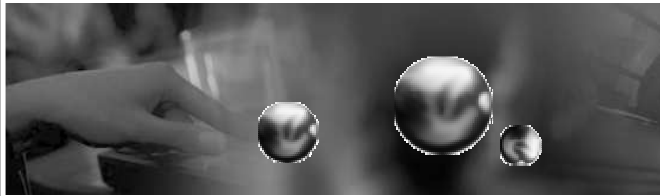


# Design of an energy efficient Medium Access Control protocol for wireless sensor networks



Masters Thesis Defense  
Kiran Tatapudi

## Thesis Committee

Dr. Chansu Yu,

Dr. Wenbing Zhao,

Dr. Yongjian Fu



## Organization

- Introduction
- Related Work
- Bulk Synchronous Medium Access
- Performance Evaluation
- Conclusion



## Introduction

### ***What is a Wireless Sensor Network ?***



## Introduction

### ***What is a Wireless Sensor Network ?***

*a collection of cheap, low power wireless devices with limited processing and communication capabilities, which collectively help monitor physical or environmental conditions*



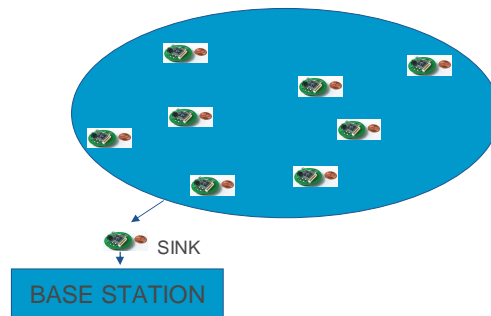
## Introduction

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*a collection of cheap, low power wireless devices with limited processing and communication capabilities, which collectively help monitor physical or environmental conditions*

### Applications

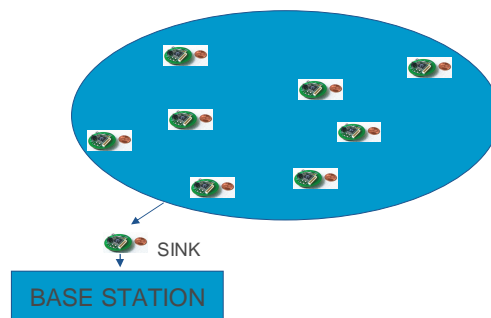
- Habitat Monitoring
- Home Automation
- Surveillance



## Introduction

### Key Aspects

- Sink based

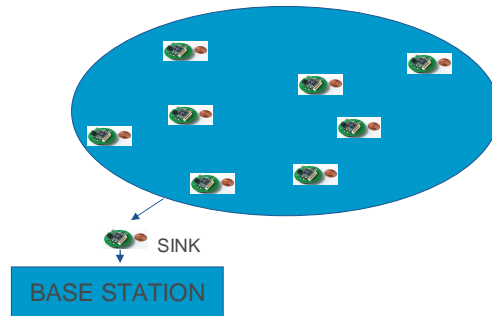




# Introduction

## Key Aspects

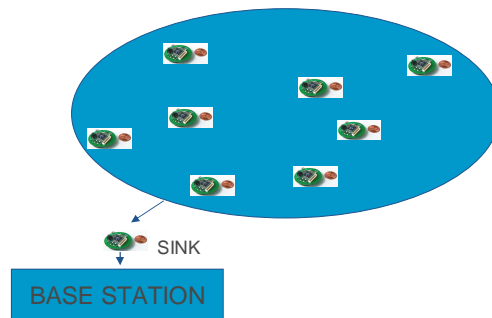
- Sink based
- Multi-hop communication



# Introduction

## Key Aspects

- Sink based
- Multi-hop communication
- Time and space correlated



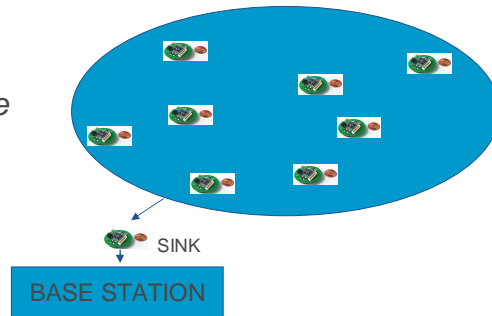


# Introduction

## ***Key Aspects***

- Sink based
- Multi-hop communication
- Time and space correlated (Message bursts)

*How to Arbitrate the medium !!*



# Introduction

## ***Medium Access Control***



## Introduction

### **Medium Access Control**

*arbitrate the shared communication medium among competing nodes and thus provide a robust communication channel to applications*



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### ***Medium Access Control***

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➤ **802.11 ??**

### ***Unique requirements of Sensor networks***

- Energy Efficiency
- Handle traffic bursts



## Related Work

### ***Two classes of protocols :***

- Contention based protocols
- Time Division Multiple Access protocols



## Related Work

### ***Contention based protocols***

- CSMA for collision avoidance

### ***Drawbacks***

- Higher number of Collisions
- Re-transmissions
- Non-deterministic



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### ***Contention based protocols***

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- ACK packets for collision detection

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## Related Work

### ***Contention based protocols***

- CSMA for collision avoidance
- ACK packets for collision detection
- Sleep schedules for energy conservation

### ***Drawbacks***

- Higher number of Collisions
- Re-transmissions
- Non-deterministic



## Related Work

### ***Time Division Multiple Access***

- Exclusive slot assignment



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## Related Work

### ***Time Division Multiple Access***

- Exclusive slot assignment
- Collision free
- Automatic duty cycle
- Deterministic

### ***Drawbacks***

- Synchronization Overhead
- Improper schedule formation

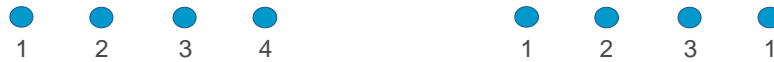


## Related Work

### ***Two-hop graph coloring for slot scheduling in TDMA***

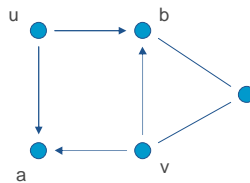
- Communications within two-hops interfere with each other, but beyond that the communications are safe
- Allot different slots for nodes within two-hop neighborhood and reuse the slots for other nodes

### ***Example:***



## Related Work

### ***Two-hop coloring is not always correct***



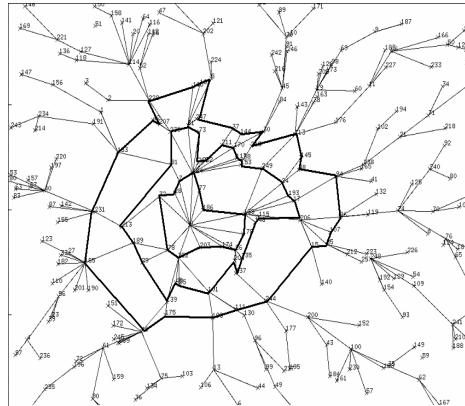
*Exploit the unique feature of sink-based sensor net to simplify the message exchange procedure while achieving collision-free slot schedule !!!*



## Bulk Synchronous Medium Access

### Key Aspects

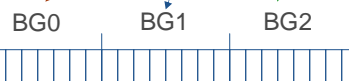
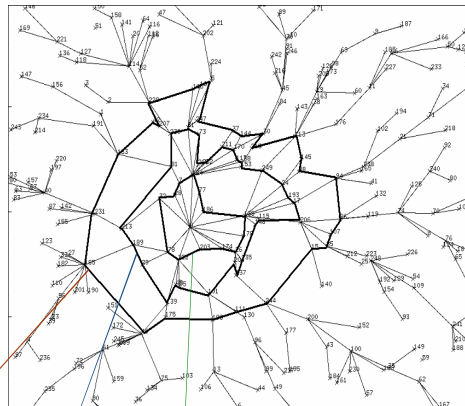
- Optimized for sink-based networks
- Tree structure (rooted at sink and grouped as non-interfering sets based on hop-count from sink)
- Parent child relationship between two sets of nodes
- Slot-based scheduling for tree links
- Automatic Routing



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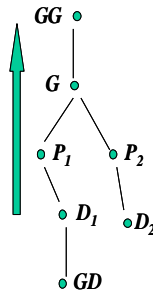




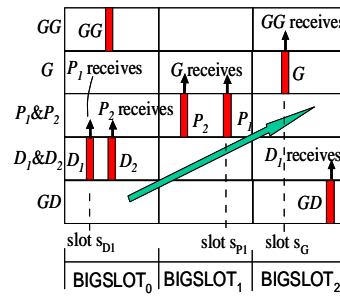
## Bulk Synchronous Medium Access

### Data flow

- BIGSLOT
- Three-way Handshaking
- PADV, PSEL, SCH messages



(a) 7-node scenario



A TDMA frame in data phase

(b) TDMA schedule in BSMA



## Bulk Synchronous Medium Access

### Parameters for evaluating performance

- Message Latency = (hop-count) \* BIGSLOT
- Energy Efficiency = ((TX slot) + ('n' RX slots)) / (BIGSLOT \* 3)



## Bulk Synchronous Medium Access

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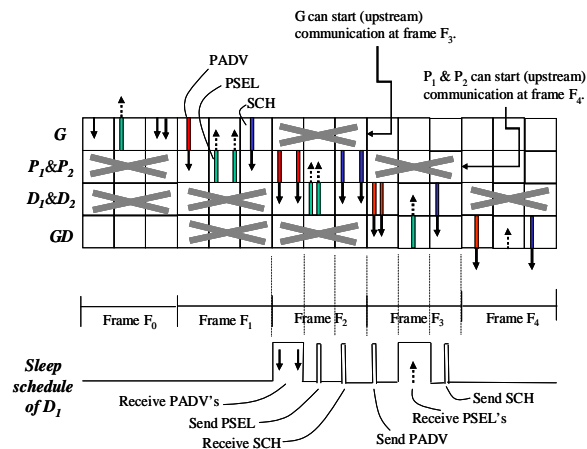
- Message Latency = (hop-count) \* BIGSLOT
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**How to form such a tree !!**



## Bulk Synchronous Medium Access

### Tree formation & slot scheduling

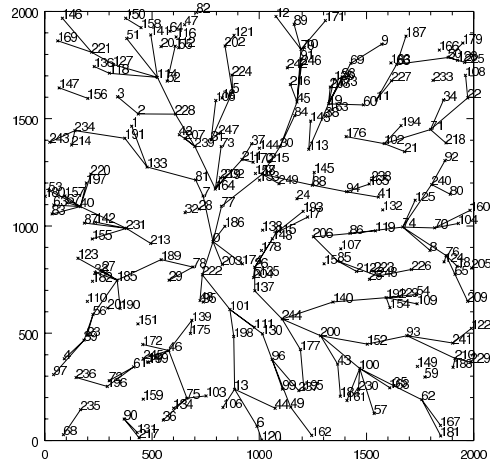




## Bulk Synchronous Medium Access

### Design Issues

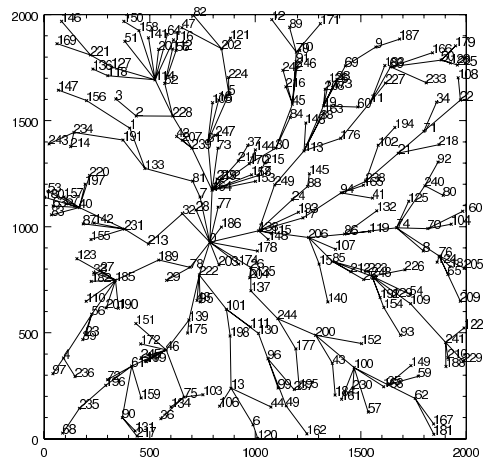
- Orphan Nodes



## Bulk Synchronous Medium Access

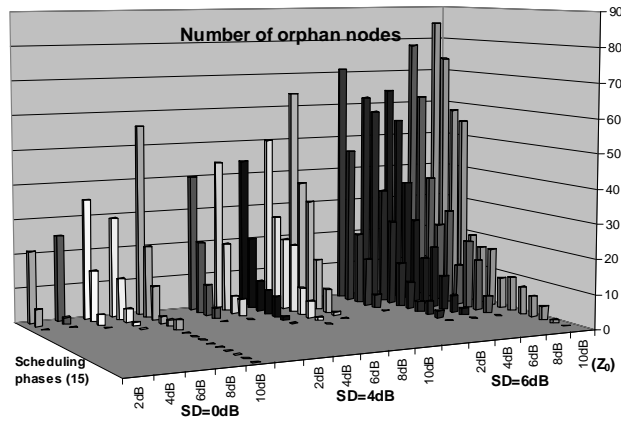
### Design Issues

- Orphan Nodes
- Tree Convergence





## Performance Evaluation



BIGSLOT size = 25



## Conclusion

- TDMA schemes based on two-hop graph coloring algorithm fail to provide collision-free medium access and to utilize available transmission opportunities
- BSMA is a simple, robust and energy efficient MAC protocol
- Our simulation study based on ns-2 network simulator shows that BSMA constructs a proper tree and collision-free schedule in reasonable number of scheduling phases



## Q & A

THANK YOU