Adaptive Energy Efficient and Low Latency MAC for Data Gathering in WSN (DMAC)

Shreyas Bhargav Raghunathan
1334387
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Introduction- Important Design features (WSN)

- Energy Efficiency- At any cost…
- Latency- Application oriented
- Throughput- Sampling resolution (application oriented)
- Fairness- Sharing the scarce bandwidth

What do we need?

- Energy Efficient protocol with fair bandwidth sharing, increasing the throughput with least possible sleep latency…

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Immediate Solution …

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Previously – Protocols …

- S MAC – low duty cycle protocol
  - Periodic Sleeping
  - Message passing
- L MAC – light weight MAC (TDMA Based)
  - TDMA based
  - Base station independent
  - Time slot allocation (local knowledge)

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Previously – Disadvantages

- S MAC
  - Extremely large sleep latency
  - Fixed duty cycle & inability to adapt to traffic
  - Increased possibility of collision
- L MAC
  - Large network set up time
  - Large overhead in slot maintenance
  - Inability to adapt to traffic condition

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D MAC Protocol Design – communication patterns & Data Gathering tree

- Local Data Exchange (gossip) – localized phenomenon
- Control packet and interest packet to sink – can withstand latency...
- Data gathering from sensor to sink – highly sensitive to latency

Data gathering tree – assumptions

- Unidirectional flow of data
- Stationary sensors and route changes
- Multiple source to sink
- All nodes forward packet – except sink

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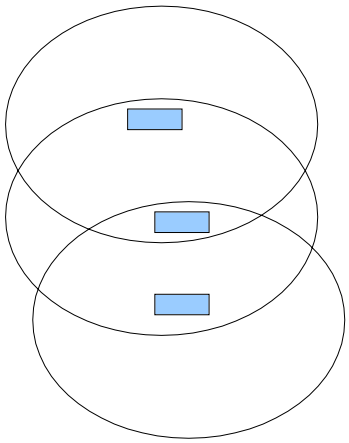
D MAC Focus – Data Forwarding Interruption (DFI) – General Case



- Limited receiving range
- 2 hop neighbor – no overhearing
- Sleep latency and data aggregation
- Inability to propagate duty cycle adjustments

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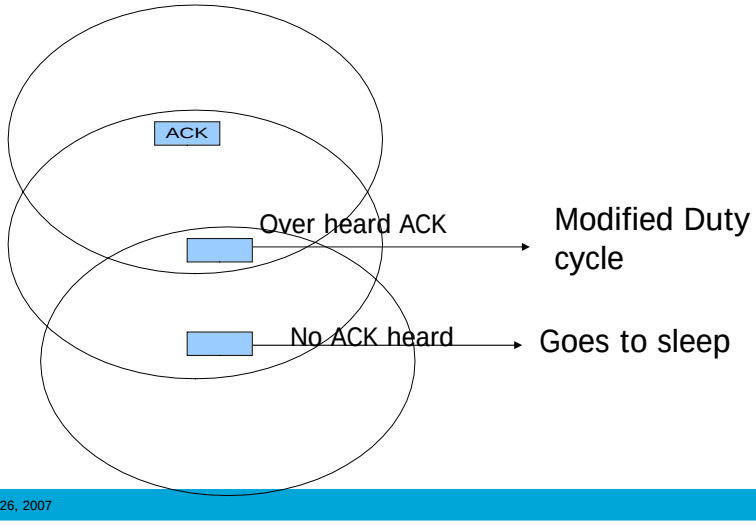
D MAC Focus – Data Forwarding Interruption (DFI) – S MAC



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D MAC Focus – Data Forwarding Interruption (DFI) – S MAC...

- Delay increases linearly with number of hops
- Sleep latency still very high
- D MAC – reduce this, enable continuous transmission

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D MAC Protocol Design – key areas

- Staggered sleep cycle – based on gathering tree architecture
- Data Delivery (Continuous)
- Duty cycle adaptation
  - Data Prediction
  - More To Send packets (MTS)

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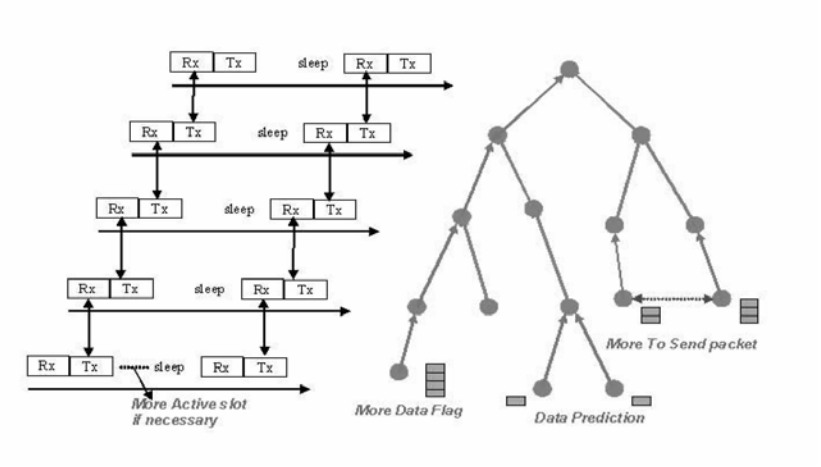
D MAC Protocol Design – Staggered sleep cycle



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D MAC Protocol Design – Staggered sleep cycle – Advantages…

- Sequential wake up – reduced sleep delay
- Request propagation – continuous among multihop neighbors
- Reduced contention – separate active periods…
- Nodes in sink path increase duty cycle – others sleep…

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D MAC Protocol Design – Duty Cycle adaptation

- Multiple packets to send…
- Increase own duty cycle – request increase of others too…
- Slot – by – slot renewal mechanism
- 'More Data' – flag…
  - When to set more data?
  - What happens after 'more data' is set?
  - Inconsistencies

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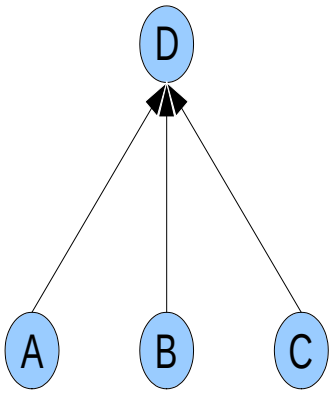
D MAC Protocol Design – Data Prediction



•Small source rate and large aggregated data

Parent
•Data anticipation from children
•Changes sleep cycle

Children
•Hears ACK from parent
•Sleeps for fixed period

Disadvantage – increased latency

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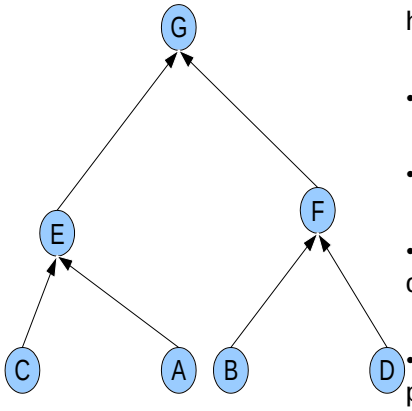
D MAC Protocol Design – More To Send (MTS) – Need…



- Two nodes are in interference range – have different parents
- A wins contention B keeps quiet
- B and D have no slots – sleep latency…
- Data Prediction model fails – B does not over hear ACK…
- No change in sleep cycle of B and its parent

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D MAC Protocol Design – More To Send (MTS)

- MTS – short packet with ID and flag (1 – request, 0 – clear)
- Request MTS – circumstances
  - lost channel and Rx a request MTS from children

Parent – wakes up every interval until Clear MTS

- Clear MTS – Circumstances
  - Empty buffer (after Request MTS),Cleared Requests

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Comparison - SMAC

D MAC	S MAC
Application specific	General purpose
Adaptive to traffic circumstances	Fixed duty cycle, non adaptive to traffic
Lower sleep latency	Higher sleep latency

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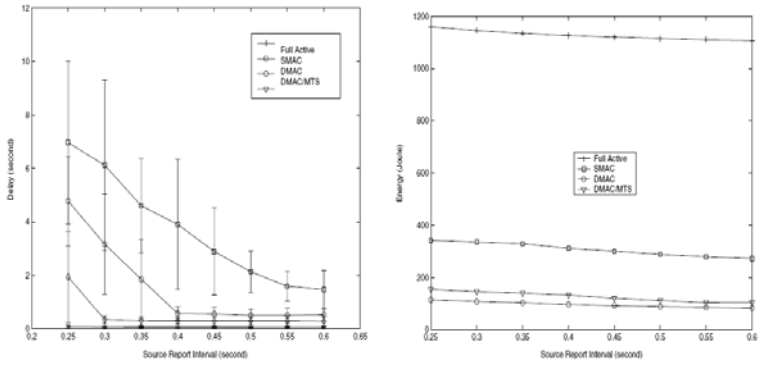
Comparison – few graphs…



(a) latency (b) energy

Different Traffic loads in tree topology

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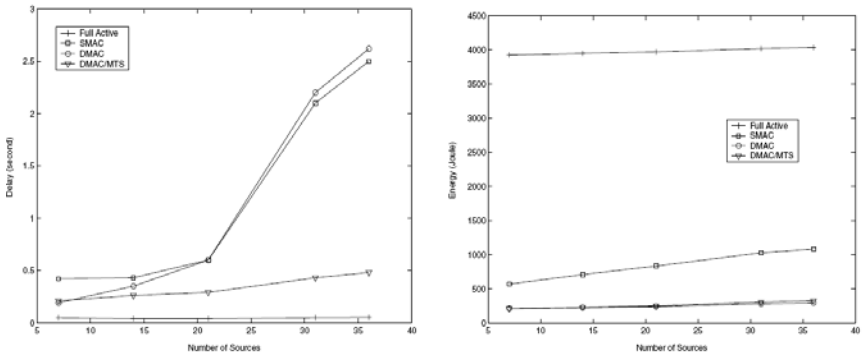
Comparison – few graphs…



(a) latency (b) energy

Different number of sources on tree topology

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Conclusion

D MAC

- Energy efficient and low latency tree based data gathering protocol
- Data gathering tree – low latency and energy efficiency
- Skew in sleep cycle – depends on depth of tree
- Data prediction for aggregated traffic
- MTS packets – multihop latency reduction

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Conclusion

- Initially we wanted
  - ➢ Energy Efficient protocol with fair bandwidth sharing, increasing the throughput with least possible sleep latency...
- Now we have
  - ✓ Energy efficient
  - ✓ Low sleep latency
  - ✓ Increased throughput

  But only for tree based data gathering system