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[Poster Presentation]
SVM Based Orthogonal Resource Allocation in CSMA/CA

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Abstract Due to the widespread of machine-to-machine (M2M) communications and Internet-of-things (IoT), a larger number of wireless nodes are densely deployed in wireless networks. Under such a dense deployment of wireless nodes, it is important to manage or avoid the mutual interference among the wireless nodes. If carrier-sense multiple access/collision avoidance (CSMA/CA) is adopted as a random access protocol, some wireless nodes may not be able to carrier sense each other due to large distance and/or the obstacles between them. This is known as hidden terminal problem. Wireless nodes may start packet transmission although there is an active transmission if carrier sense fails. The packet collision may happen due to the hidden terminal and degrades the packet delivery rate (PDR) performance. To avoid such packet collision, in this paper, an orthogonal resource allocation scheme using machine learning is proposed. The information whether or not the particular two wireless nodes are in the hidden terminal relation is an *unobservable* information from the network controller. Thus, it is difficult to obtain such information directly. The machine learning learns the relation between the *unobservable* information and *observable* information such as the wireless node locations and the received signal strength. Once the learning process completes, the wireless controller estimates the *unobservable* information from the *observable* information. Then, based on the estimated information about the relationship between the wireless nodes, orthogonal resources are allocated to the wireless nodes in order to avoid the packet collision due to the hidden terminal. The numerical evaluation elucidates that the proposed scheme using support vector machine (SVM) can improve the PDR performance by 15% compared to the system with random resource allocation which does not take into account the relationship among the wireless nodes.

Keywords Frequency Sharing, Machine Learning, Wireless Resource Allocation

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Background

- Dense distribution of wireless terminals in wireless network
  - ✓ Packet collision frequently happens in random packet transmission
  - ✓ Packet delivery rate (PDR) degradation due to packet collision and interferences
    - ➢ Random access protocol which is suitable for distributed network is necessary
  - ➔ CSMA/CA [1]
    - ➢ Distributed channel sharing based on carrier-sensing (CS)
    - ➢ If CS fails, packet loss happens due to collision: Hidden terminal problem
    - ➢ Feedback of wireless environment is required for effective resource wireless utilization
      ➔ Overhead
- Related research : Machine learning based resource allocation for explicit feedback avoidance [2][3]

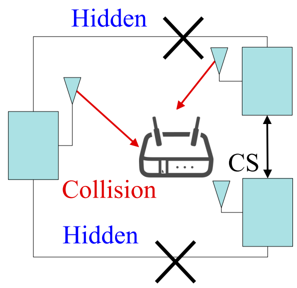


Fig. 1. Hidden Terminal Problem

Proposed Method

- Estimation of CS availability between terminals using support vector machine (SVM) [4]
  - ✓ Training data
    - ➢ Feature information $\boldsymbol{x}$: Location of terminal
    - ➢ Learning label: CS availability between terminals
  - ✓ Kernel function : Liner kernel, RBF kernel
  - ✓ Communication area is split into multiple grids
  - ✓ Different SVM is used in each square grid
    - ➢ Grid index v is calculated by following equation

$$v = \text{floor}(\{x_1 + (y_1 * D)\}/G)$$

D : Length of communication area
G : width of Grid
(x_1, y_1) : Locations of terminal 1

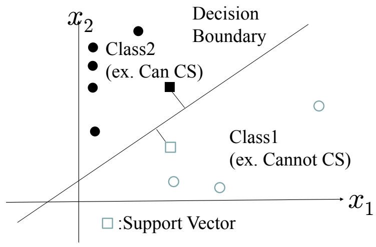


Fig. 2. Support Vector Machine

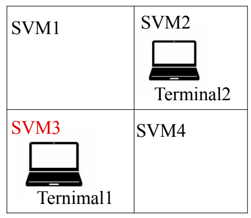


Fig. 3. Dividing Grids

- Orthogonal resource allocation in network controller
  1. Sorts wireless terminals in descending order of number of other terminals that cannot carrier sense
  2. Allocates exclusive resources to first $K-1$ terminals
  3. Allocates same resource to the remaining terminals

Numerical Simulation

- Channel Model : Pathloss + Spatially correlated shadowing [5]
- Packet generation with a probability of 0.8
- Each terminal transmits packets based on CSMA/CA in allocated orthogonal resource (time slot)

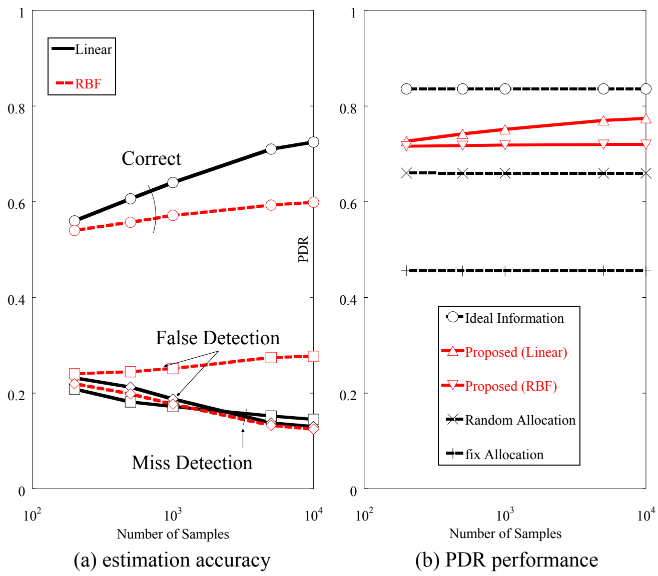
Table 1. Performance metric

Performance metric	Actual CS relation	Estimated CS relation
False detection	×	○
Miss detection	○	×
Correct	○	○
	×	×

Table 2. Simulation parameters

Communication Area	100×100[m²]	Shadowing deviation	6 [dB]
No. of terminals	3	CS threshold	-82.0 [dBm]
No. of APs	3	No. of time slots	2
Noise power density	-174 [dBm/Hz]	No. of samples	200,500,1000,5000,10000
Bandwidth	10 [MHz]	No. of test data	100000
Carrier frequency	2.4 [GHz]	No. of grids	100

- Result
  - ✓ Improvement of performance with increasing number of samples
  - ✓ Realization of 75% estimation accuracy
  - ✓ 15% PDR improvement from random resource allocation



(a) estimation accuracy (b) PDR performance

Fig. 4. Performance

Conclusion

- SVM based CS availability estimation for orthogonal resource allocation was proposed
  - ✓ CS availability was estimated from feature information
  - ✓ PDR was improved by 15% compared to random resource allocation

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