

Energy-efficient Data Transmission Protocol Based on Directional Antenna for Green WSNs

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Introduction

- ▶ IoT devices provide constrained execution environments with limited processing, storage, and memory resources
 - offload parts of application business logic onto these devices
 - IoT gateways
- ▶ Dynamically adapt to inevitable changes such as new requirements or adjustments in regulations
 - purchase and sell these application components in an IoT application market

Motivation

- ▶ Wireless sensor networks (WSN)
 - spatially distributed autonomous sensors to monitor physical or environmental conditions
 - node - a sensor, a micro processor, and a transceiver
- ▶ High efficiency and energy saving strategy in the communication process with the traditional Omni-directional antenna
 - distribution of energy in all directions will waste energy
 - unnecessary interference

Directional Antenna

- ▶ Gathering energy only in a predetermined direction
 - node - a sensor, a micro processor, and a transceiver
 - longer transmission and reception range in the case of the same energy consumption
 - more real-time transmission and fewer hops
 - reducing the possibility of being tapped
 - suppress unwanted interference

Main contributions

- ▶ Propose a directional antenna based routing selection protocol in WSNs
- ▶ The directional antenna technology is a recently new ... compare the two technologies in several aspects
- ▶ The directional antenna technology has exist for some time... compare our scheme with the recent protocols on the aspects of energy

Concept of Antenna Gain

- ▶ Gain of the directional antenna is mainly used to represent the relative power in one direction, which is used to represent the energy of the transmission

$$\bar{d} = \hat{r}(\theta, \phi)$$

$$G(\bar{d}) = \eta \frac{U(\bar{d})}{U_{avg}}$$

- ▶ An Omni-directional antenna gain is 0 dBi

Concept of Directional Antenna

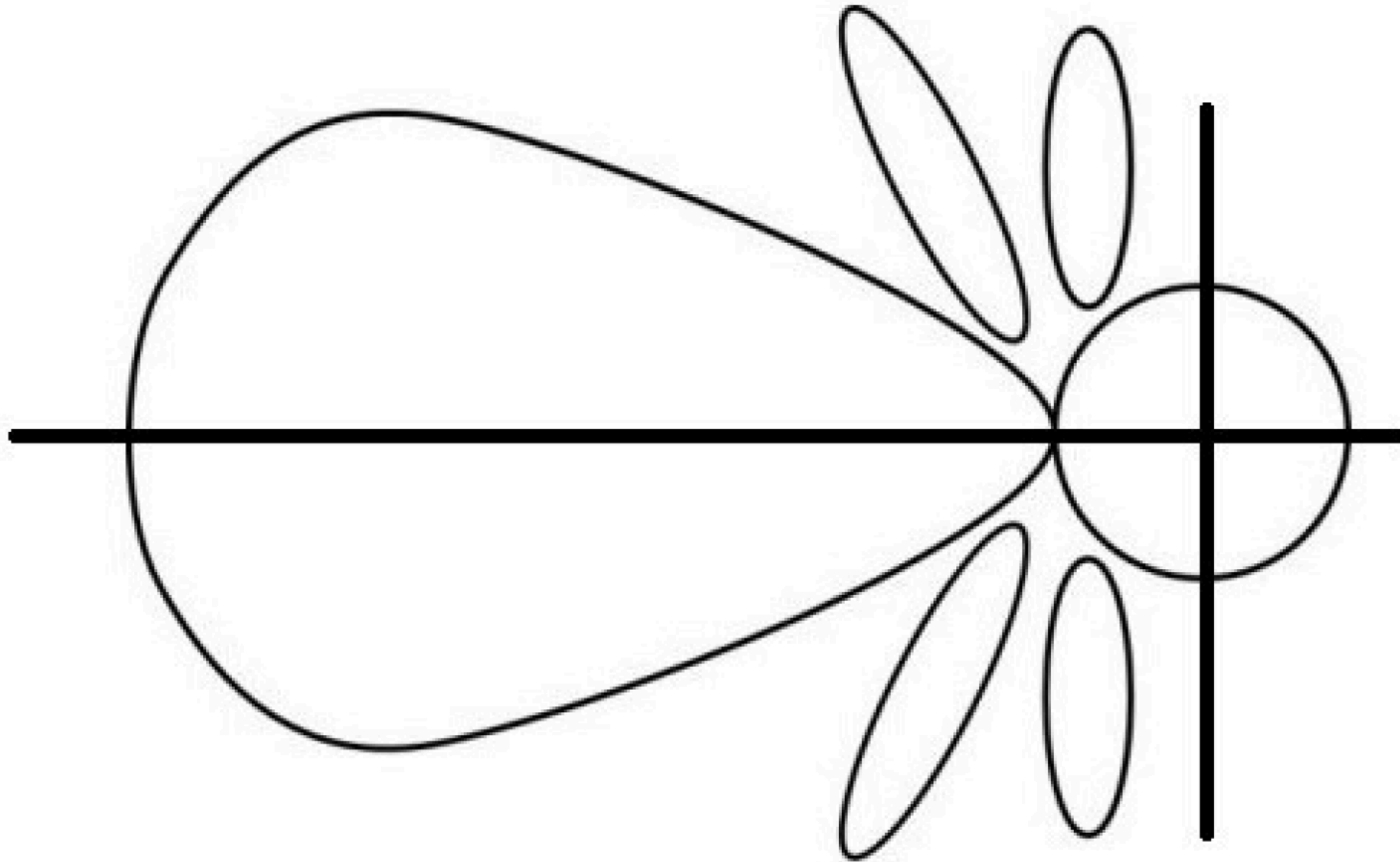


Fig. 1: Radiation Diagram of Directional Antenna

Key Issues in WSN - Hidden Terminal Problem

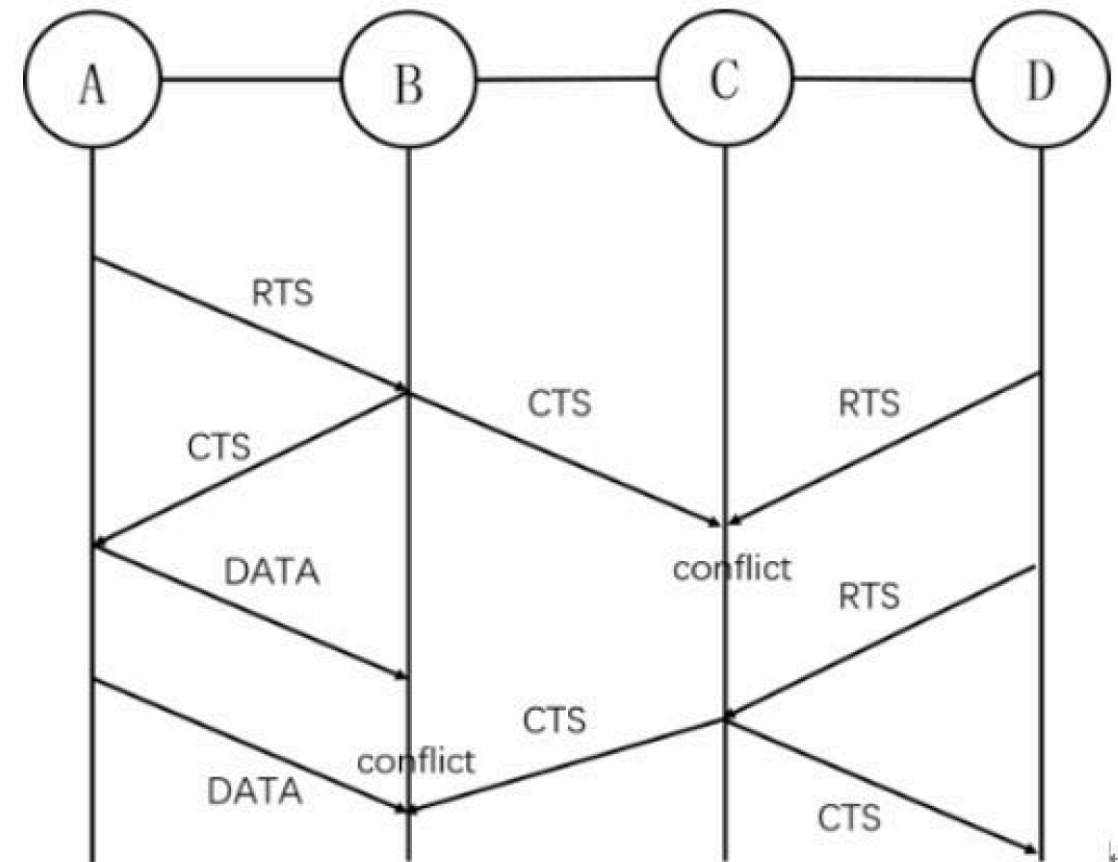
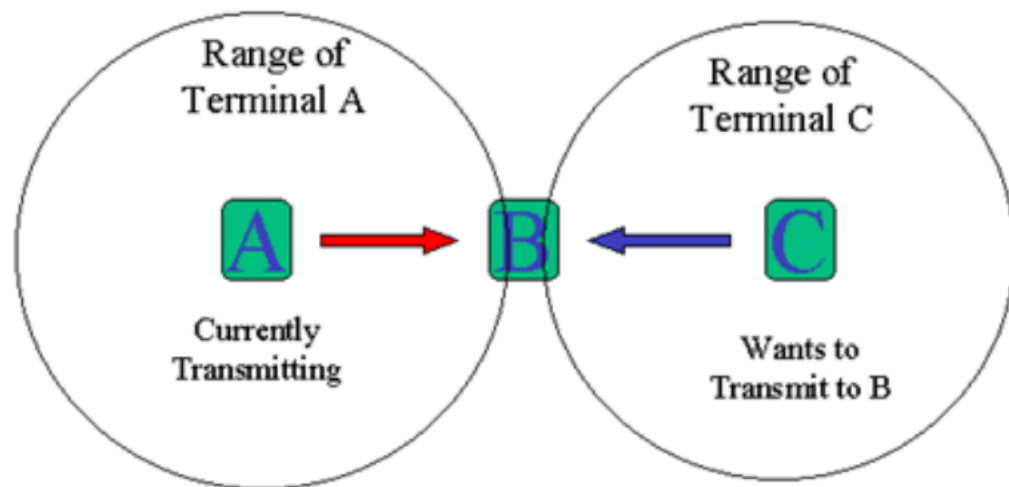


Fig. 2: The Hidden Terminal Problem

- ▶ solve this problem by using directional antennas, so that all of the above problems can be solved with less energy consumption and high throughput

Key Issues in WSN - Exposed Terminal Problem

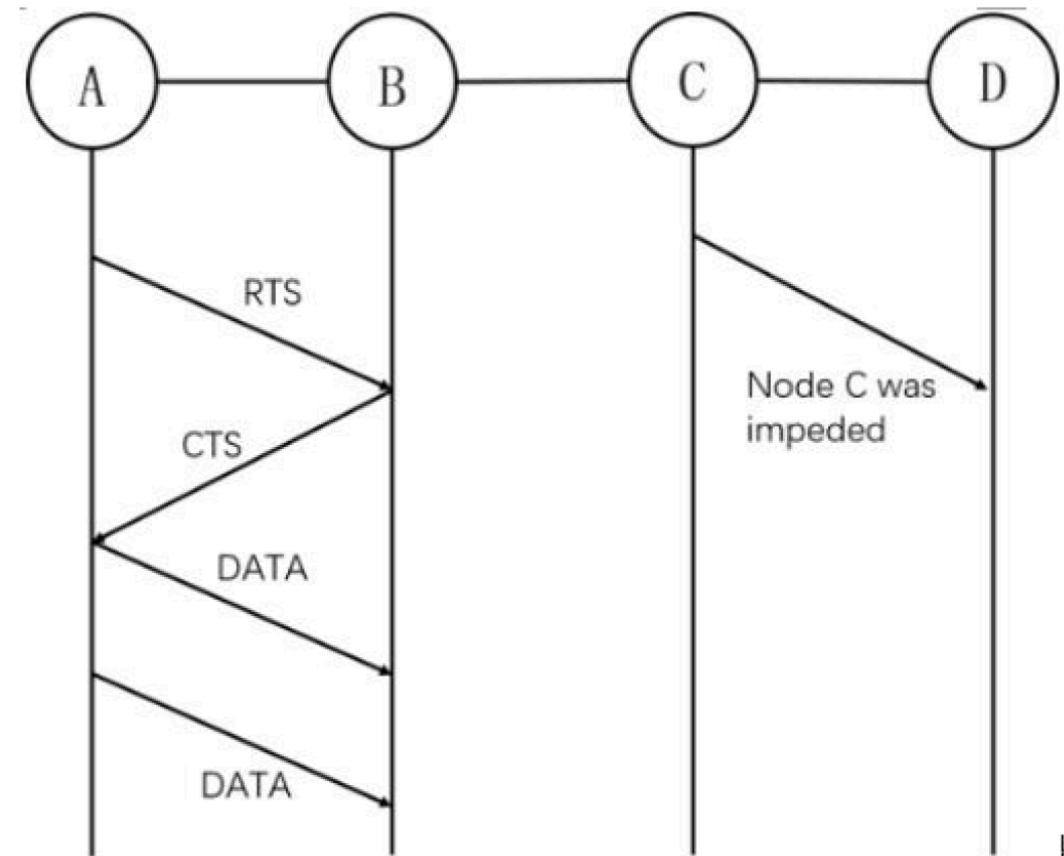
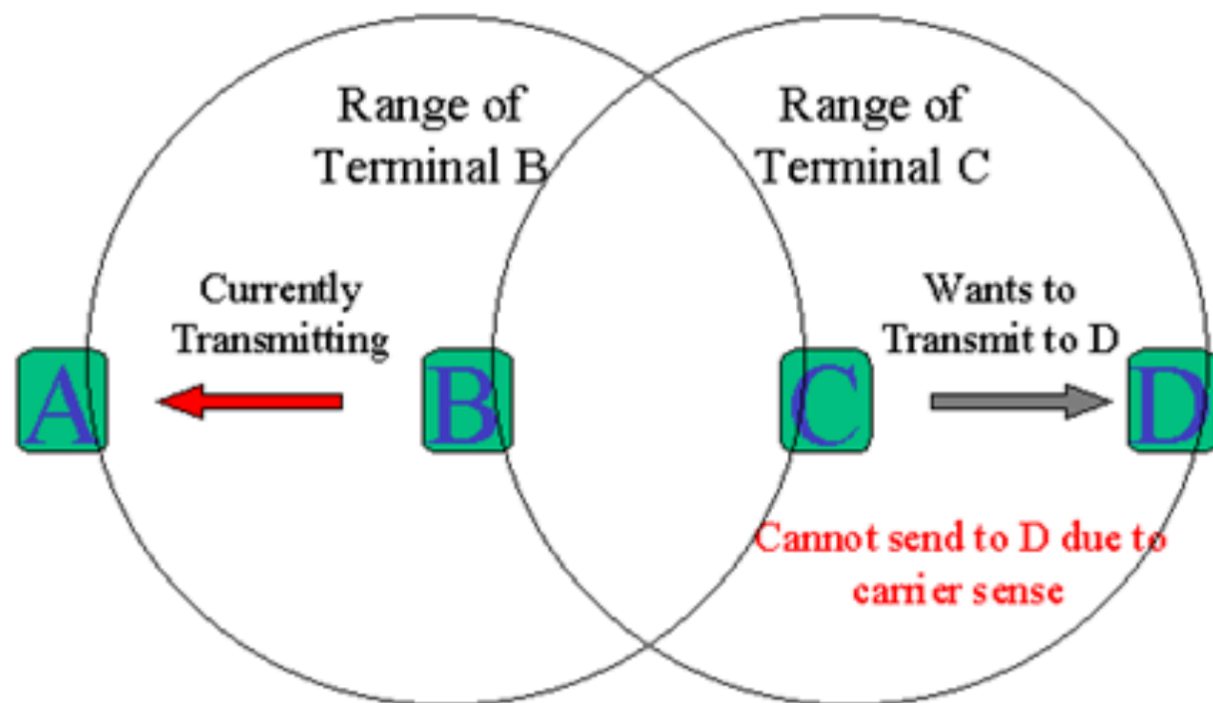


Fig. 3: Exposed Terminal Problem

- ▶ solve this problem by using directional antennas, so that all of the above problems can be solved with less energy consumption and high throughput

Data Transmission Method (DTM)

- ▶ calculate the parameters of the two node in the position, direction, distance
- ▶ define the linear transmission of S to D
- ▶ S node will broadcast a wake-up message to the node in the transmission range
- ▶ the weights of each path are calculated from the node S
- ▶ the path selection algorithm is used to calculate the minimum weight of the path.

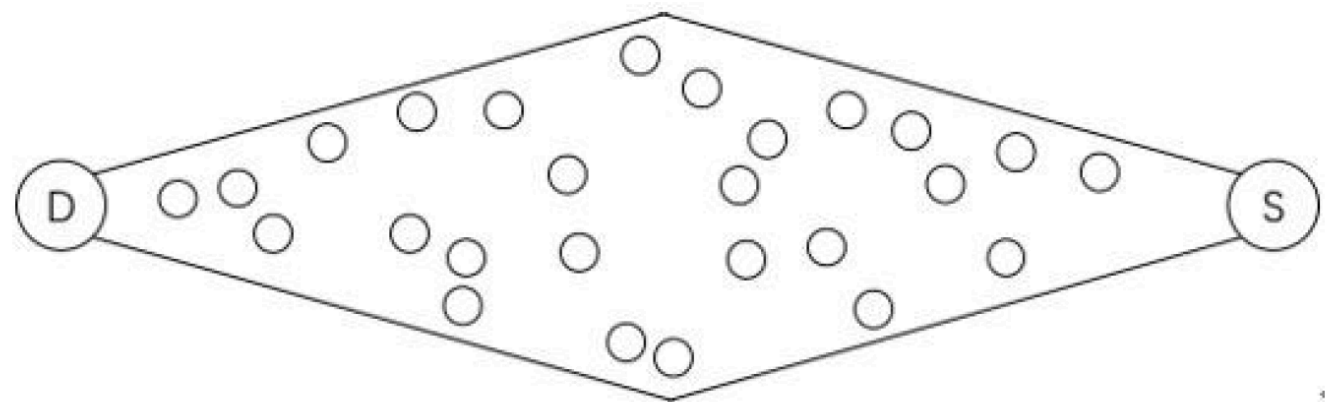


Fig. 4: Multi-hop Path Selection

Performance Evaluation

TABLE I: Comparison between the directional antenna and the omnidirectional antenna

Values	Omnidirectional antenna	Directional antenna
Broadcast range	circular	sector
Energy consumption	large	small
Signal interference	serious	fine
Spatial multiplexing	no	yes
Network capacity	not extensible	extensible
Security	easily attacked	not easy
Accuracy	high	low
Broadcast distance	short	long

Performance Evaluation

TABLE II: The comparison of directional antenna routing protocols

protocols	DO/DD	multi-path	network throughput	end to end delay	routing overhead
DRP	DO/DD	No	Good	Low	Common
EEDR	DD	Yes	Good	Common	Common
MDAR	DO	Yes	Good	Low	Common
ADA	DO	Yes	Good	Low	Low
DTM	DO/DD	Yes	Very good	Low	Lower