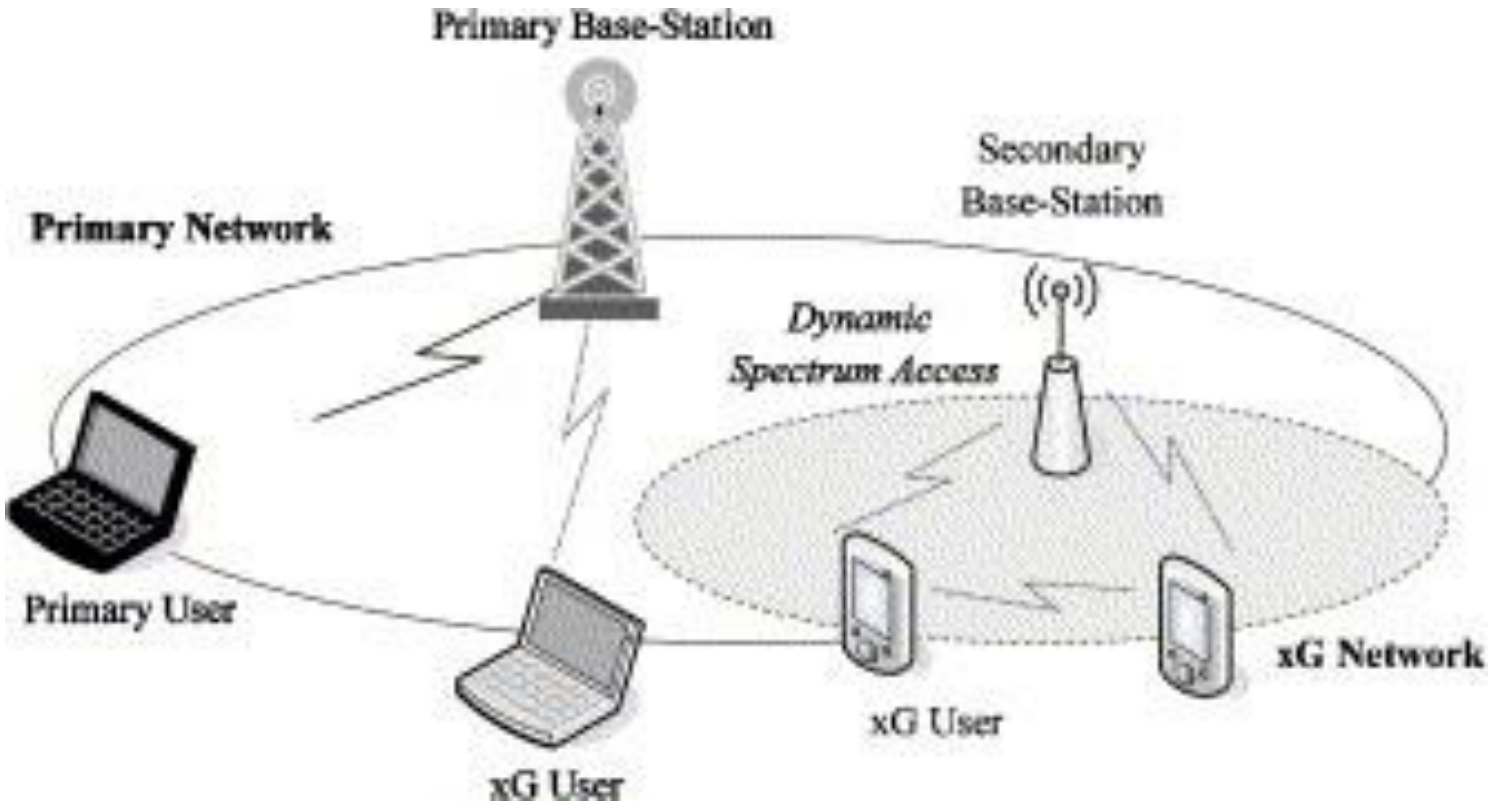
Interference-Aware Spectrum Sensing and Sharing in Cognitive Network

Cognitive Network

- Primary user / secondary user



Interference-aware spectrum sensing

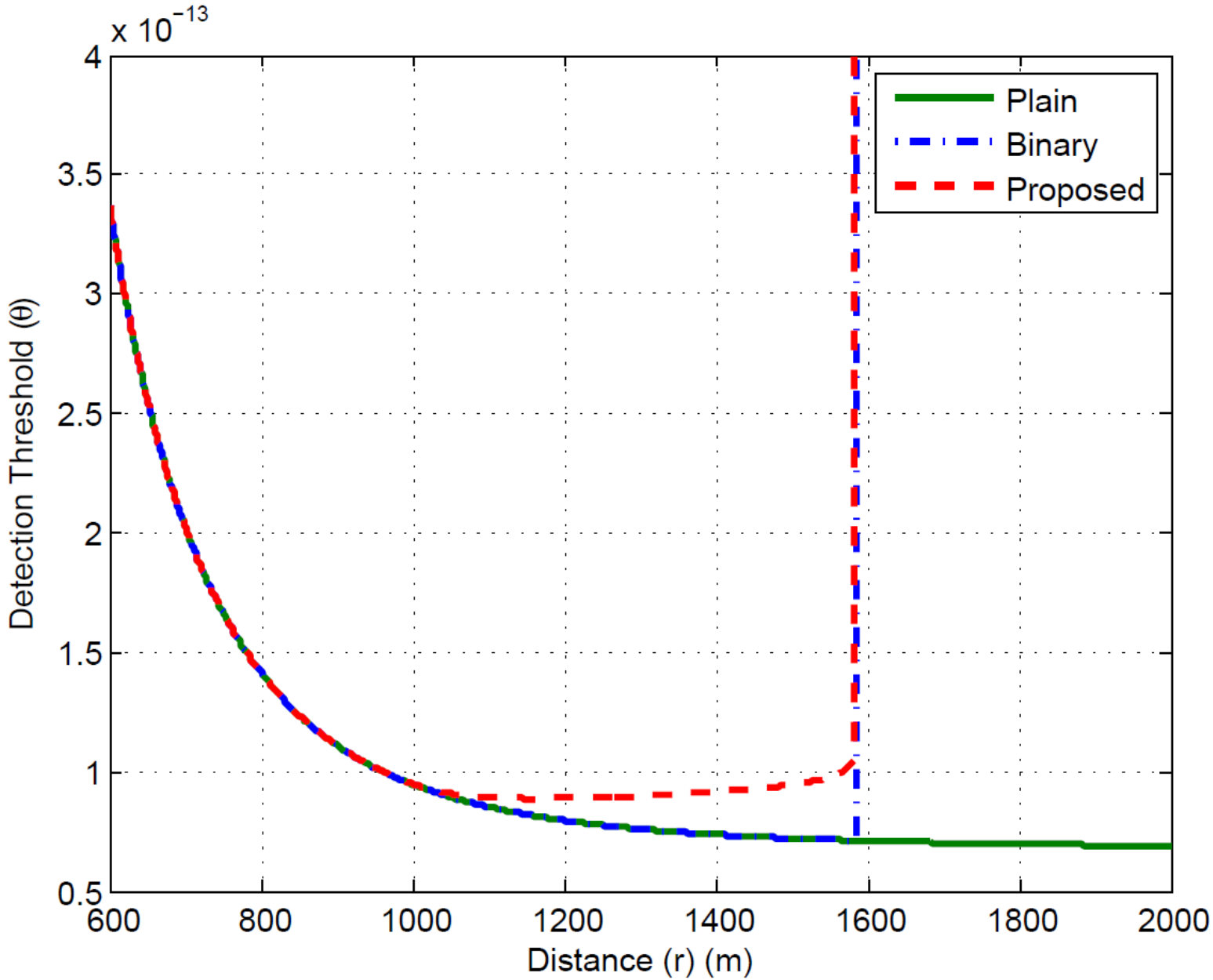
Detection threshold θ

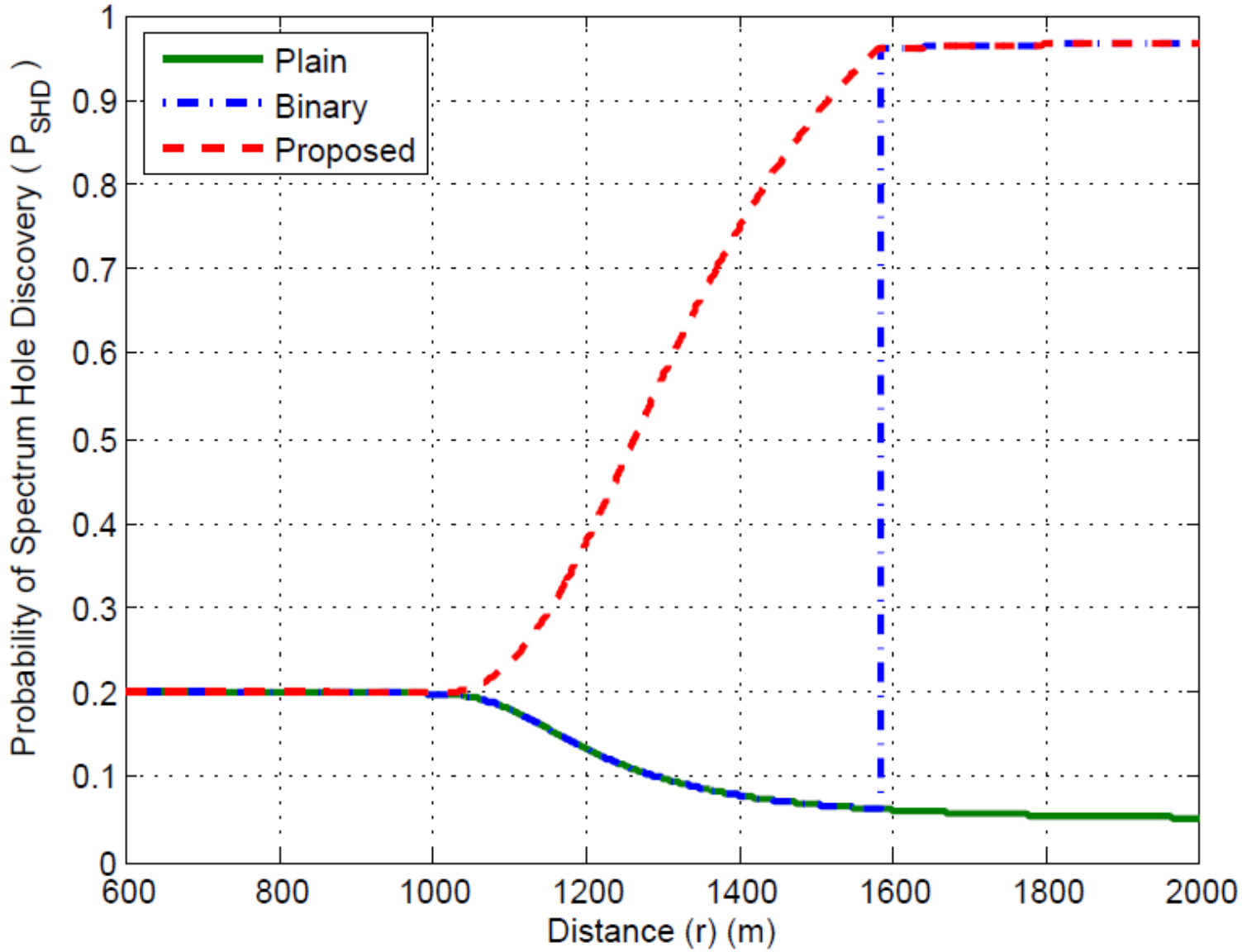
Spectrum hole discovery

$$P_{SHD} = P_E P_{MD}(1 - P_I) + (1 - P_E)(1 - P_{FA})$$

Constraint

$$P_{MD} P_I \leq \varepsilon$$


x 10^-13
4
3.5
3
2.5
2
1.5
1
0.5
Detection Threshold (θ)
600
800
1000
1200
1400
1600
1800
2000
Distance (r) (m)
Plain
Binary
Proposed

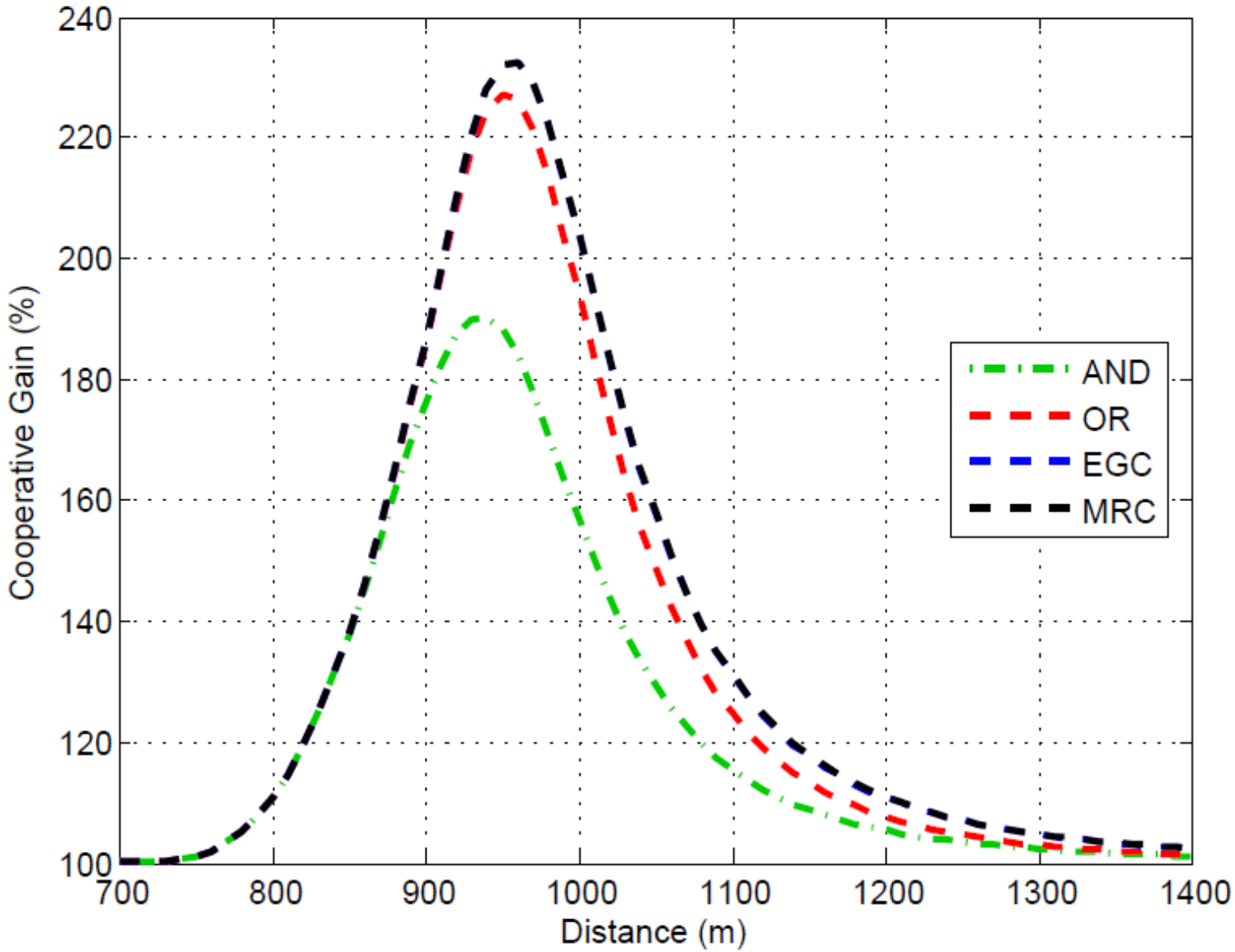

Plain
Binary
Proposed
Probability of Spectrum Hole Discovery (P_{SHD})
Distance (r) (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
600
800
1000
1200
1400
1600
1800
2000

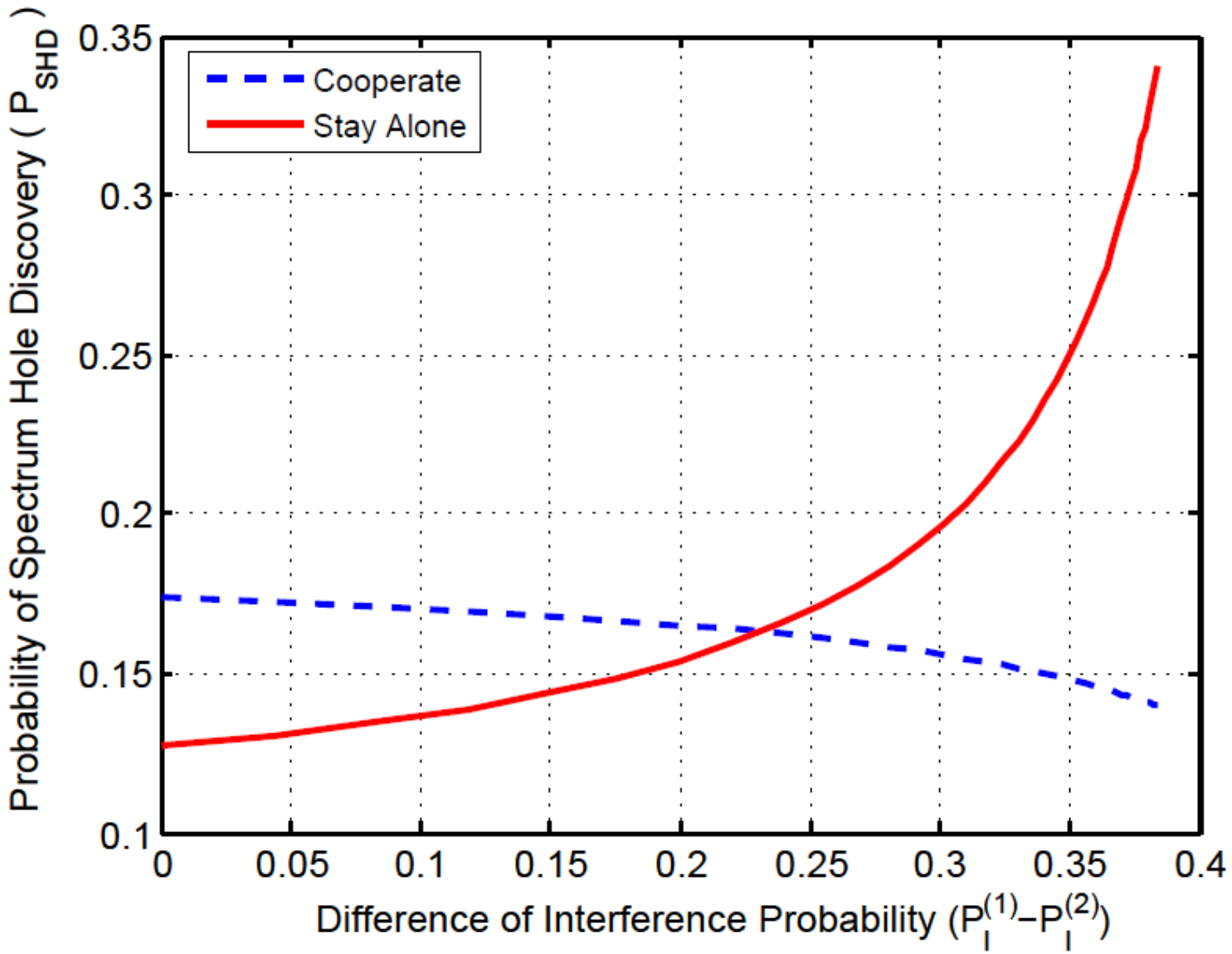
Cooperative spectrum sensing

- Decision fusion
  - Soft (EGC, MRC)
  - Hard (OR, AND)
- problem

$$P_{SHD} = P_E P_{MD}^{(G)} \left(1 - P_I\right) + \left(1 - P_{FA}^{(G)}\right)\left(1 - P_E\right)$$

$$\underset{\theta_j, j \in G}{Maximize} \left(1 - P_{FA}^{(G)}\right), \; subject\ to\ P_{MD}^{(G)} = \frac{\varepsilon}{P_I}$$


240
220
200
180
160
140
120
100
Cooperative Gain (%)
700
800
900
1000
1100
1200
1300
1400
Distance (m)
AND
OR
EGC
MRC


Cooperate
Stay Alone
Probability of Spectrum Hole Discovery (P_{SHD})
0.35
0.3
0.25
0.2
0.15
0.1
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Difference of Interference Probability ($P_I^{(1)}-P_I^{(2)}$)

Coalition Formation

- Decision voting

$$P_{MD}^{(G_k)} = 1 - \sum_{g \subseteq G_k, |g| \geq \Psi} \left[\prod_{i \in g} \left(1 - P_{MD}^{(i)}\right) \prod_{j \in G_k \setminus g} P_{MD}^{(j)} \right]$$

$$P_{FA}^{(G_k)} = \sum_{g \subseteq G_k, |g| \geq \Psi} \left[\prod_{i \in g} P_{FA}^{i} \prod_{j \in G_k \setminus g} \left(1 - P_{FA}^{(j)}\right) \right]$$

- problem

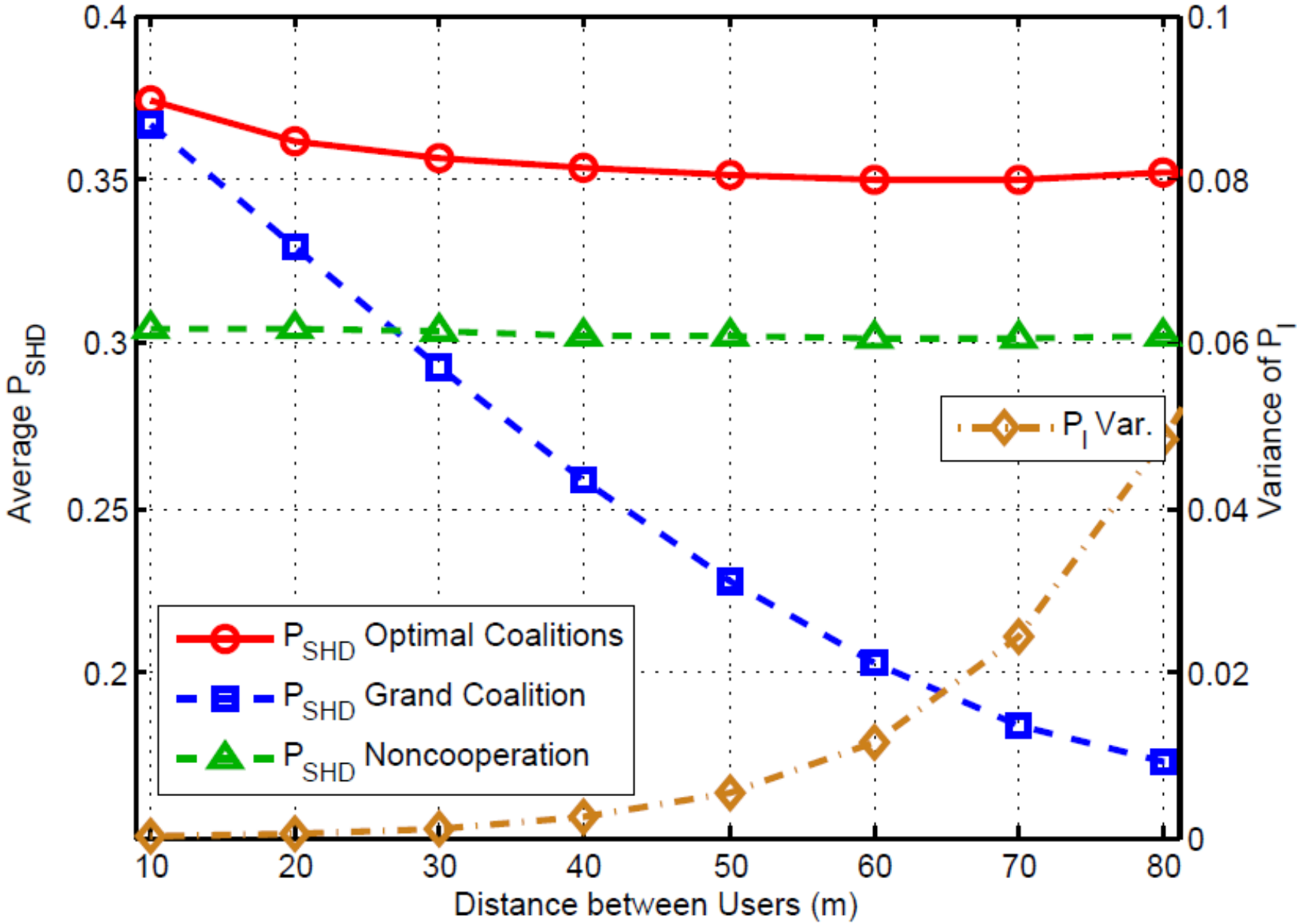
$$Maximize \sum_{i \in V} U_i^{(G_k)}(\mathrm{P}_{SHD}^{(i)}), \text{ subject to } P_{MD}^{(G_k)} P_I^{(i)} \leq \varepsilon,\ i \in V$$

Coalition formation proposition

- Bound by Pi $$P_{MD}^{(G_k)} = \min_{i \in G_k} \frac{\varepsilon}{P_I^i}$$
- Independent of Coalitions
  - Depends only on members in the coalition
- Orderly search
  - From layer 1, 2, |V|, |V|-1, … , 4, 3

$$\frac{U^{S'}}{U^{S*}} \geq \frac{1}{L-1} \text{ , } L = |V| \sim 4$$

- Contiguous coalition
  - Given i, j, k and $P_I^i \geq P_I^j \geq P_I^k$, j would like to join {i, k}


0.4
0.35
0.3
0.25
0.2
0.1
0.08
0.06
0.04
0.02
0
10
20
30
40
50
60
70
80
Average P_{SHD}
Variance of P_I
Distance between Users (m)
P_{SHD} Optimal Coalitions
P_{SHD} Grand Coalition
P_{SHD} Noncooperation
P_I Var.

CS_opt

- [1x4 double] [1x3 double]
- [1x3 double] [1x2 double] [1x2 double]
- [1x2 double] [1x2 double] [5] [6] [7]
- [1x2 double] [3] [4] [5] [6] [7]
- [1x2 double] [3] [4] [5] [6] [7]
- [1x2 double] [3] [4] [5] [6] [7]
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- [1x2 double] [3] [4] [5] [6] [7]