

# Node Localization in Wireless Networks Through Physical Layer Network Coding

## Purpose

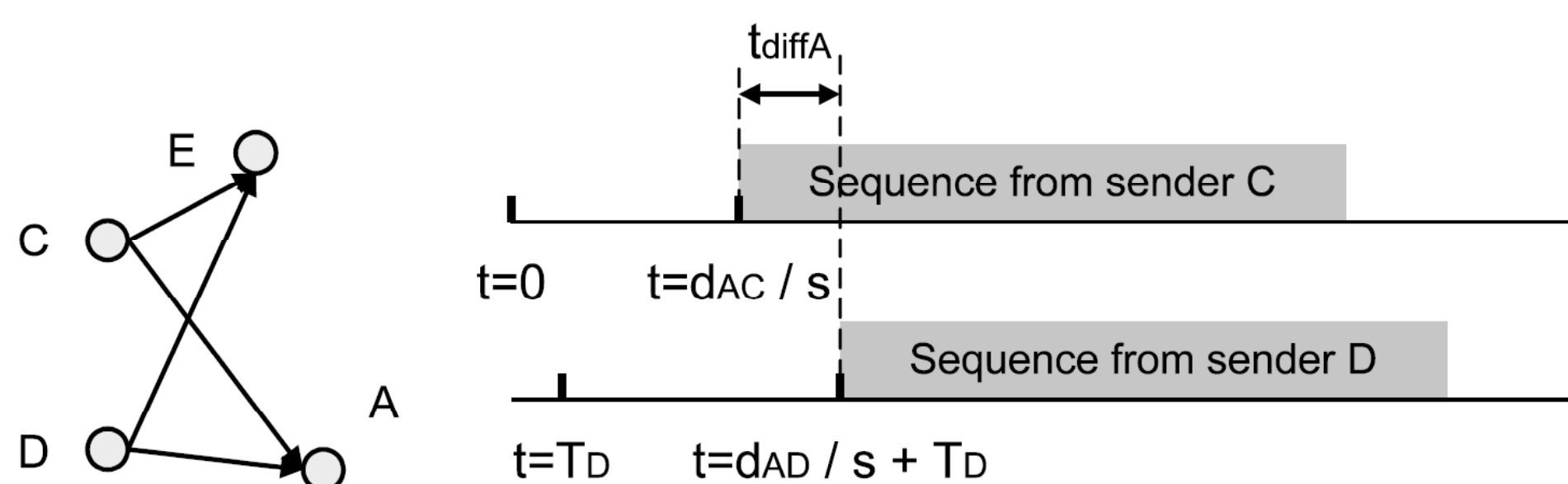
Locating the absolute (or relative) positions of the wireless nodes can assist the performance and safety of the networks from multiple aspects.

- more efficient location based routing
- authenticate the senders
- detect Sybil attacks

## Methods

### Assumptions

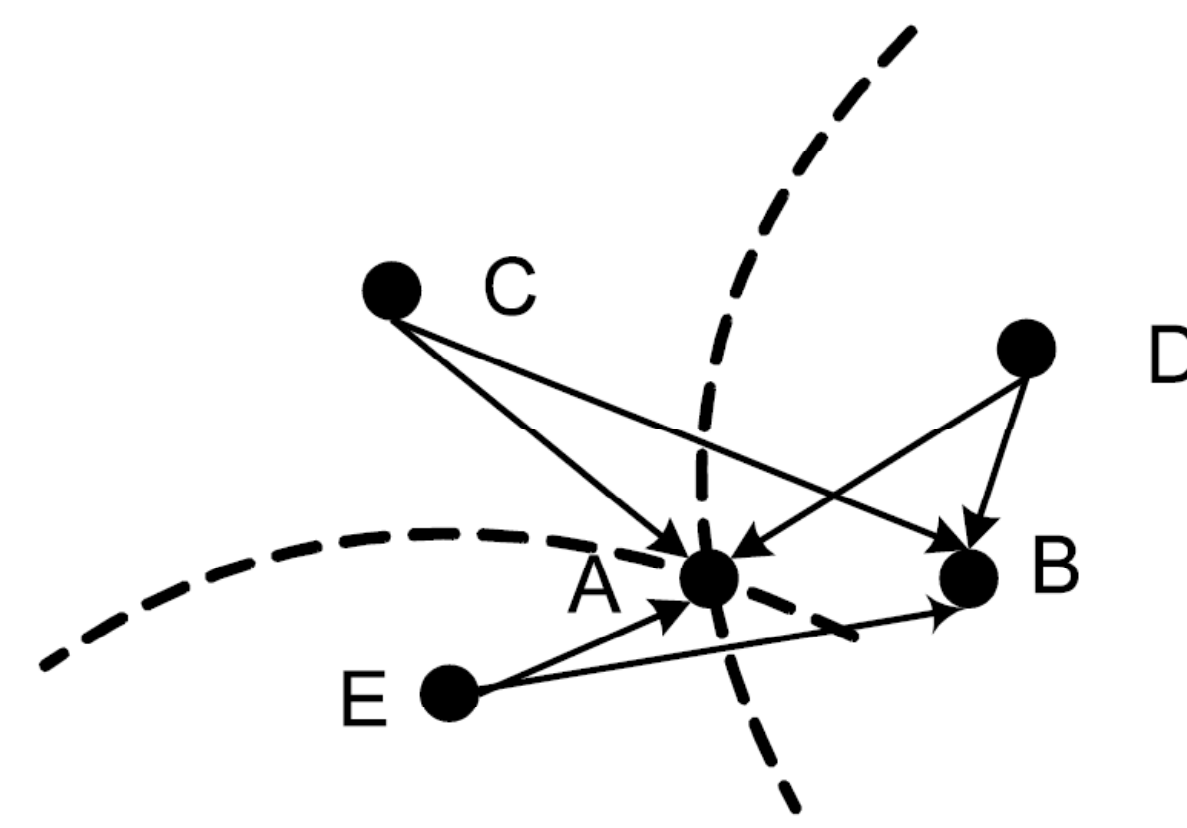
- a shared secure, lightweight pseudo random bit generator
- pre-distributed pairwise keys
- anchor nodes



(a) Left: sequences from *C* and *D* collide at *A*. Right:  $t_{diffA}$ : difference b/w arriving time of two sequences at *A*.

$d_{AB}$ : Euclidean distance between *A* and *B*  
 $T$ : a specific moment  
 $t$ : a time duration  
 $s$ : the radio wave propagates at the speed

$$d_{AD} - d_{AC} = (d_{ED} - d_{EC}) + s \times (t_{diffA} - t_{diffE})$$

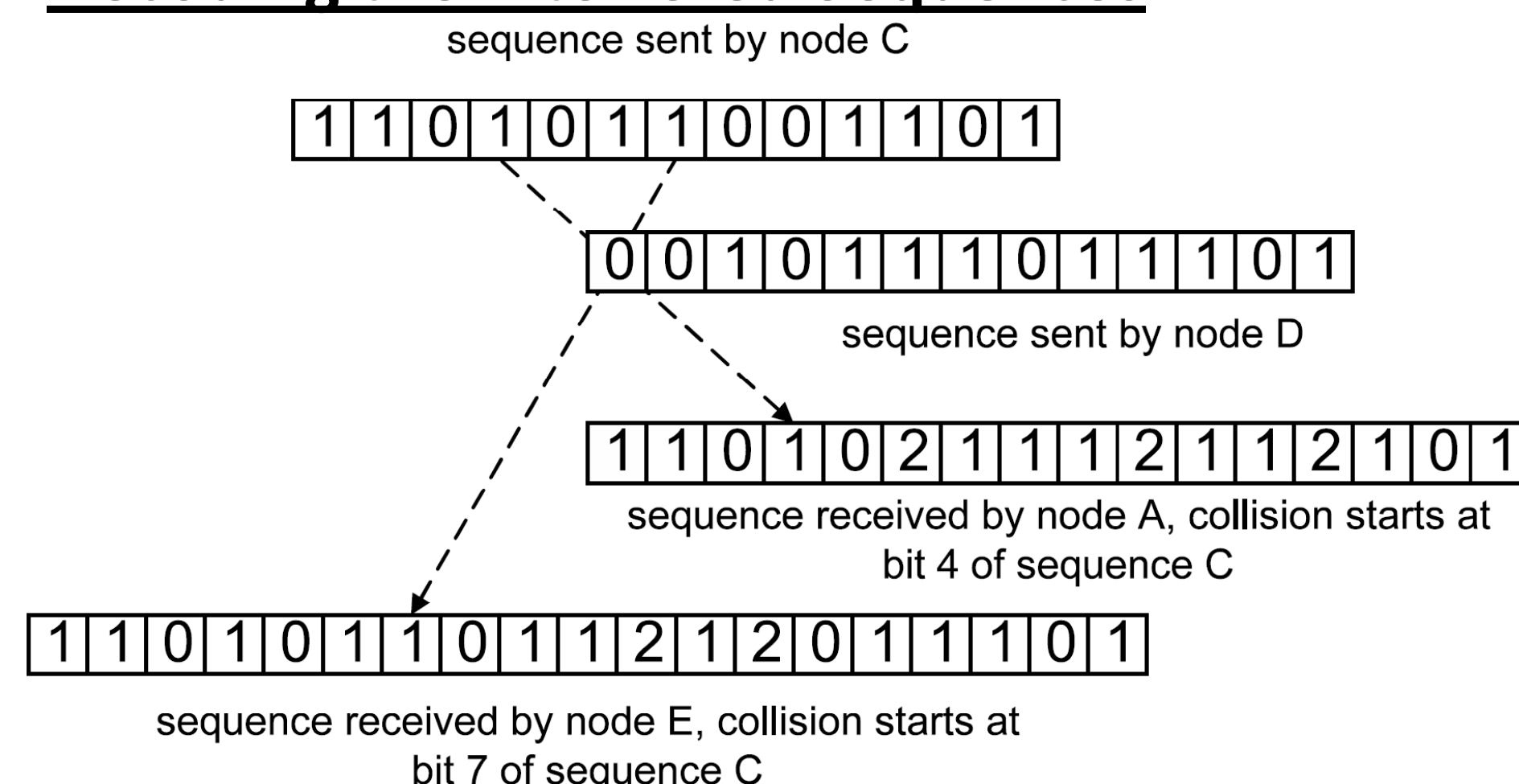


(b) Node *A* is at the intersection of the hyperbolas.

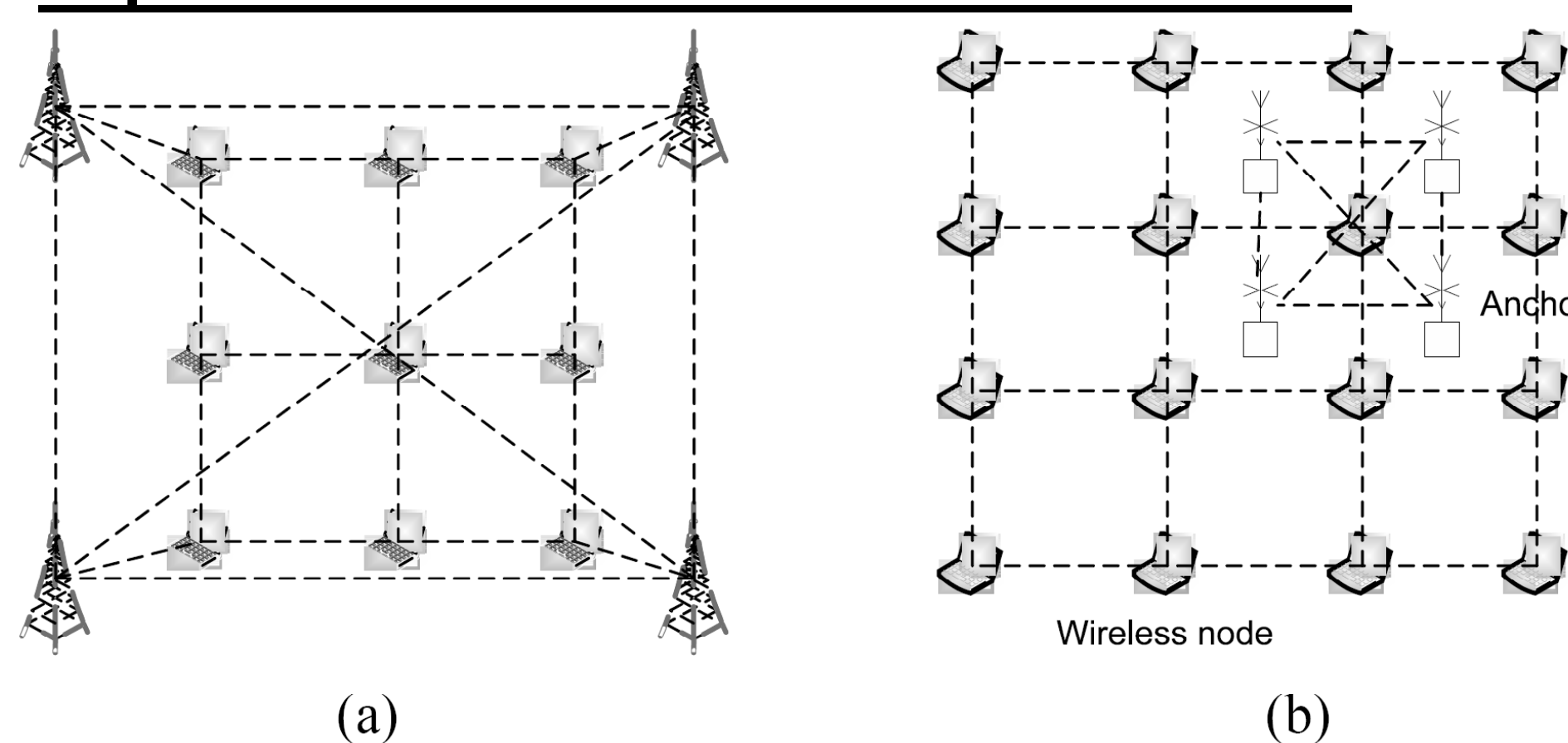
- ❖ no need to synchronize clocks.
- ❖ no need of special hardware
- ❖ no centralized controller

## Issues

### Decoding the Interfered Sequences



### Impacts of the Anchor Node Distribution



## Evaluation

### Overhead of the Proposed Approach

- efficient computation by simple add and shift operations
- communication (interference results, anchor nodes)

### Location Accuracy

- pilot bit sequence with known contents
- frequency jitter
- error accumulation

### Security

- false position information
- clustering algorithm to detect out-siders
- jamming attacks
- adjust the carrier frequency

## Conclusion

In this paper we propose a node localization mechanism for wireless networks based on physical layer network coding. The analysis shows that the difference between the starting points of interference at the receivers can be used to determine the hyperbolas based on the positions of the anchor nodes. We can then estimate the positions of the nodes by calculating the intersection points of the hyperbolas. To turn this mechanism into a practical approach, we study various problems in the network and physical layers. We also analyze the overhead, localization accuracy, and safety of the proposed approach.

## Abstract

In this paper, we propose a new mechanism based on physical layer network coding to achieve node localization. When two signal sequences collide at the receiver, the starting point of the collision is determined by the distances between the receiver and the senders. When the signal interference results from two receivers are combined together, we can determine a hyperbola with two senders as the respective focal points. In this way, by using multiple pairs of anchor nodes as senders, we can determine multiple hyperbolas and the node position will be at the intersection point of these hyperbolas.

## Authors

Zhiwei Li, Di Pu, Weichao Wang, Alex Wyglinski