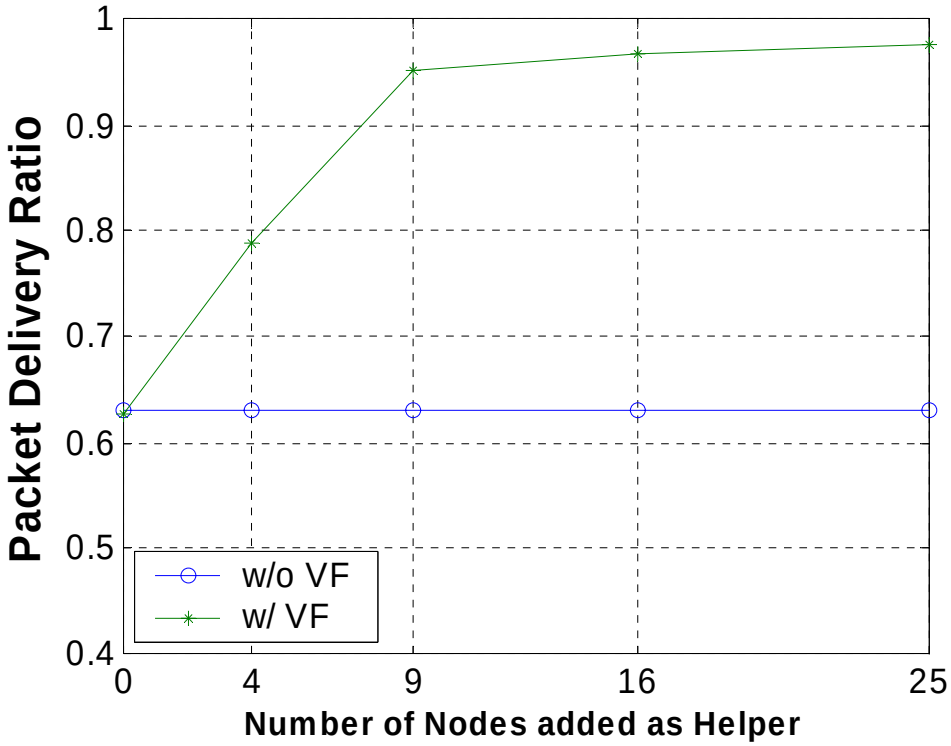


Density of Helpers

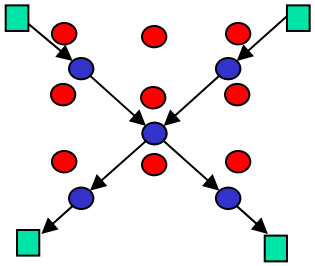


Two crossing flows

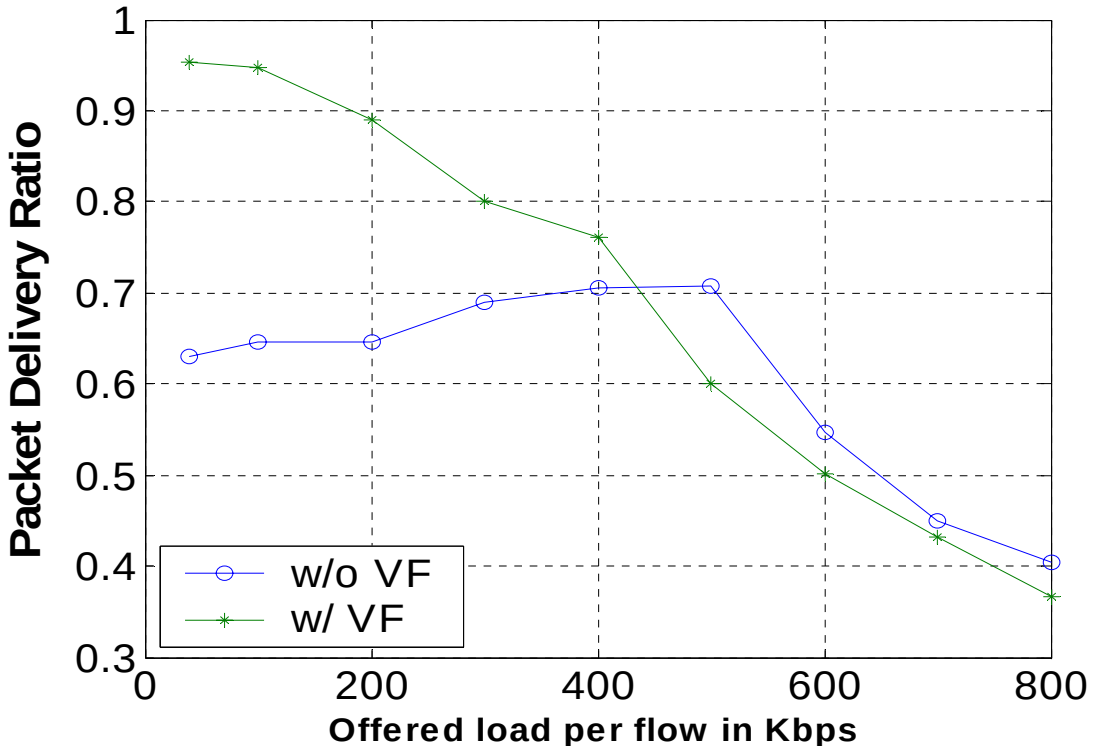
- Varying density of helpers
- Helpers reach a density to maximize the benefits

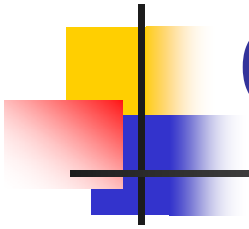


Varying Load



- Varying offered load of each flow
  - Before congested: Do Help
  - After congested: Not hurt much





Conclusions & Future Work

- Conclusion
  - A simple design to exploit wireless broadcast for cooperative forwarding
    - Packet delivery ratio increase 5%-35% in Light and Medium Load
  - Evaluate "delay-trigger" scheme
    - Good with a certain density of helpers
    - Robust with increased load and imperfect estimation
- Future work
  - Other methods: RSSI-trigger or a "combo" mechanism
  - Methods to handle best-effort traffic and real-time traffic differently.