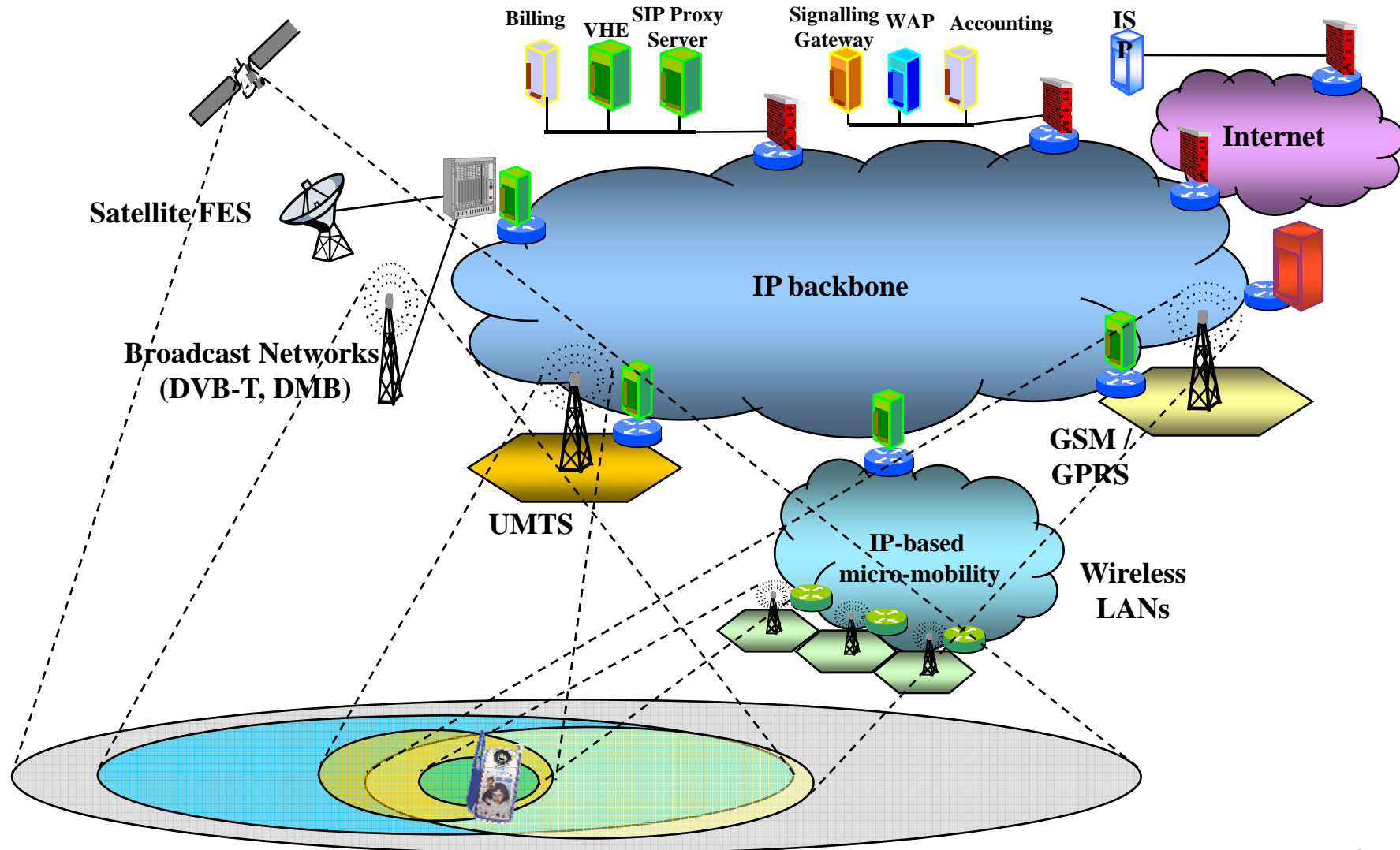


A Network-Assisted Inter-RAT Handover Scheme

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25 August 2009

Heterogeneous Wireless Networks



Case Study: 3G-WLAN VHO (1/2)

□ WLAN

- ❖ Low cost, high data rate, small coverage
- ❖ Designed for low terminal velocity (non-contiguous spots)
- ❖ Office, Stations, Department store, Subway etc.

□ 3G Cellular Network

- ❖ High cost, medium data rate, large coverage
- ❖ Even a fast moving vehicle can use on-line browser

Case Study: 3G-WLAN VHO (2/2)

	3G	WLAN
Data rate	< 2Mbps	< 11Mbps
Range	3-5 Km	50-60 m
Handover	Yes	Limited
Security	High	Low (being improved)
Coverage	Wide area (continuous)	Hot spots (non continuous)
Mobility	High speed	Stationary, Nomadic
Service	Voice and data	Primarily data

Related Works (1/2)

□ Numerous works on network discovery, **handover decision/execution**

- ❖ [1] Wengui Zhang, "Handover Decision Using Fuzzy MADM in Heterogeneous Networks," in Proc. IEEE WCNC 2004.
- ❖ [2] A. Hasswa et al. "Generic Vertical Handoff Decision Function for Heterogeneous Wireless Networks," in Proc. IEEE WOCN 2005.
- ❖ [3] R. Tawil, O. Salazar and G. Pujolle, "Vertical Handoff Decision Scheme Using MAMD for Wireless Networks," in Proc. IEEE WCNC 2008.
- ❖ [4] W. Ying et al., "Vertical Handover Decision in an Enhanced Media Independent Handover Framework," in Proc. IEEE WCNC 2008.
- ❖ [5] E. Stevens et al., "An MDP-Based Vertical Handoff Decision Algorithm for Heterogeneous Wireless Networks," IEEE Trans. Vehicular, March 2008.
- ❖ [6] F. Zhu and J. McNair, "Optimizations for Vertical Handoff Decision Algorithms," in Proc. IEEE WCNC 2004.

Related Works (2/2)

- **Handover decision**: depending on VHO criteria
 - ❖ **Channel condition** is a key criteria for VHO

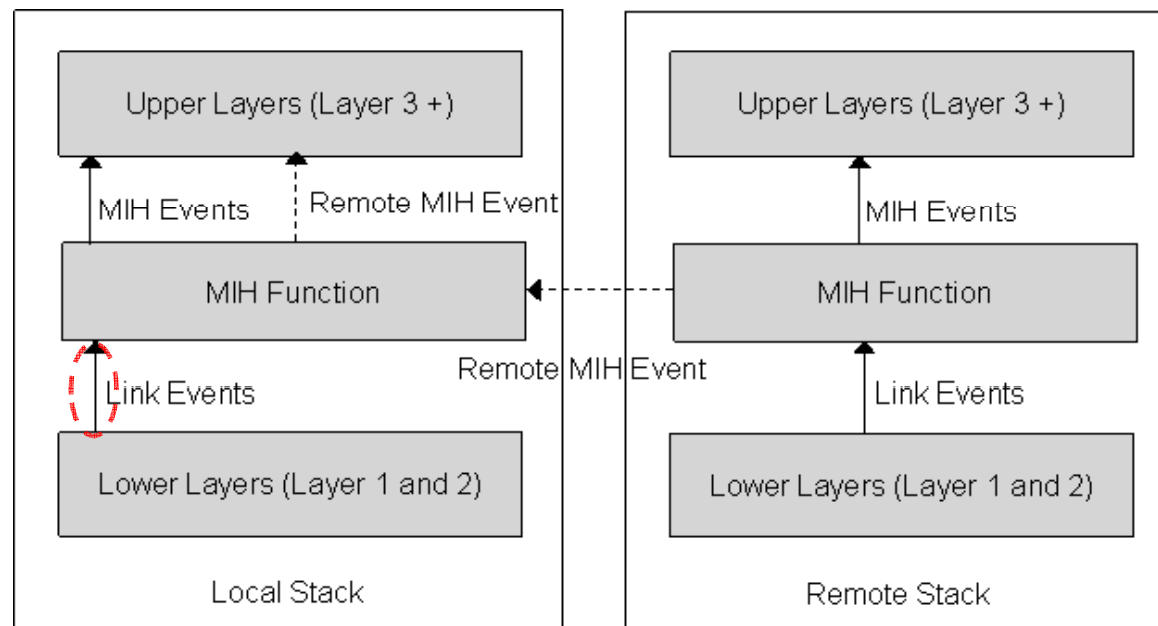
	Price	Bandwidth	Channel condition	Sojourn time	Power	Security	User preference
[1]	O	O	O	O	O	X	X
[2]	O	O	O	X	O	O	O
[3,4]	O	O	O	X	X	X	X
[5,6]	X	O	O	X	X	X	X

Motivation

- **Channel scanning** is indispensable to obtain channel conditions; However, channel scanning leads to significant latency!
 - ❖ In WLANs, scanning latency is about 200-300 msec!
- How to reduce channel scanning latency in VHO?
 - ❖ IEEE 802.21 MIH provides useful information via Information Server (IS)
 - ❖ *Exploit temporal and spatial locality* in IS!

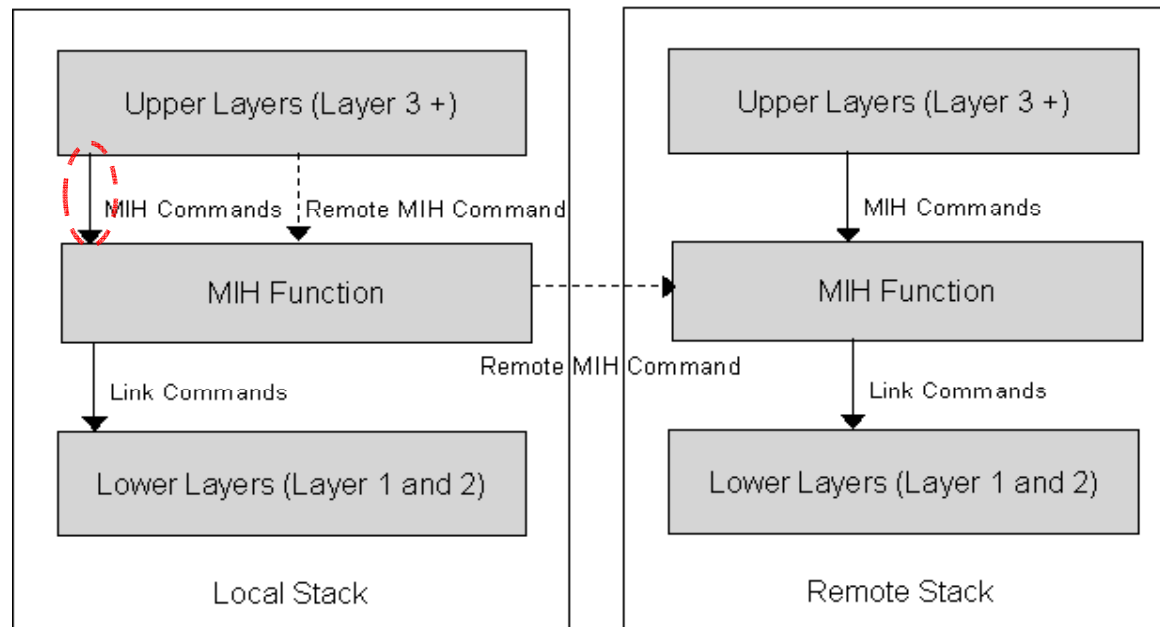
MIH Services (1/3)

- ❑ **MIES (Media Independent Event Service)**
 - ❖ Link up/down, link parameters change,
 - ❖ link going down, link event rollback



MIH Services (2/3)

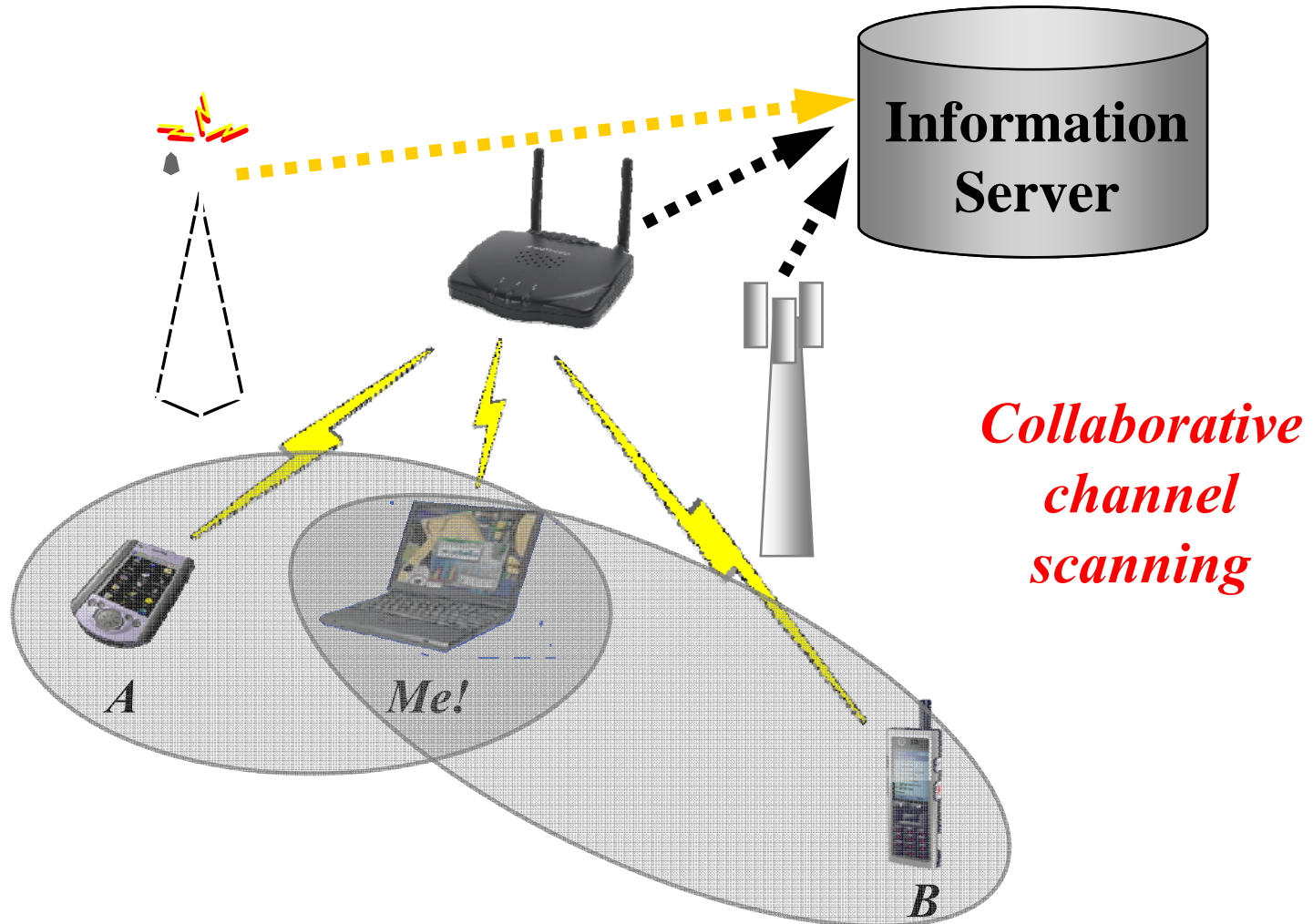
- **MICS (Media Independent Command Service)**
 - ❖ MIH Scan, MIH Configure



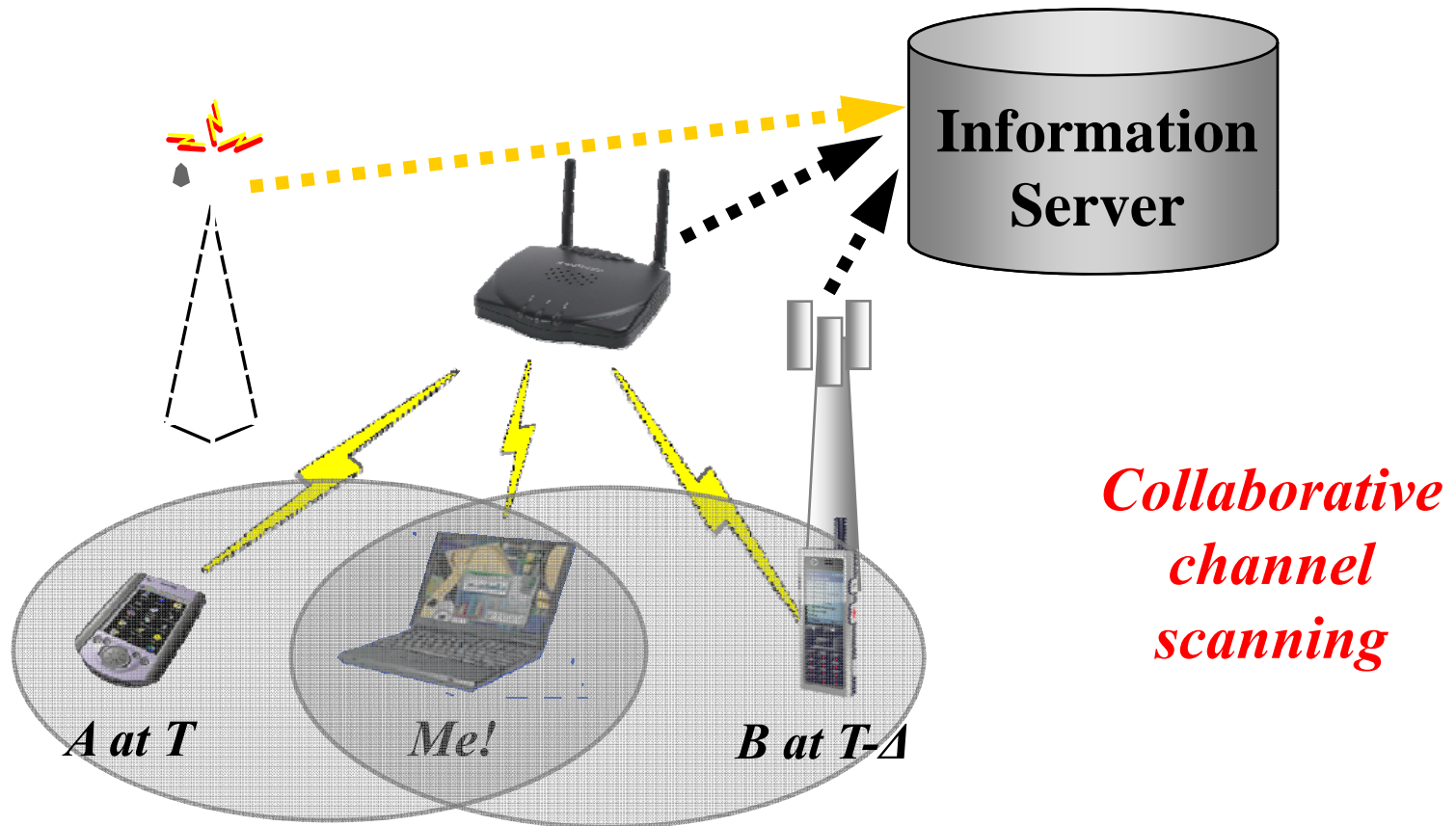
MIH Services (3/3)

- MIIS (Media Independent Information Service)
 - ❖ Discover and obtain neighboring network information within a geographic region
 - Communicate with neighboring network elements
 - Query/response mechanism: neighboring network names, providers and cost, MAC addresses of neighboring network elements, channel information, security, QoS, ...

Spatial Locality



Temporal Locality



System Model (1/2)

□ DB Schema in enhanced IS (EIS)

❖ *Extended channel state information (ECSI)*

• $(id, t, (x, y), \delta)$

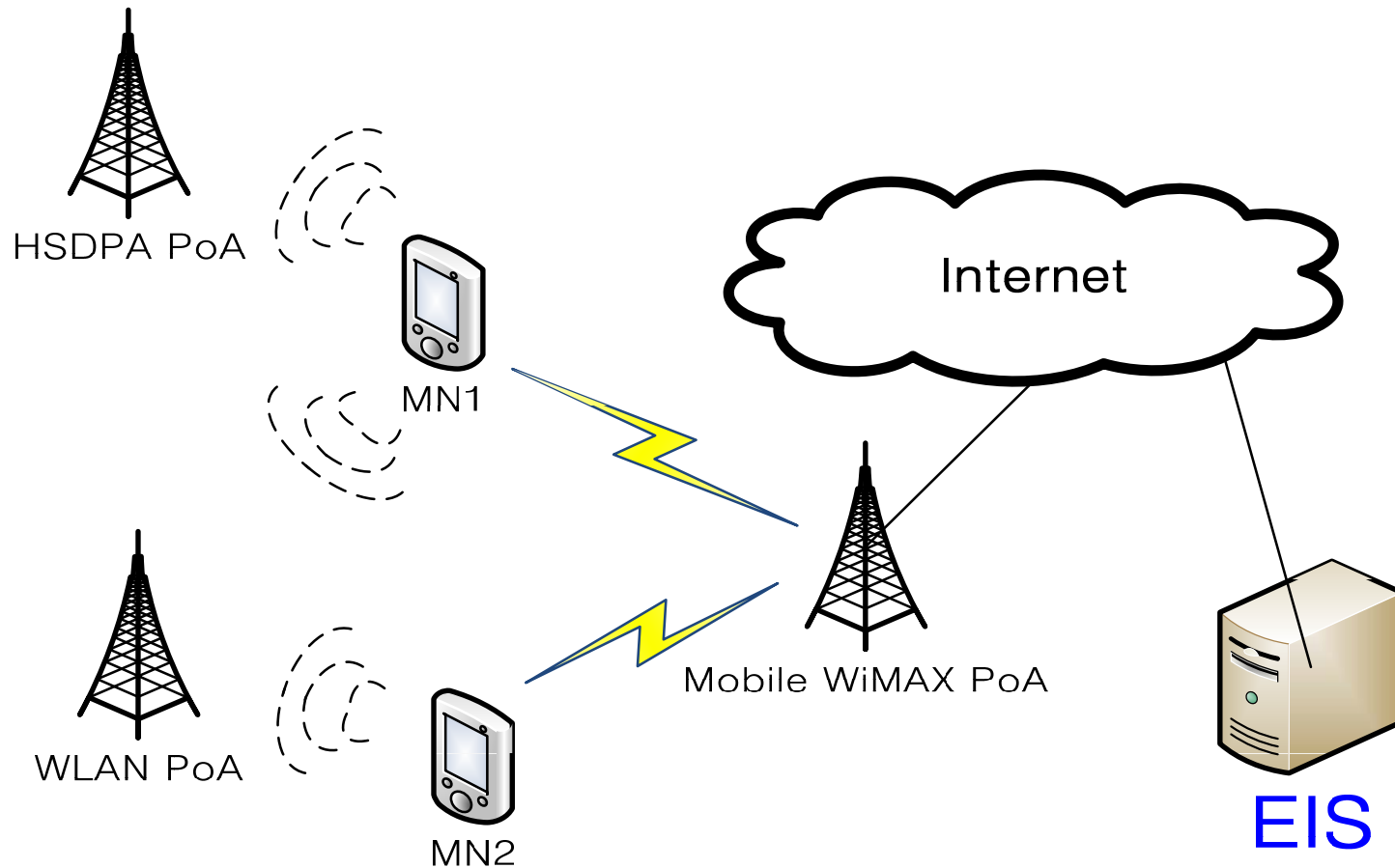
❖ Access point identification, id

❖ Measurement time, t

❖ Measurement location, (x, y)

❖ Signal-to-noise ratio (SNR), δ

System Model (2/2)



❖ Each MN should notify the ECSI to EIS

Estimating the SNR (1/2)

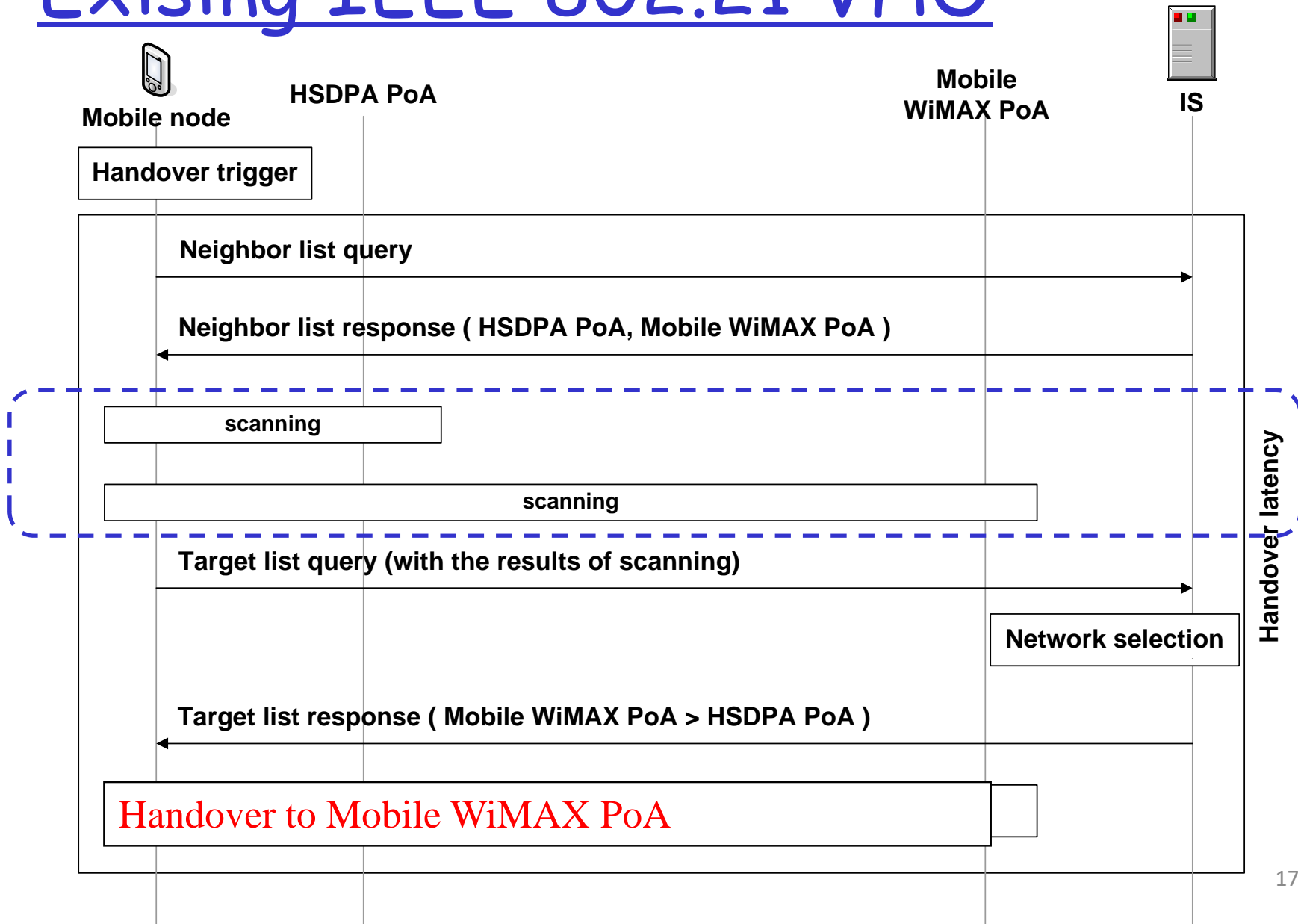
Algorithm 1 SNR estimation

```
1: initiate  $R_M, W, N$ ;  
2:  $i \leftarrow 0$ ;  
3: while  $i < N$  do  
4:    $j \leftarrow 0$ ;  
5:    $m \leftarrow 0$ ;  
6:   while  $j < n_i$  do Temporal Locality  
7:     if  $t_0 - ESCI_i(j).t < W$  &&  
        $\sqrt{(x_0 - EC SI_i(j).x)^2 + (y_0 - EC SI_i(j).y)^2} < R_M$  Spatial Locality  
     then  
8:        $\theta(m) \leftarrow ESCI_i(j)$   
9:        $m ++$ ;  
10:    end if  
11:     $j ++$ ;  
12:  end while
```

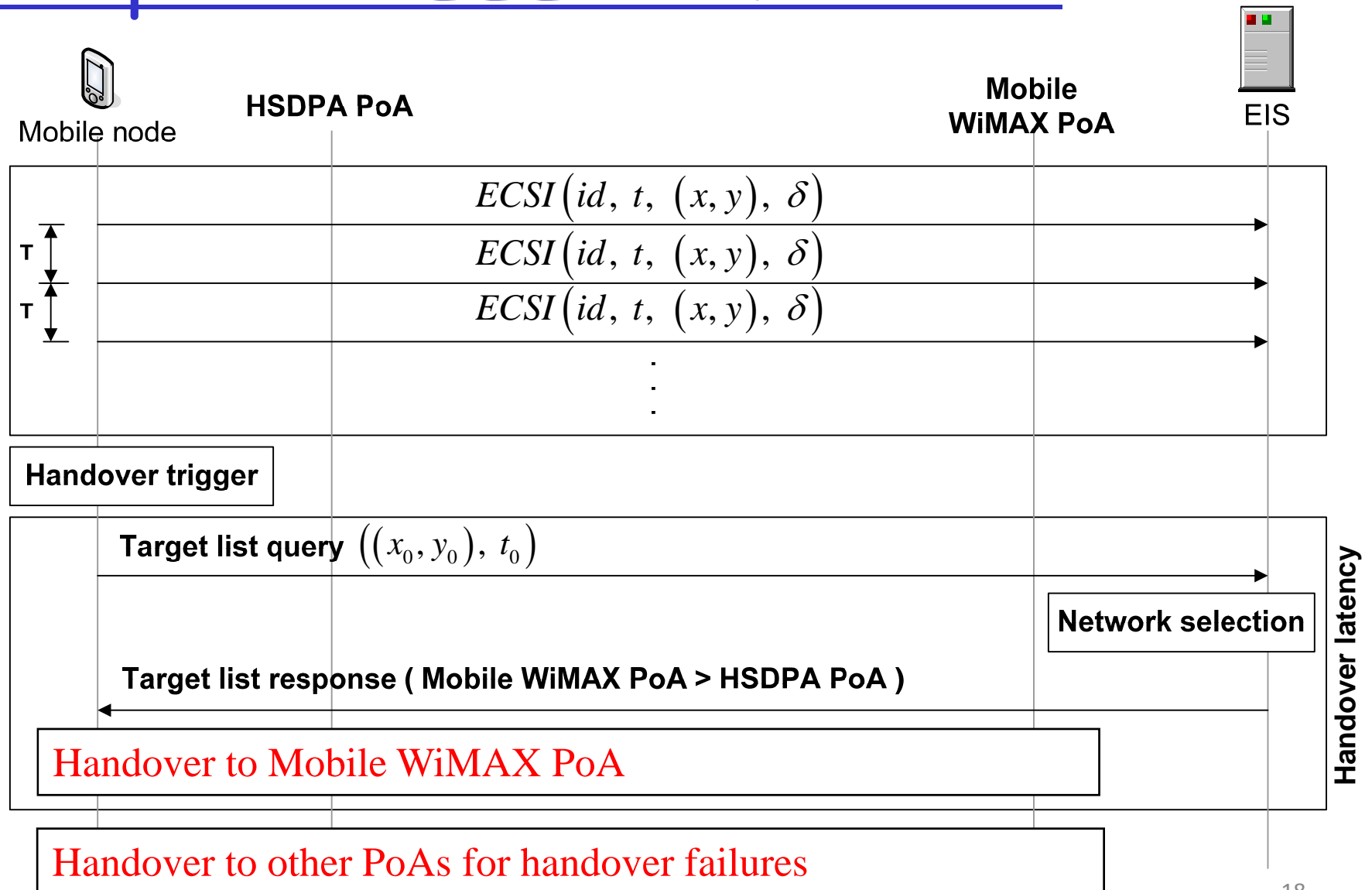
Estimating the SNR (2/2)

```
13:  if  $m == 0$  then  
14:    exit;  
15:  end if  
16:  sort( $\theta$ ,  $\sqrt{(x_0 - \theta(k).x)^2 + (y_0 - \theta(k).y)^2}$ ),  
        for  $0 \leq k \leq m - 1$  ;  
17:   $\delta_i^E = \theta(0). \delta$ ;  
18:   $j \leftarrow 1$ ;  
19:  while  $j < m$  do  
20:     $\delta_i^E = \alpha \cdot \delta_i^E + (1 - \alpha) \cdot \theta(j). \delta$ ;  
21:     $j ++$ ;  
22:  end while  
23:   $i ++$ ;  
24: end while
```

Existing IEEE 802.21 VHO



Proposed IEEE 802.21 VHO



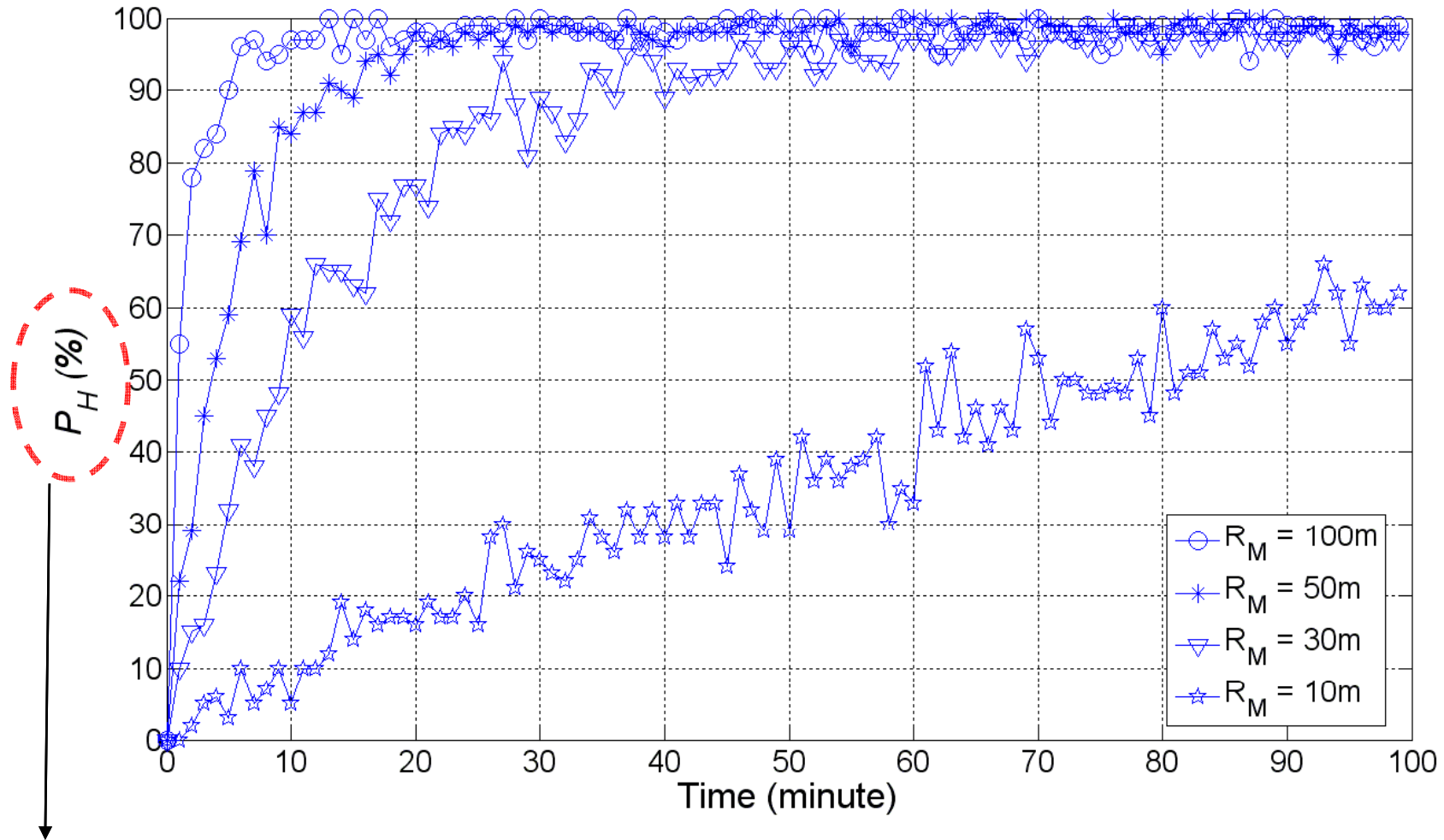
Simulation Environment

- Wireless channel model
 - ❖ COST-231 Hata model

- Mobility model
 - ❖ Random way-point mobility model

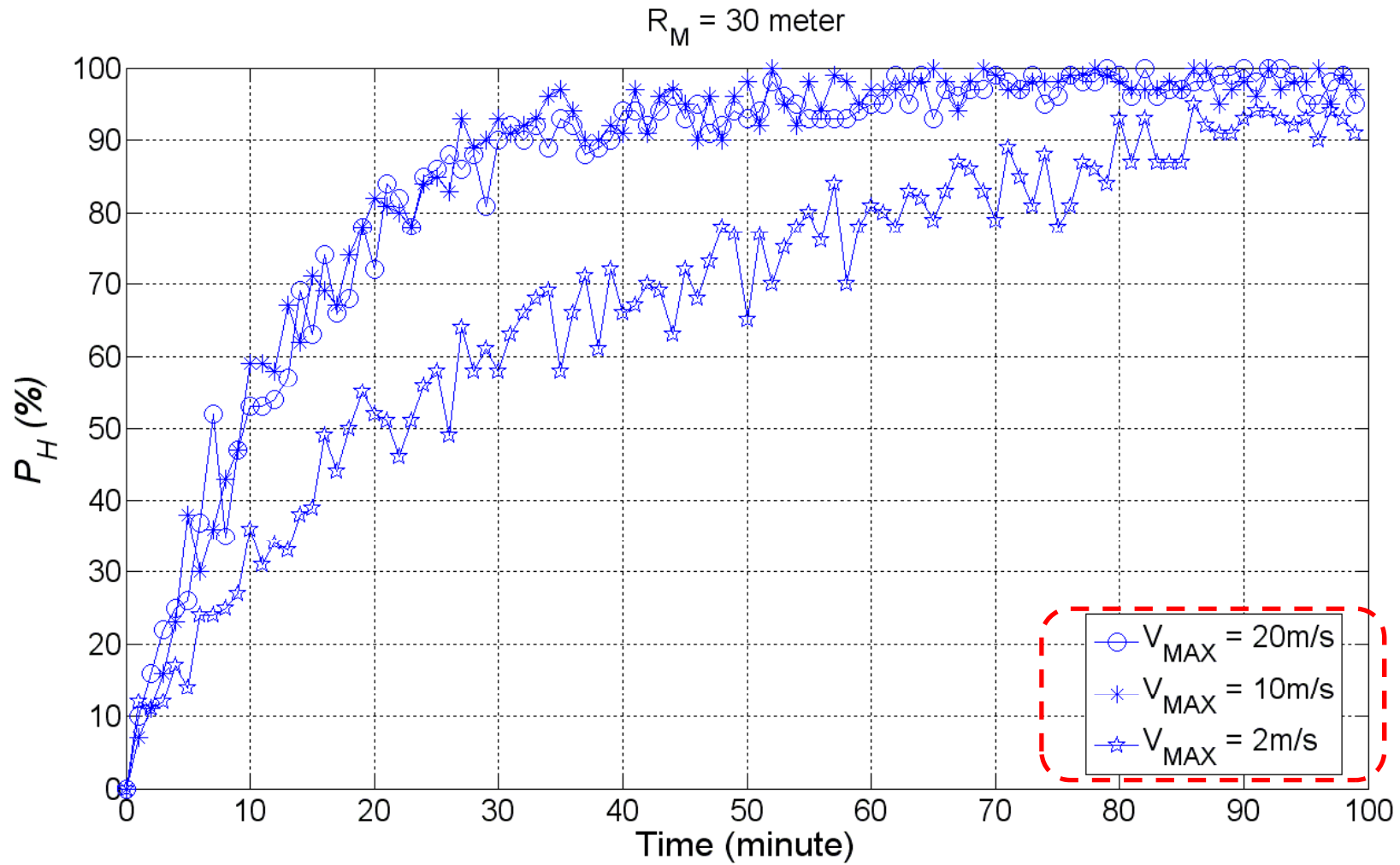
- Heterogeneous network model
 - ❖ HSDPA + Mobile WiMAX + WiFi

Simulation Results (1/4)

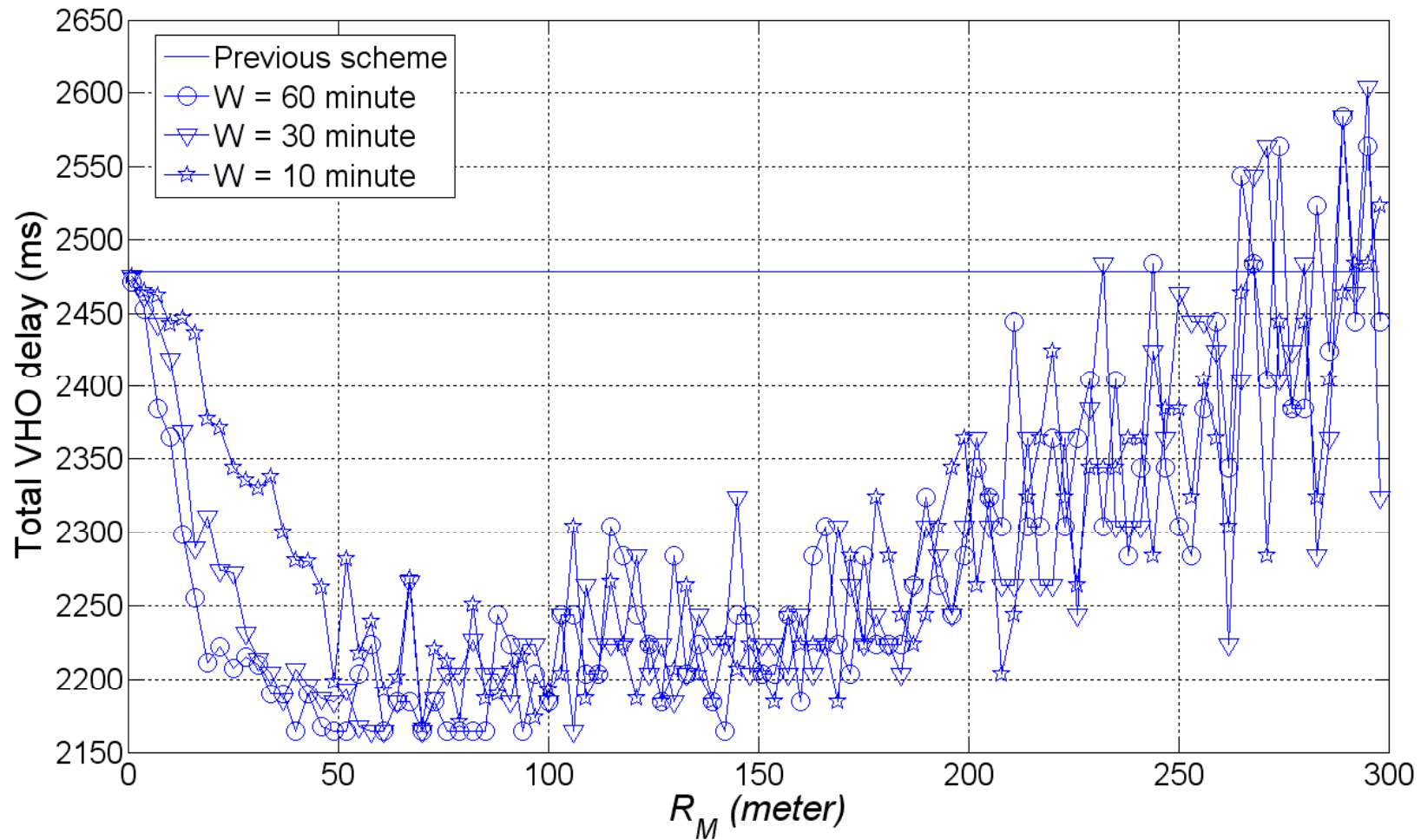


Hit: PoA by the proposed scheme = PoA by full scanning procedure

Simulation Results (2/4)

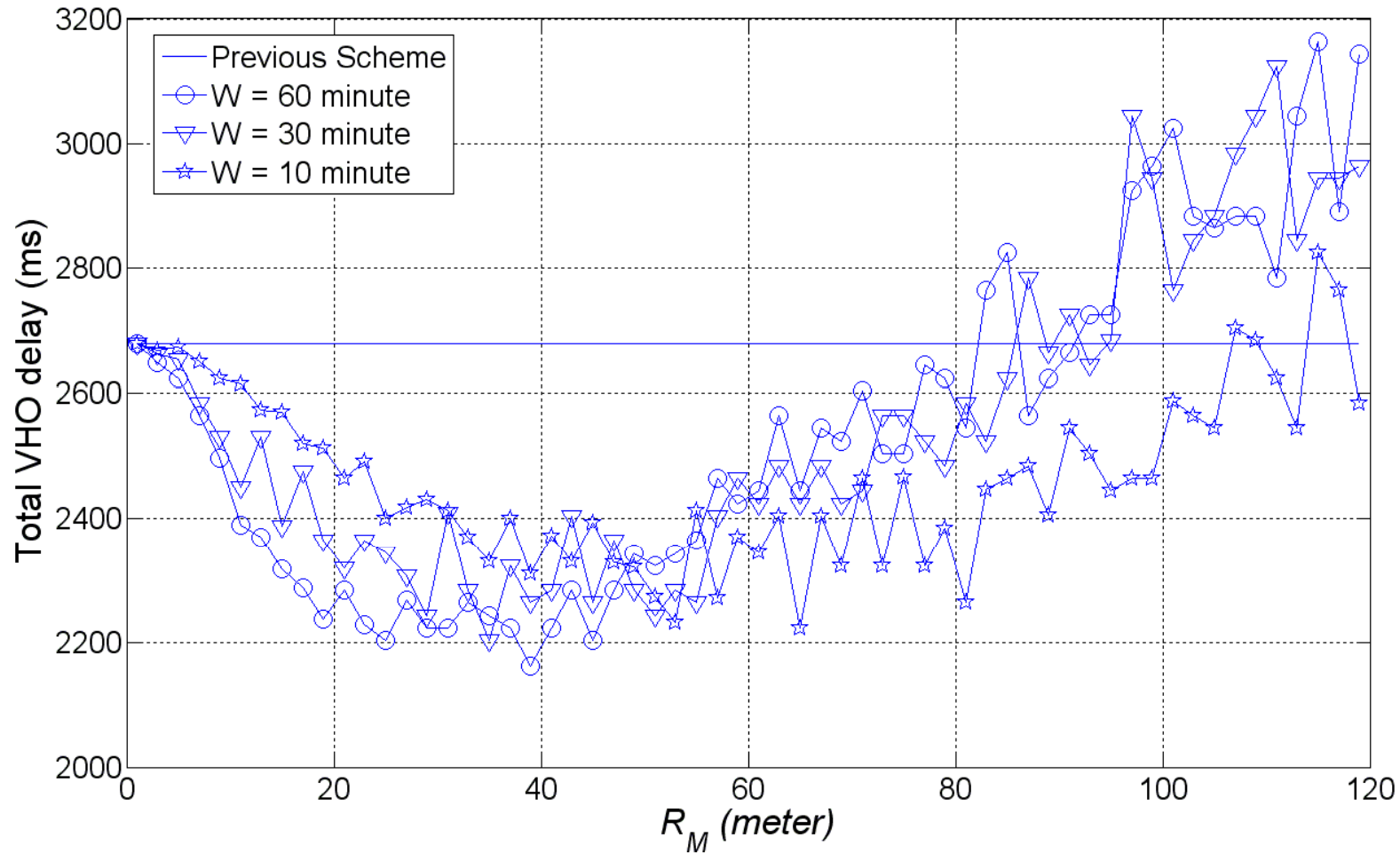


Simulation Results (3/4)



❖ There is optimal R_M for minimizing VHO delay

Simulation Results (4/4) (+ WiFi PoA)



❖ Optimal R_M is dependent on the smallest network coverage in heterogeneous networks

Conclusion



The screenshot shows the JiWire website interface. At the top, there is a navigation bar with links for Advertisers, Partners, Wi-Fi Users, Company, and Contact Us. A search bar is located on the right side. Below the navigation bar, there is a banner for the Wi-Fi Finder tool, which is described as "It's free & easy. Find & map hotspots with JiWire's Wi-Fi Finder for iPhone". The main content area features a world map with "North America" highlighted. To the right of the map is a Boingo advertisement offering "UNLIMITED WI-FI ACCESS FOR ONLY \$9.95/MO! NO CONTRACTS. NO KIDDING." with a "Sign Up Now" button. Below the map and advertisement, there is a section titled "Hotstats as of August 10, 2009" with 273,159 free and pay Wi-Fi locations in 140 countries. This section contains three tables: "Top 10 Countries", "Top 10 U.S. Cities", and "Top 10 Location Types".

Top 10 Countries		Top 10 U.S. Cities		Top 10 Location Types	
Rank	Countries	Rank	Cities	Rank	Type
1	United States	1	New York	1	Hotel / Resort
2	China	2	San Francisco	2	Other
3	United Kingdom	3	Chicago	3	Cafe
4	France	4	Seattle	4	Restaurant
5	Russian Federation	5	Houston	5	Public Space / Public Building
6	Germany	6	Los Angeles	6	Store / Shopping Mall
7	South Korea	7	Atlanta		

- ❑ Network assistance and collaboration are important in mobile Internet!
 - ❖ To achieve seamless inter-RAT handover
 - ❖ Optimization techniques are needed