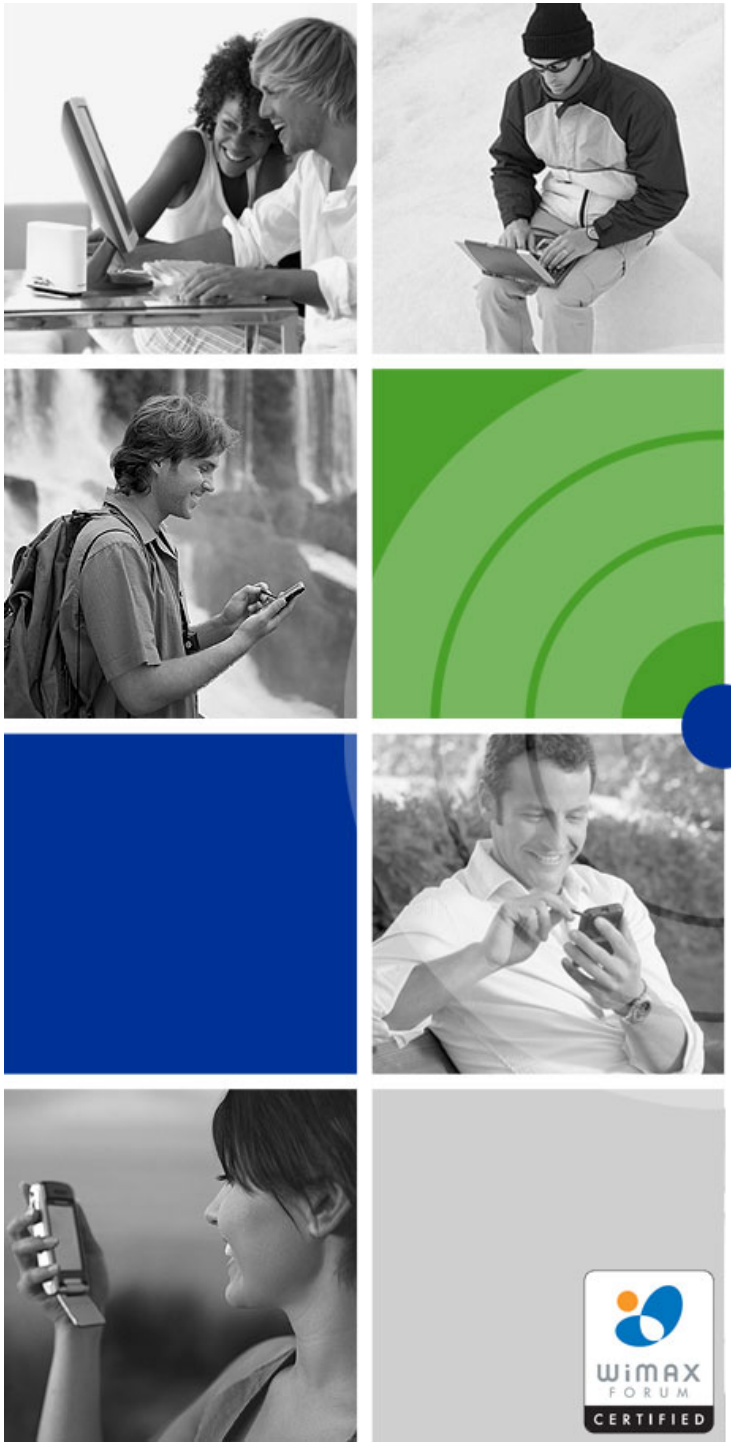

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Comments on FCC R&O 07- 99 for 3650-3700 MHz

Mariana Goldhamer
Director Strategic Technologies
Alvarion Ltd.

Patrick Leary
AVP Marketing
Alvarion, Inc.

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Presentation Purpose & Guiding Note

The purpose of this presentation is to seek additional clarification from the FCC regarding rules outlined in the recent FCC memorandum and order for the 3.650-3.7 GHz band, especially as it relates to how the Commission will interpret the rules. To that end, Alvarion further outlines some risks regarding how the rules may be interpreted.

Alvarion wishes to express also that in general we believe the Order has the potential for allowing the 3.65 GHz band to become a viable frequency range for operators seeking to scale advanced wireless broadband networks, especially but not limited to rural America, and thus may encourage investment by the private sector to help bridge the Digital Divide. But, as the saying goes, the "devil is in the details" in terms of how the rules will be interpreted. It is the interpretation that will enable this band to realize its best potential or not.

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Outline

- Alvarion's Position
- An Analysis of Listen-Before-Talk (LBT) as an Unrestricted Protocol
- Conclusions & Recommendations
- Supporting Slides with Simulation Results

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Alvarion position

- We agree with the general rules and appreciate the FCC's attempts to make the band viable for diverse technologies that can be affordable for operators large and small.
- We urge and advise that more clarifications are needed, especially with respect to:
  - Operator coordination [non-technical human coordination]
  - Interference criteria
  - Out-of-channel emissions
  - Unrestricted protocol
- We have concerns relative to using the energy detection at very high levels as the mechanism for interference avoidance since this would severely impact 802.16 performance (because 802.16 devices have much lower sensitivity power levels).

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5 Operator Coordination - The Challenge

- Alvarion appreciates the intentions of adding this new element to the rule, which previously relied on all "cooperation" to exist at the equipment level. According to the new rules providers will not be permitted simply to turn up their transmitters and overwhelm others in the area; instead, they will be required to reach a reasonable accommodation with the other operators nearby. We are concerned that this may create a problem since it, in practice, would create a legal circle. For example:
  - Assume Operator A has been in operation for some period of time without competition. In comes Operator B, and as per the rules, A & B meet and agree upon a plan to co-exist.
  - A few months later Operator C enters the market and per the rules is able to compel A and B back to the table. The previous agreement essentially becomes invalid by force of the FCC 3.65 rules. A, B, and now C hammer out a new agreement. A and B then return to re-configure their networks and C begins operation.
  - Some period later (hours, days, weeks or months), Operator D enters the market. The previous agreement now also becomes invalid and another must be created, etc.
- Our experience shows that it is not unusual, even in rural market, for there to be three or more operators of a band, especially when combining private and government entities, so the above scenario is not unrealistic. This will impose undue burden on operators since no amount of good intentions or spending to cooperate matters since the rules force any agreement to become invalid the moment a new entrant emerges.

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Operator Coordination - Our Recommendation

- Alvarion believes this part of the new rule is unworkable in practice and accordingly recommends the FCC revert to the original model that calls for all *mandated* cooperation to happen at the equipment level.
- Operators will still be inclined to work together just as years of established evidence show they do in Part 15 bands since it is in their interest to do so.
- Removal of the human cooperation element will remove the entitlement aspect the current rule enacts that essential grants any user, no matter how inefficient, an equal right to a performance outcome, i.e. compels other operators to make equal room for them. We believe that investment in high quality, whether that be better hardware, better services, or more efficient operations, will enable the market to make the decision who succeeds in the any shared frequencies.
- The band's technical rules and the state of technology negate the need to compel parties to negotiate an agreement legally (which in any event becomes invalided the moment the next user emerges).

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Interference Criteria, Adjacent Channel Interference, & the Unrestricted Protocol

- **In the revised rules the FCC does not define the interference criteria**
  - There is no objective criteria as basis for operator coordination (previous slide)
  - There is no objective criteria for the validation of an unrestricted protocol
- **The FCC does not take into account the adjacent channel interference**
  - As a minimum FCC should define equipment masks
- **The FCC gives a good definition for an unrestricted protocol, but the example of such a protocol violates the definition**
  - Quote: "A listen-before-talk technology such as is used by Wi-Fi devices is a prime example of an unrestricted contention-based protocol."
  - We demonstrate in continuation (see attached simulations) that such protocol, at the high detection levels set by 802.11y, is not able to avoid creating significant interference to more sensitive technologies
  - We are concerned that FCC may overlook the impact of such protocol on the higher cell sizes required by the rural markets (as well as any 802.16 use overall)

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The Probable Negative Effect on Cell Size Using 802.11y LBT Mechanism

- **Wi-Fi sensitivity levels at BPSK1/2, both downlink (DL) and uplink (UL):**
  - -82dBm **for 20MHz,** -85dBm **for 10MHz,** -88dBm **for 5MHz channels**
- **WiMAX UL sensitivity levels at BPSK1/2, 32 OFDMA sub-channels:**
  - **-**92dBm **for 5MHz, -**89dBm **for 10MHz and -86dBm for 20MHz channels, no OFDMA**
  - **-107dBm for 5MHz, -104dBm for 10MHz and -101dBm for 20MHz channels with UL OFDMA**
  - **Different producers may have better performance due to better noise figure and lower implementation loss**
- **802.11y/D4 - CCA-ED: Clear Channel Assessment – Energy Detection**
  - **<u>The 802.11y carrier is detected at sensitivity levels only by devices using the same channel widths</u>**
  - **Levels to detect non-802.11a technologies or 802.11a systems with a different channel width are described in Annex I (informative) I.2.4 CCA-ED Threshold**
    - **"For operation in the 3.65-3.7 GHz band, the optional CCA-ED thresholds shall be less than or equal to** -72dBm **for 20 MHz channel widths;** -75 dBm **for 10 MHz channel widths; and** -78 dBm **for 5 MHz channel widths (minimum sensitivity for BPSK, R=1/2 + 10 dB in Table 145)."**
- **A 802.11y 20 MHz system will NOT detect the energy of a WiMAX 5 MHz system below the Energy Detect threshold**
  - ***Causing a*** *20 to 35dB link-budget degradation* ***(-92dB – 72dB = 20dB; 107 – 72 = 35dB)***
  - *WiMAX cell size degradation according to 802.11y energy detection is 20dB – 35dB*

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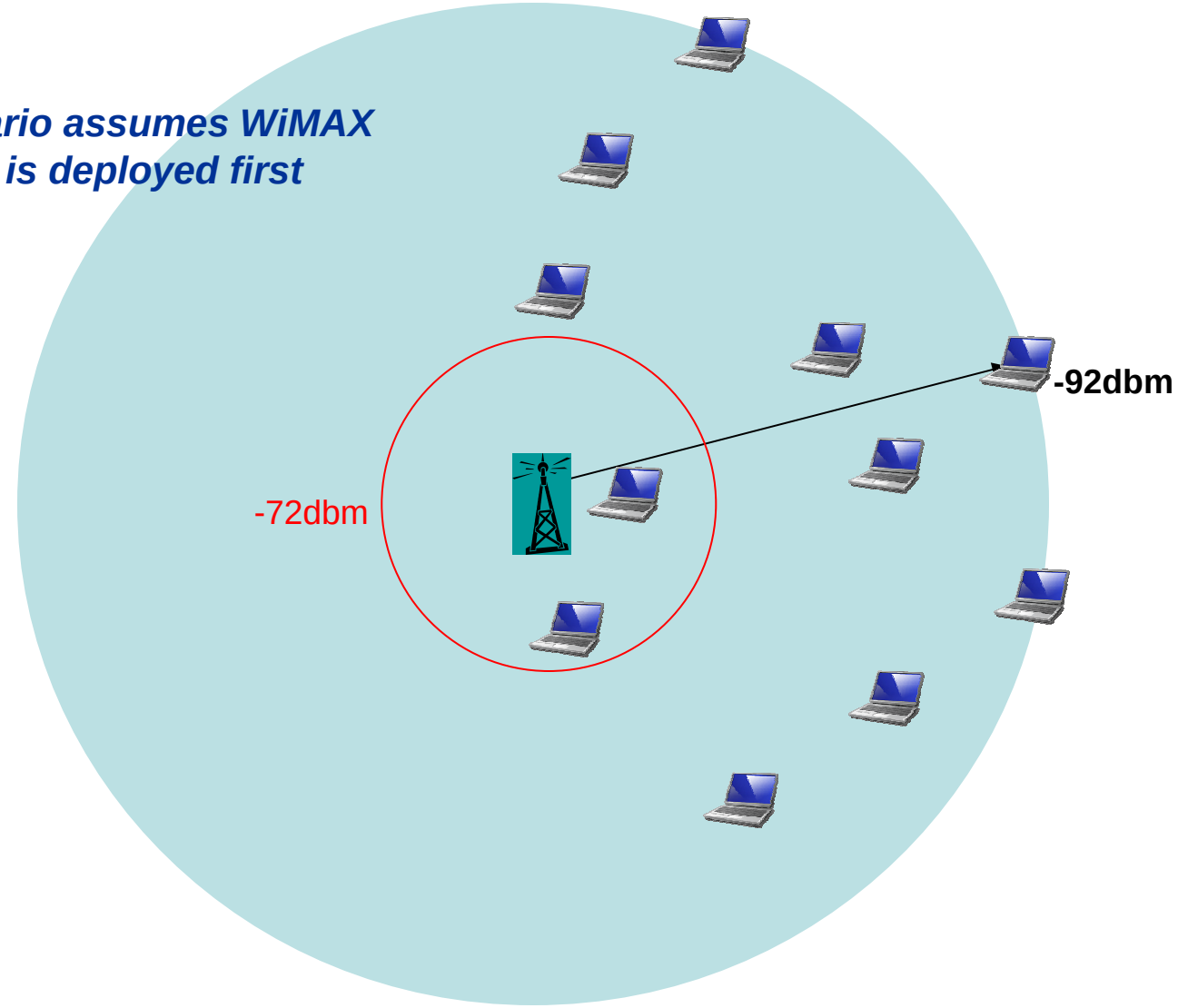
WiMAX Down-Link: Cell Size Degradation Due to -72dBm Energy Detection Levels

1. Scenario assumes WiMAX network is deployed first



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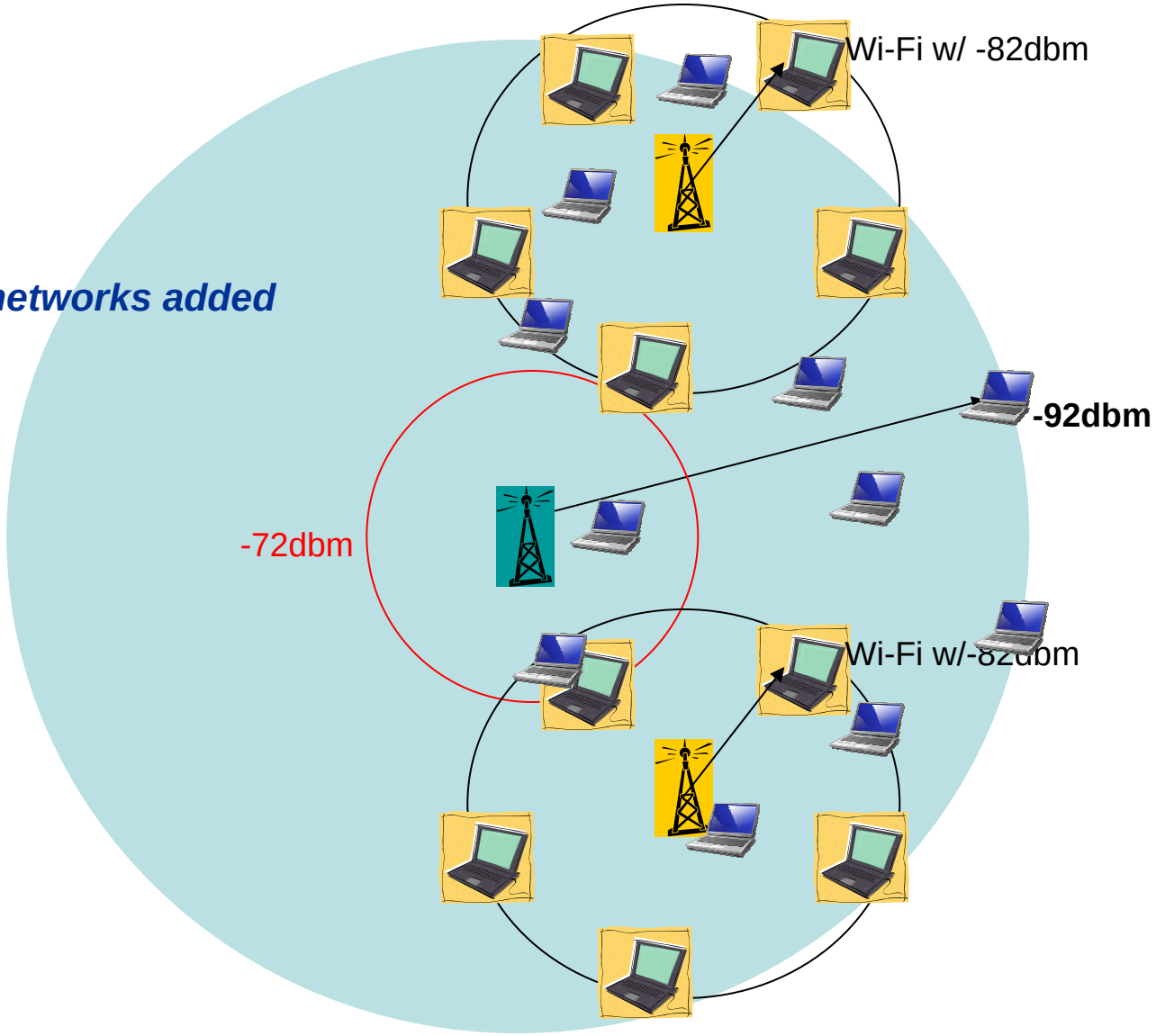
WiMAX Down-Link: Cell Size Degradation Due to -72dBm Energy Detection Levels

2. Wi-Fi networks added



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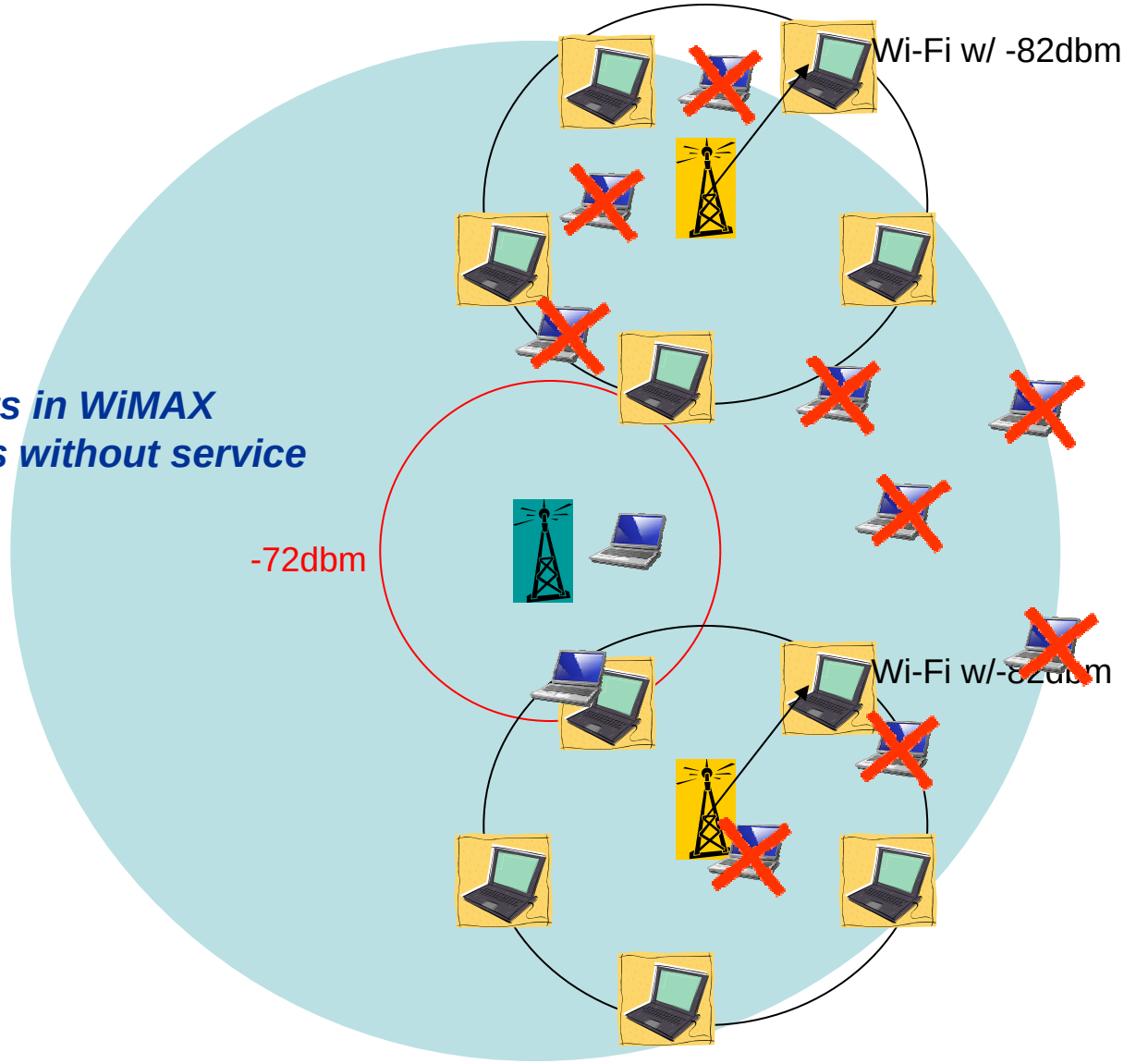
WiMAX Down-Link: Cell Size Degradation Due to -72dBm Energy Detection Levels

3. Results in WiMAX locations without service



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FCC Rules Do Not Take into Account the Interference Caused by 802.11 Systems

- **All 802.16 links operating at levels under -72dBm are "hidden" to 802.11y**
  - **Most of the WiMAX receivers have 20dB-35dB lower sensitivity levels than -72dBm**
  - **Most of WiMAX receivers will be interfered by 802.11**
- **CCA (Clear Channel Assessment) for 802.11**
  - **10dB lower levels as compared with detection levels for other technologies**
    - 802.11 has a 10dB advantage with LBT (Listen Before Talk) over other technologies
      - **LBT works at the 802.11y sensitivity levels, when 802.11 systems use the same channel width**
      - **802.16 or 802.11 with other channel width or any other technology are detected at much higher energy-detection levels, creating a significant advantage to first operator to deploy 802.11!**
- **CCA detection time is too short to accommodate the 802.16 TX/Rx gaps**
  - **CCA detection time in 802.11 as described in 802.11 -17.3.8.6 Slot time**
      - **The slot time for the OFDM PHY shall be 9 µs, which is the sum of the RX-to-TX turnaround time, MAC processing delay, and** CCA detect time (< 4 µs). **The propagation delay shall be regarded as being included in the CCA detect time.**
- **Alvarion comments**
  - 802.11y may not meet the definition of an unrestricted protocol because does not meet the condition:
    - **(1) An unrestricted contention-based protocol is one which can avoid co-frequency interference with devices using all other types of contention-based protocols**
  - WiMAX cell size degradation according to 802.11y is 20-35dB
  - 802.11y interference levels annihilate the advanced technology used by WiMAX
    - The net effect is that the current FCC rule gives preference to a single technology – Wi-Fi - to the detriment of other technologies, more suitable to large area deployments

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Avoiding Interference - There is a Way to do It That Does Not Advantage One Technology Over Another

- It is necessary to separate the 802.11 and 802.16 interferers in time. LBT drastically affects the cell size for WiMAX, but:
  - Synchronization of time intervals for operation of different systems and technologies offers a perfect isolation
    - Can use GPS (extra 40USD/ Base Station) or active cognitive radio signal to be provided by 802.16h
    - A channel may be split between different technologies in time domain
      - See the Alvarion's accepted contribution to 802.16h – C802.16h-07/070
        - Temporary link: http://dot16.org/CSUpload//upload/LE_db/C80216h%2d07_070.pdf
        - Probable link: http://www.wirelessman.org/le/contrib/C80216h-07_070.pdf
      - It does not preclude Wi-Fi, which has already synchronization messages
        - See Alvarion's contribution
        - http://www.wirelessman.org/le/contrib/C80216h-07_024r1.pdf
    - Compatible technologies will use in common the allocated time intervals

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Acceptable Interference Levels

- **The FCC needs to define acceptable interference levels**
  - **The lack of definition favors the short-range, high power detection levels**
  - **Alvarion's recommendations: chose any one of the two methods below:**
    - **Method 1: Acceptable interference level for co-channel separation of two incompatible interferers**
      - **Equal to the best available sensitivity levels + 10dB, independent of channel width**
        - The definition is similar with the 802.11y Energy detect definition
        - The best available sensitivity level is -107dBm
        - FCC requirement for energy detect should be -97dBm
      - **This method might be VERY problematic for 802.11y and also problematic for 802.16h**
    - **Method 2: Synchronized separation in time of the two technologies**
      - **802.16h will keep its high cell size**
      - **802.11y will use the existing detection levels**
      - **Implementation possibilities such as:**
        - $40 for GPS on Base Station
        - Network synchronization using NTP: www.ietf.org/rfc/rfc1305.txt
        - Implementation of cognitive radio procedures
      - **802.11 will use the existing Quiet Element already defined in 802.11 clause 7.3.2.23**
  - **Alvarion considers Method 2 as the best solution**

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Simulations of the Energy-Detect Performance at -72dBm

- **Calculations for the case of 3 systems sharing a channel**

  http://www.wirelessman.org/le/contrib/C80216h-07_039r1.pdf

- **CCA-ED performance with 802.11y / 802.16h UCP levels**
  - **Simulation by 802.19 (Coexistence TAG) chair**
  - **Were considered same sensitivity levels for 802.16 and 802.11 (-82dBm)**
  - http://www.ieee802.org/19/pub/2007/19-07-0010-01-0000-CCA-ED-in-802.11y.ppt

- **All the available estimations show very significant interference**
  - **Cell size reduction by 93%**
  - **Hidden stations up to 100%**

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Conclusions on Simulations

- Both show that energy detection at -72dBm creates huge interference
- The high BS power allowance in the rules will create a more profound problem as compared with shorter range 2.4GHz cells
- The antenna gains which are higher than 0-2dBi gains will experience even more degradation than the simulation illustrates
  - These levels are considered after the antennas
- FCC should perform its own simulations to assess the performance of the different approaches
  - Allowing not suitable un-restricted protocols will create a huge burden on FCC to resolve the operator complaints
  - FCC has already recognized limitations with the “interference temperature” approach and this is a similar situation
  - Alternatively FCC may ask the industry for support in defining the performance of different protocols

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Alvarion's Recommendations

- **FCC to accept un-restricted protocols which comply with the rule**
  - **802.11y shall avoid to create interference to 802.16h**
    - **Interference criteria needs to be defined**
    - **FCC shall approve a protocol based on simulations using the power rules in 3.65GHz**
  - **Harmful interference levels shall be defined such to allow large cell sizes**
    - **The levels need to be technology independent**
      - **The interference levels need to be defined as absolute powers**
  - **Allow alternative approach for interference separation in time**
- **Channel masks shall be defined for Base Stations, Fixed Stations and Mobile Stations**
- **The human element of *mandated* operator coordination should be eliminated**
  - **Allowing the equipment to do the mandated work**
  - **The FCC can still *encourage* operators to cooperate on the human level**

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Main simulation results

(Supporting Slides)

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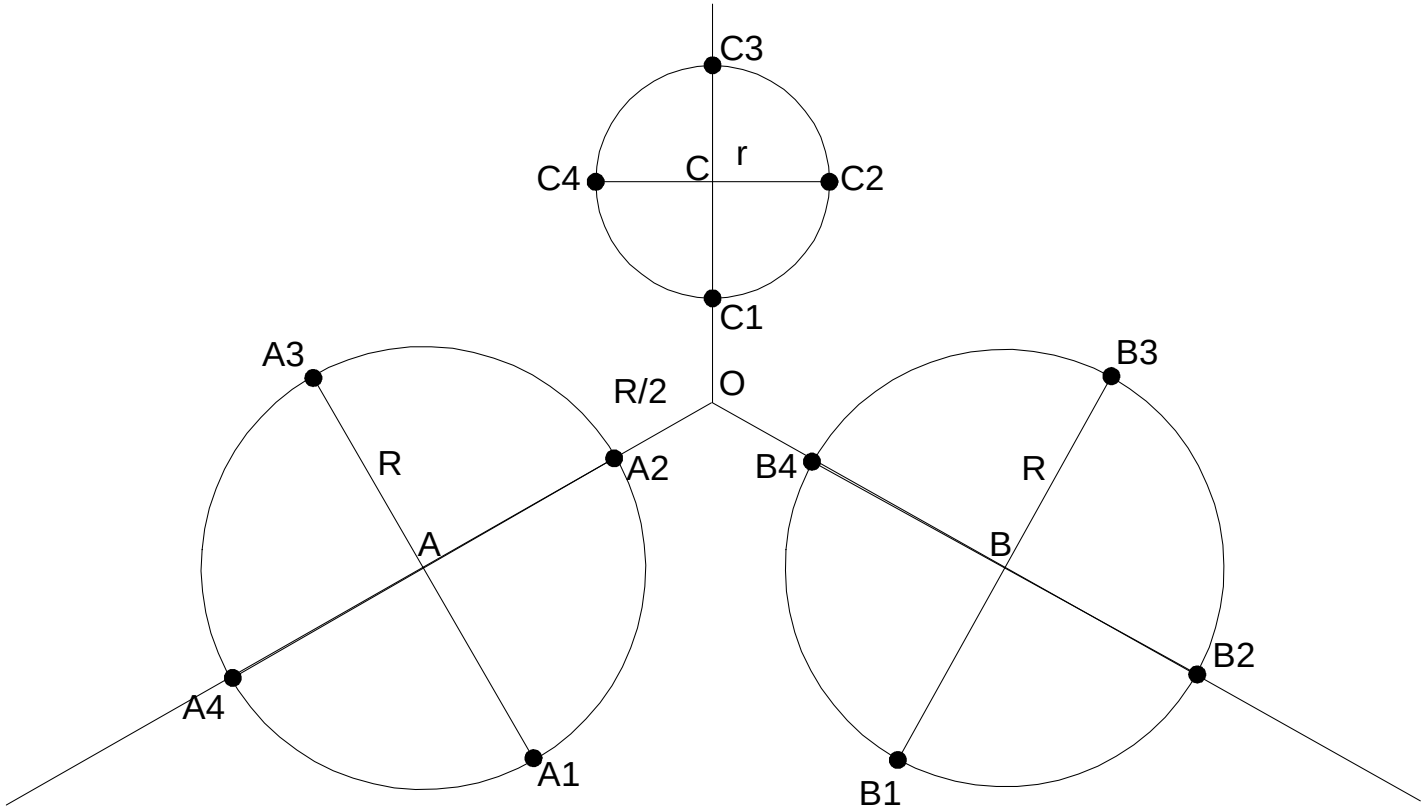
NOTE: Topology Basis for the Following Slides Simulation Systems Calculations



http://www.wirelessman.org/le/contrib/C80216h-07_039r1.pdf

R=10km for 802.16e
r = 5.2km for 802.11y (better than required BS sensitivities)
System separation: 8.5km between terminals

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Co-channel Influence of 802.11y

- **Only the 802.11y system is active**

Element in system A	I+N (dBm)	SINR	Connectivity
A	-81.49	-5.52	No
A1	-93.77	8.76	QPSK3/4
A2	-81.25	-3.76	No
A3	-88.30	3.29	QPSK1/2 rep 2
A4	-95.83	10.82	QPSK3/4

- **Cell size degradation**
  - **At QPSK ¾: from 10km to 2.5km**
    - **Cell coverage reduced from 100% to 6.7%**
  - **At QPSK ½: from 10km to 5km**
    - **Cell coverage reduced from 100% to 25%**

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Adjacent Channel Influence of 802.11y on Subscribers

- **Subscriber blocking level: -30dbm**

Distance between 802.11 BS and 802.16 SS/MS	Interference in the adjacent channel (dBm)	Interference translated into channel (dBm)	I+N (dBm)	RSL degradation (dB)	New cell size at QPSK3/4 (km)	New cell size at QPSK1/2 (km)
10	-14.65	-37.65	-37.6458	56.34	0.02	0.03
20	-20.67	-43.67	-43.6664	50.32	0.04	0.05
50	-28.63	-51.63	-51.625	42.36	0.09	0.13
100	-34.65	-57.65	-57.6448	36.34	0.18	0.25
185	-39.99	-62.99	-62.9858	31.00	0.33	0.47
500	-48.63	-71.63	-71.6001	22.39	0.89	1.26
1000	-54.65	-77.65	-77.5462	16.44	1.76	2.49
2000	-60.67	-83.67	-83.2809	10.71	3.41	4.82
5000	-68.63	-91.63	-89.6382	4.35	7.09	9.24
10000	-76.04	-99.04	-92.8085	1.18	9.33	11.08

- **The subscribers will not be able to receive for distances lower than a few km from a BS transmitter in the adjacent channel**
- **Again the cell size may be strongly deteriorated**

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Adjacent Channel Influence of 802.11y on Base Stations (BS)

- **BS Blocking level: -45dBm**

Distance between 802.11 BS and 802.16 BS	Interference in the adjacent channel (dBm)	Interference translated into channel (dBm)	I+N (dBm)	RSL degradation (dB)	New cell size at QPSK3/4 (km)	New cell size at QPSK1/2 (km)
10	-14.65	-37.65	-37.6459	58.34	0.01	0.02
20	-20.67	-43.67	-43.6664	52.32	0.03	0.04
50	-28.63	-51.63	-51.6251	44.36	0.07	0.10
100	-34.65	-57.65	-57.6452	38.34	0.14	0.20
325	-44.88	-67.88	-67.8768	28.11	0.46	0.65
500	-48.63	-71.63	-71.6094	24.38	0.71	1.00
1000	-54.65	-77.65	-77.5827	18.41	1.41	1.99
2000	-60.67	-83.67	-83.4193	12.57	2.75	3.89
5000	-68.63	-91.63	-90.2706	5.72	6.06	8.54
10000	-74.65	-97.65	-93.729	2.26	8.76	10.42

- **Absurd situation: the BS may be blocked for d<350m**
  - **For d>500m the BS will not “detect” other BS**
  - **Needed much more than 5km separation for acceptable cell size degradation**

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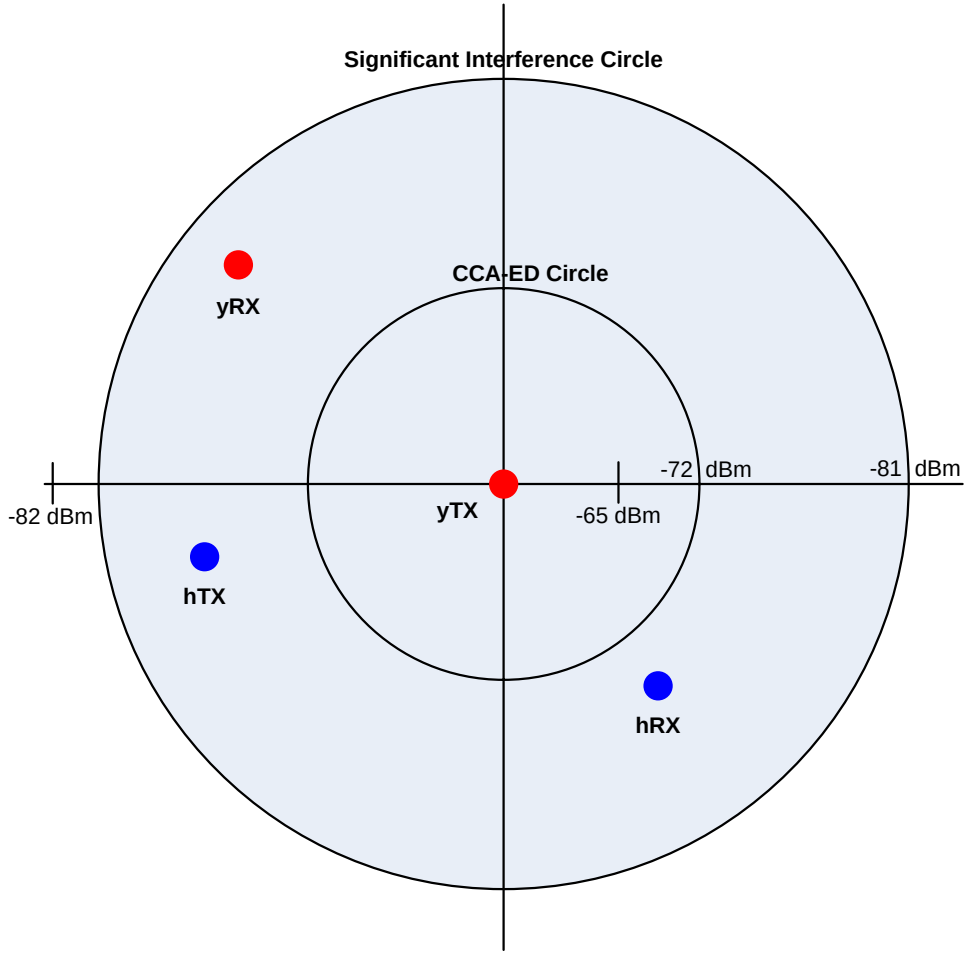
CCA-ED Performance with 802.11y / 802.16h UCP Levels – simulation by the 802.19 Chair

Hidden Node Event



- 802.11y CCA-ED does not detect a busy channel
- 802.11y transmits and jams 802.16h

http://www.ieee802.org/19/pub/2007/19-07-0010-01-0000-CCA-ED-in-802.11y.ppt

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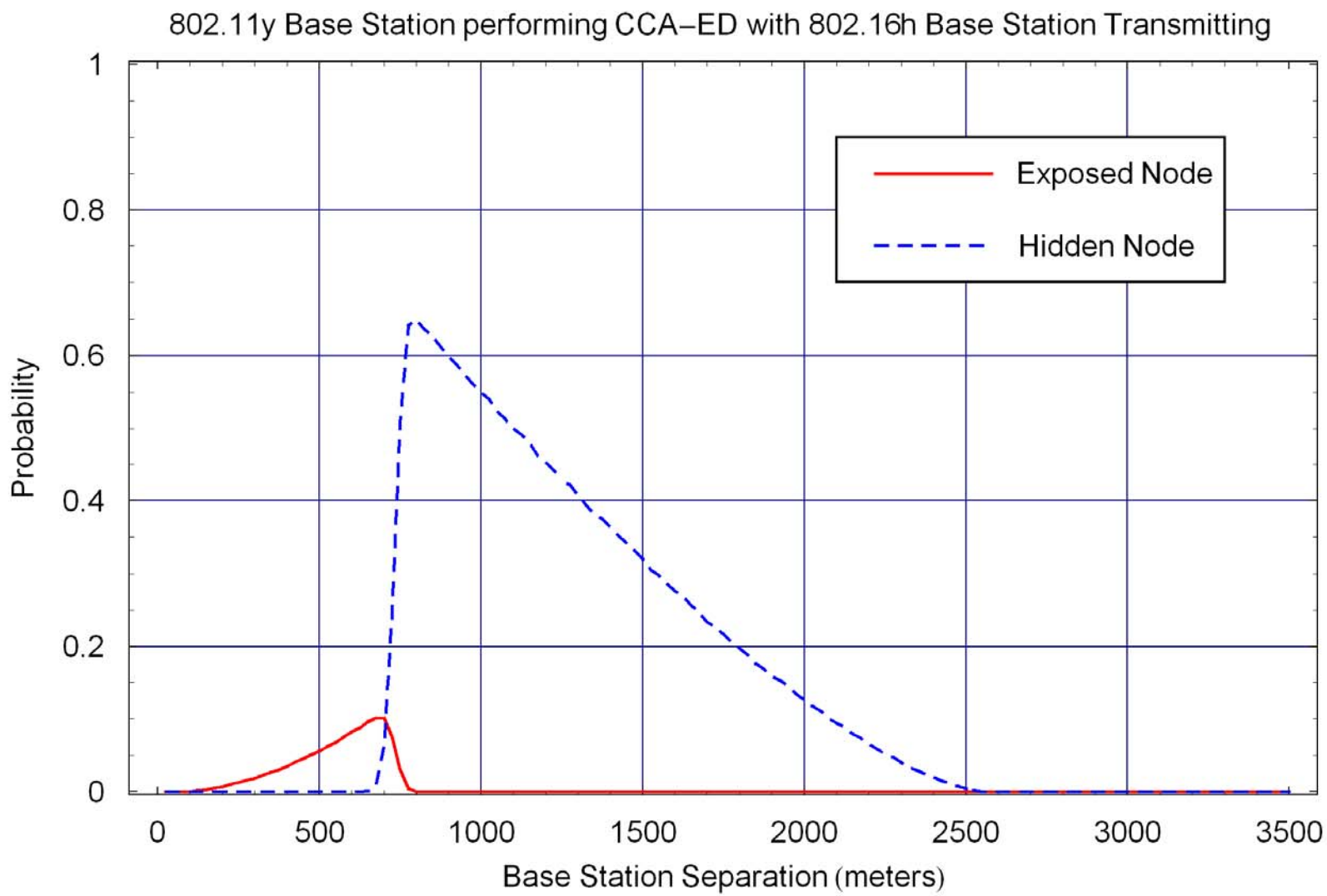
Example Results for Fixed Operation - Case 1



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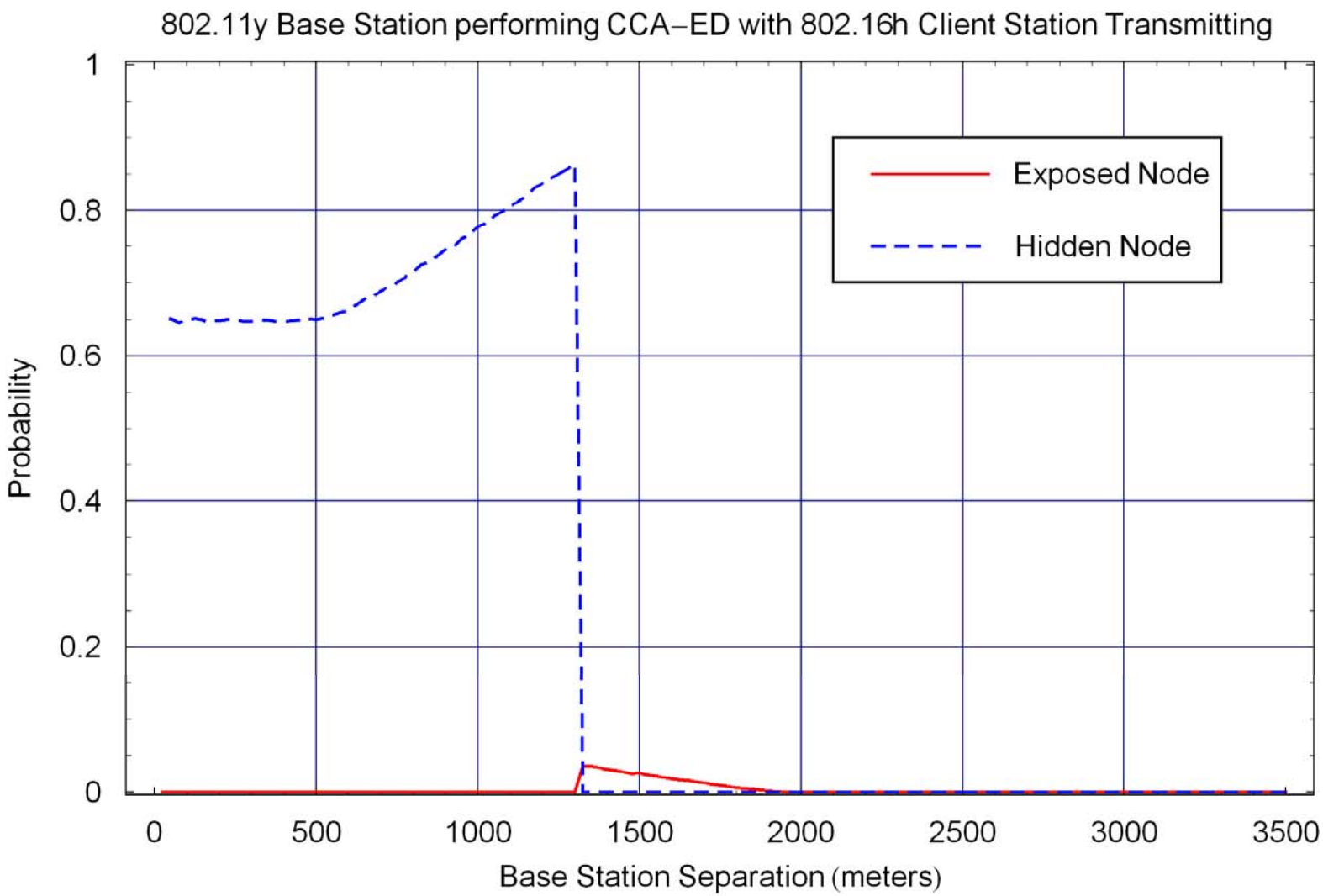
Example Results for Fixed Operation – Case 2



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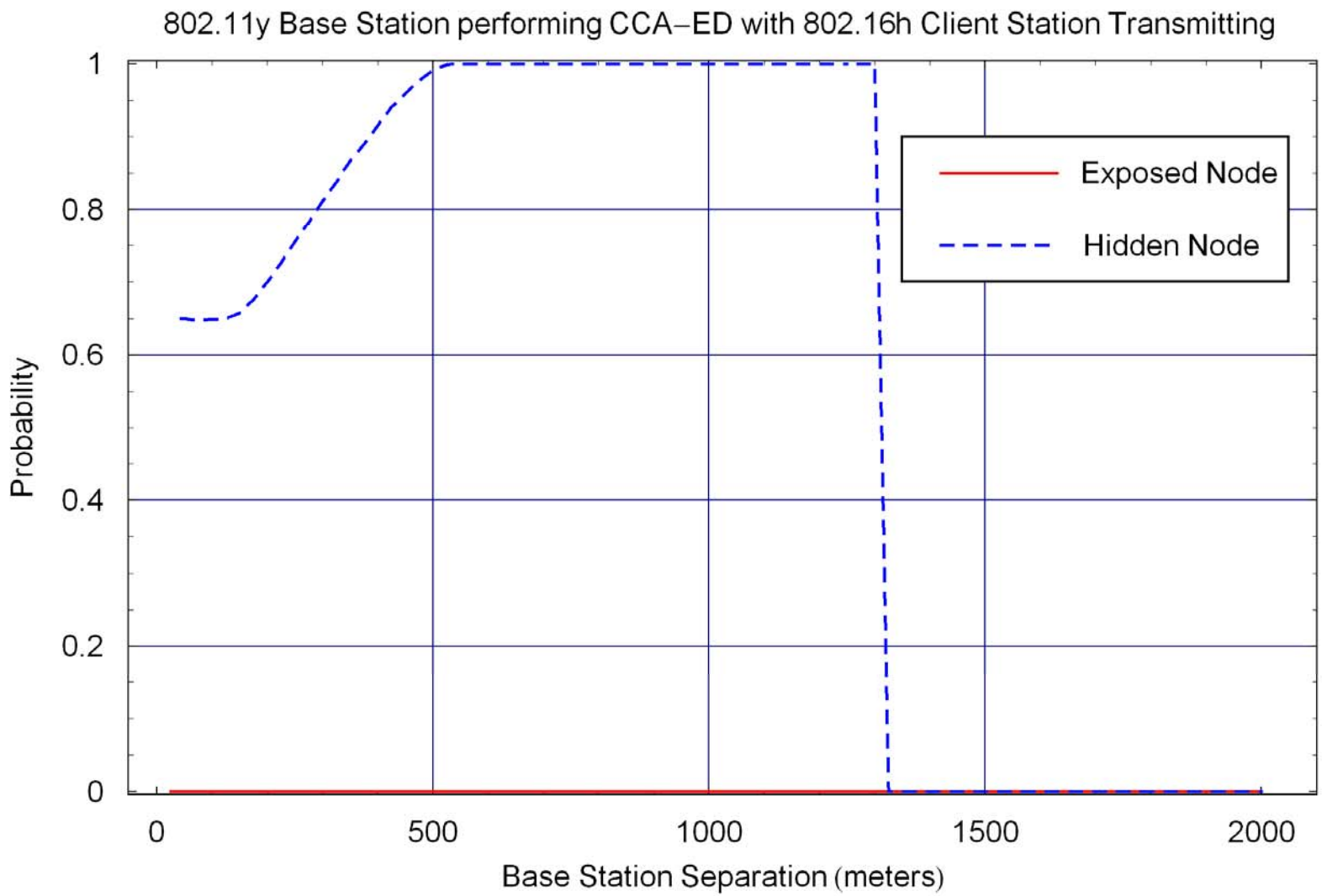
Example Results for Mobile Operation



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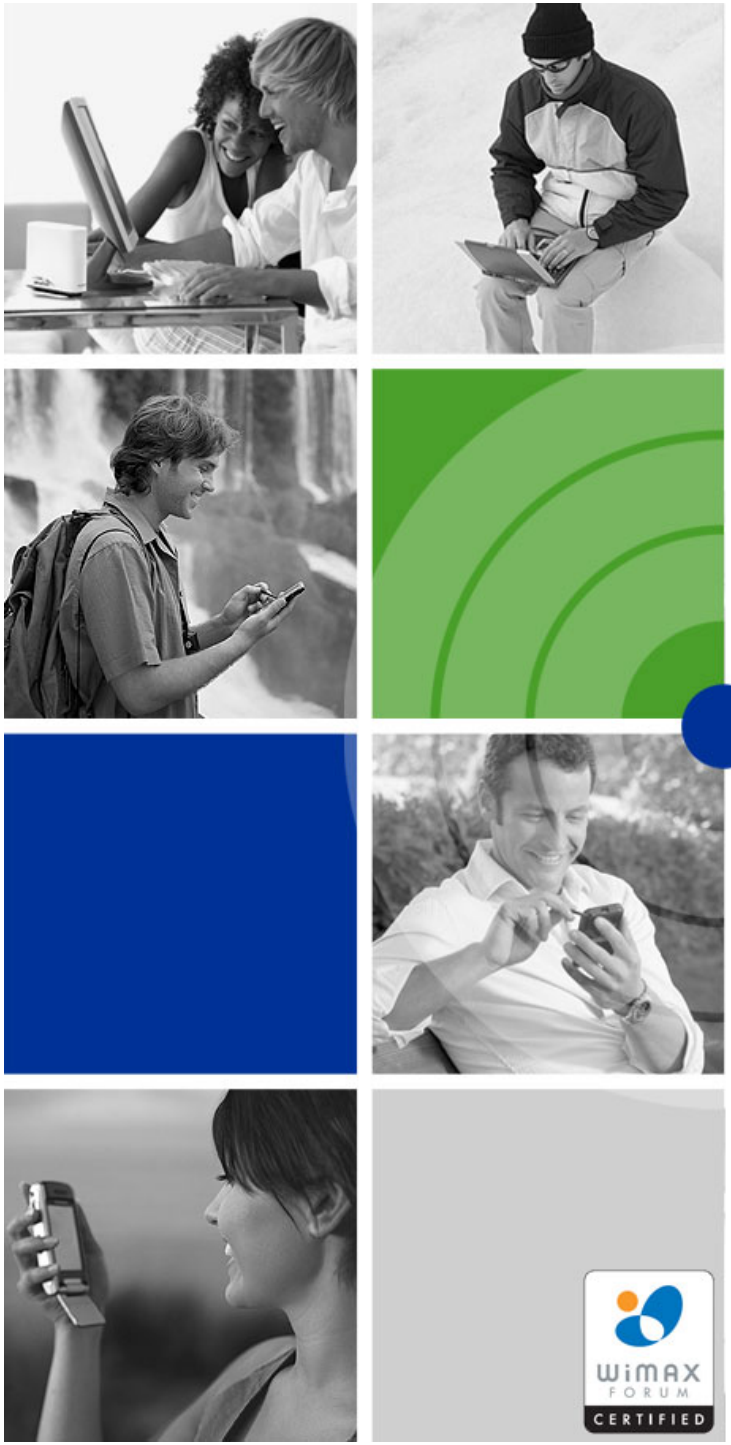

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