

# *WiMax*

## *Worldwide Interoperability for Microwave Access*

- What is WiMax?
  - Why was Wimax defined
  - What needs does it cover?
- Wimax Technology
  - Different use cases
  - Technologies used in Wimax
  - Range examples
  - Personal experience

# *What is WiMax?*

## *Its wireless broadband*

- WiMax is a standard for wireless broadband
- Describes as «WiFi on steroids», having greater range and bandwidth than WiFi
- A WiMax base station typically covers a radius of 2 km for indoor terminals and 10 km for outdoor terminals



# *What is WiMax?*

## *Its a WMAN*

- WiMax was designed to be a Wireless Metropolitan Area Network
- Wireless alternative to cables
- Deployment in disasters
  - Aceh, Indonesia - Tsunami in 2004
  - Hurricane Katrina in 2005

# *What is WiMax?*

## *It consists of many different standards*

- WiMax is a commercialization of the IEEE 802.16 Standard, which specifies the radio-frequency technology for wireless metropolitan networks. Many different WiMax standards exist
  - Fixed WiMax
  - Mobile WiMax
  - WiMax II

# *What is WiMax?*

## **Fixed WiMax**

- 802.16 - 2001
  - Fixed Broadband Wireless Access (10–66 GHz)
  - Only Line-of-sight capability
- 802.16a – 2003
  - Physical layer and MAC definitions for 2–11 GHz
  - WiMax as we know it
  - Designed to provide 30-40 Mbits/s

# *What is WiMax?*

## Mobile WiMax

- 802.16e - 2005
  - Adding Support for Mobility (Soft and hard handover between basestations)
  - Scalable Orthogonal Frequency Division Multiple Access
  - MIMO technology
  - Denser sub-channelization
    - Improving indoor penetration

# *What is WiMax?*

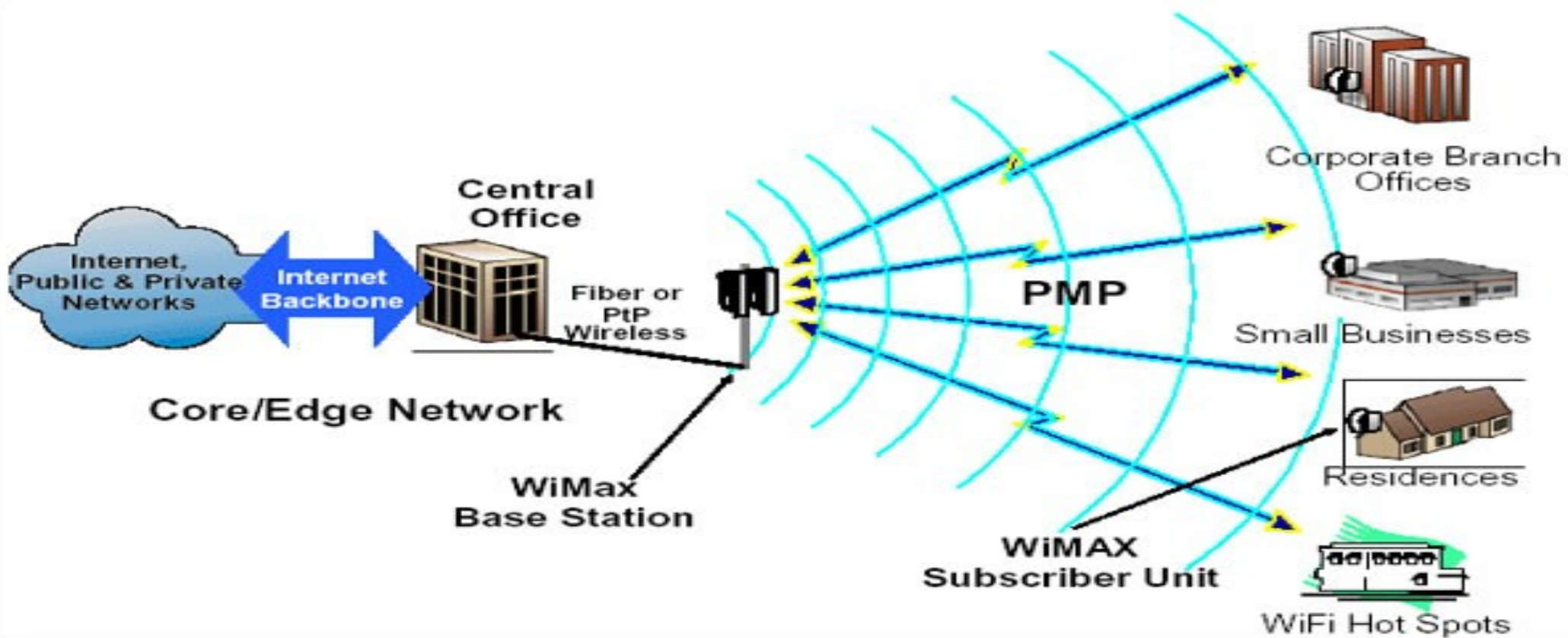
## WiMax II

- 802.16m - 2011
  - Data rates of 100Mbit/s mobile and 1 Gbit/s fixed
  - MIMO, Turbo principle error-correcting codes, Channel-dependent scheduling

# *What is WiMax?*

## *Last Mile alternative*

- WiMax can be described as a point-to-multipoint microwave networks, providing a wireless alternative to cable and DSL for «last mile» broadband access





# What is WiMax?

## Use Case - Norway

- Offered to rural communities in some areas of Norway



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[Bedrift](#) > [Internett](#) > [WiMAX](#)

### WiMAX radiobasert bredbånd

Nå tilbyr vi bredbånd via radiomaster til enkelte områder i landet som hittil ikke har kunnet få bredbånd på andre måter.

#### Abonnementer

Velg mellom disse abonnementene:

Abonnement	kbps inn	kbps ut	Pris pr måned
Full Brekke Bedrift 1000	1 000	350	399,-
Full Brekke Bedrift 2000	2 000	400	429,-
Full Brekke Bedrift 3000	3 000	500	499,-
Full Brekke Bedrift 4000	4 000	600	599,-

Etablering	Engangspriser
Etablering	299,-
Montering - utendørs	1 998,-
Frakt av utstyr	99,-

Alle abonnement har 12 måneders binding. Alle priser er eks. mva.

Se også [abonnement for privatkunder](#).

#### Dekningsområde

WiMAX er tilgjengelig i deler av kommunene Agdenes, Bjugn, Hitra, Osen, Rissa, Ørland og Åfjord i Sør-Trøndelag.



[Hjem](#) > [Privat](#) > [Bredbånd](#) > [WiMax](#)

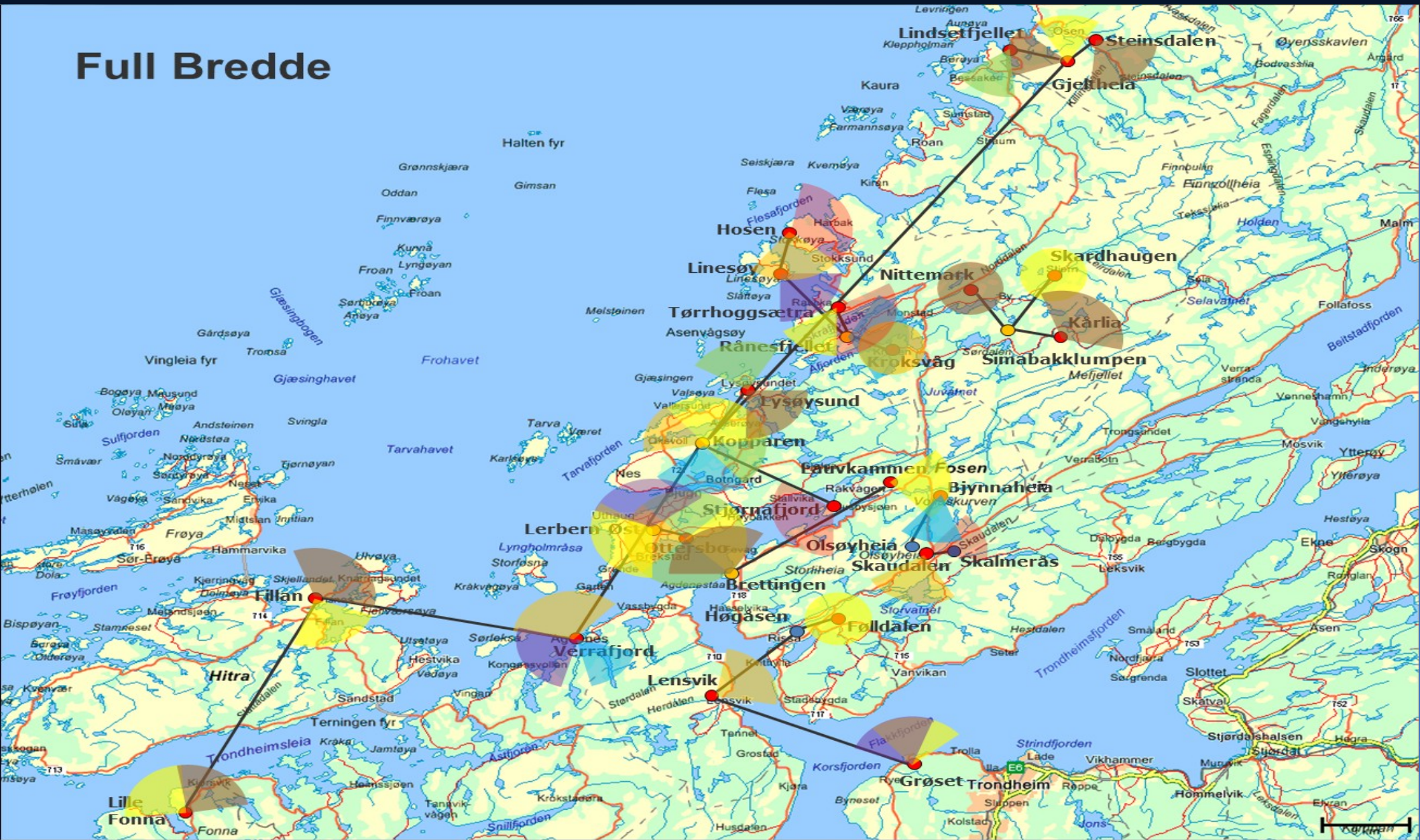
## WiMax Bredbånd

Bredbånd WiMax er et tilbud til deg som ikke kan få ADSL. WiMax er et fullverdig bredbåndsprodukt basert på radioteknologi.

	Basis Beregnet på privatpersoner	Premium Beregnet på bedriftsmarkedet
Pris pr mnd	359,-	999,-
Pris pr år	4308,-	11988,-
Hastighet	2500/400 kbit/s	3000/1500 kbit/s
Trådløst multimodem	799,- ⓘ	799,- ⓘ
Oppklingshjelp av Bredbåndspatroljen	999,- ⓘ	999,- ⓘ
Etablering	0,- ⓘ	0,- ⓘ
Vilkår	<a href="#">Se vilkår for WiMax</a>	<a href="#">Se vilkår for WiMax</a>
	Ring 800 30 325 for bestilling	Ring 800 30 325 for bestilling

# What is WiMax? Use Case - Norway

Full Bredde



# What is WiMax?

## Use Case - Norway

Fjord1

### Bredbånd på Fjord1

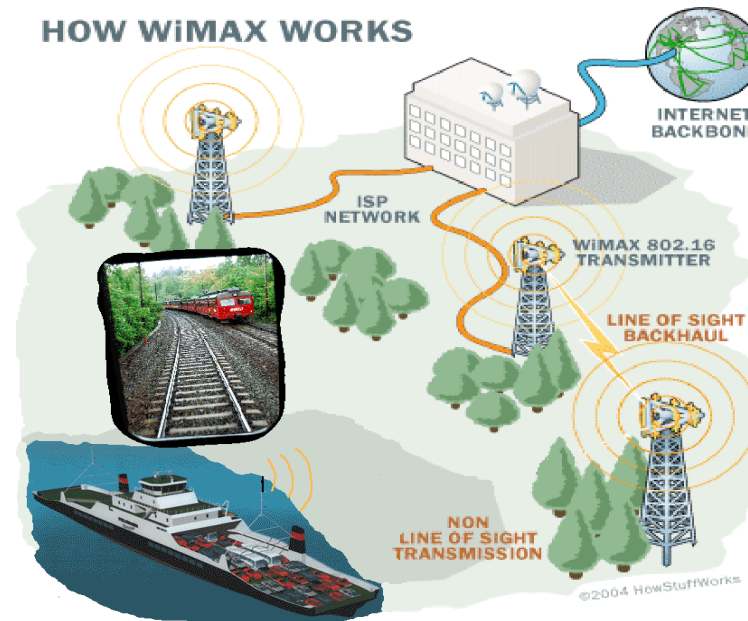
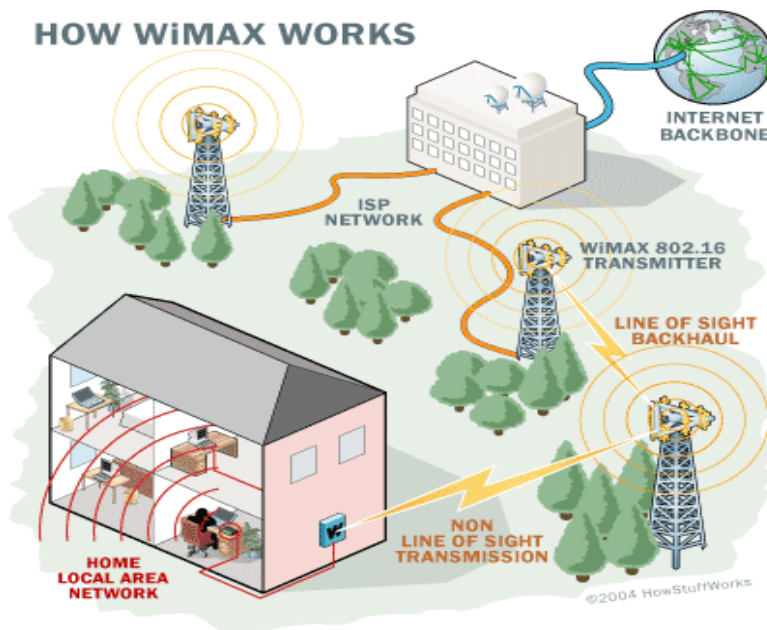
- Administrative tjenester
  - VPN-tjenester for Fjord1 Intranet
    - E-post, server-tilgang, etc.
    - Billettering og handel (betalingsterminaler)
    - Nyheter og reklame
- Driftstekniske behov
  - Overvåkning av tekniske installasjoner
    - Gasskraftverk
- Bredbånd til folket
  - Trådløst bredbånd for passasjerer
    - HomeRun



# WiMax Technology Fixed and Mobile

## The development of WiMAX

- Phase 1:
  - An alternative to other fixed broadband technologies
  - 3.5 GHz band
- Phase 2:
  - An alternative to other mobile broadband technologies
  - 2.3 GHz band

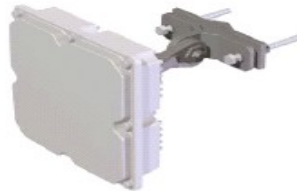


# WiMax Technology

## Fixed and Mobile

### Frequency bands for WiMAX

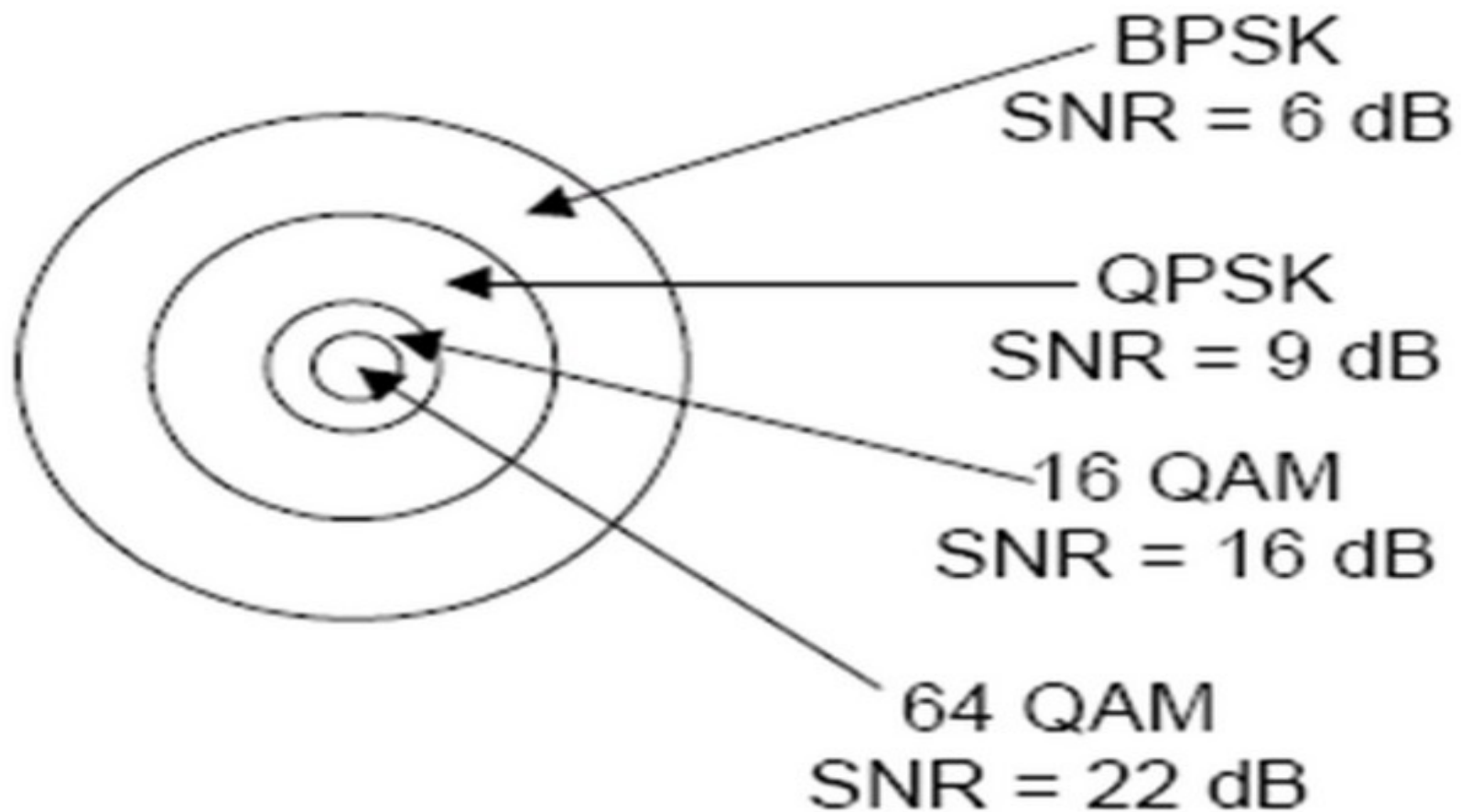
- Fixed and nomadic WiMAX
  - 3.5 GHz frequency band
  - Private networks
  - Feeding local access points
  - Indoor and outdoor terminals
- Mobile WiMAX
  - 2.3 GHz frequency band
  - Full mobility
  - Handheld terminals



# *WiMax Technology*

## *Adaptive Modulation*

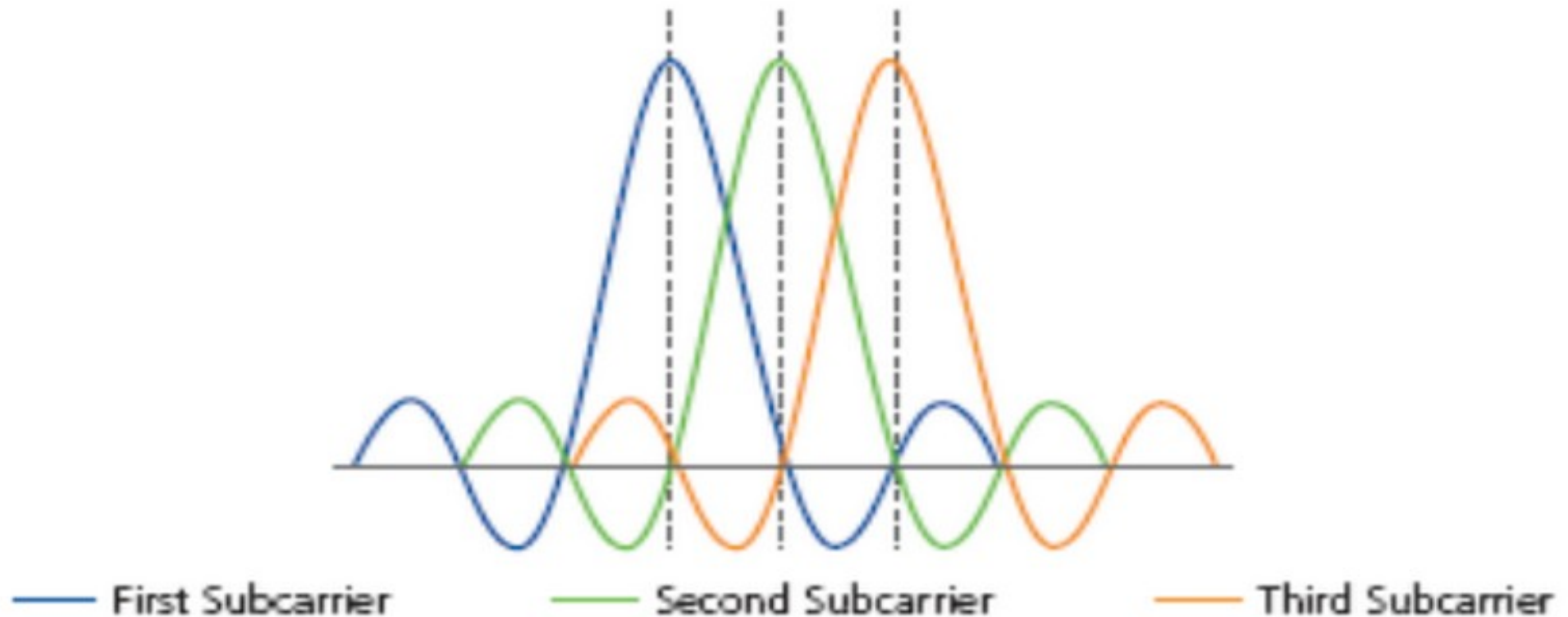
- Adaptive Modulation - Channel quality



# *WiMax Technology*

## *OFDM*

- OFDM – Orthogonal Frequency Division Multiplexing

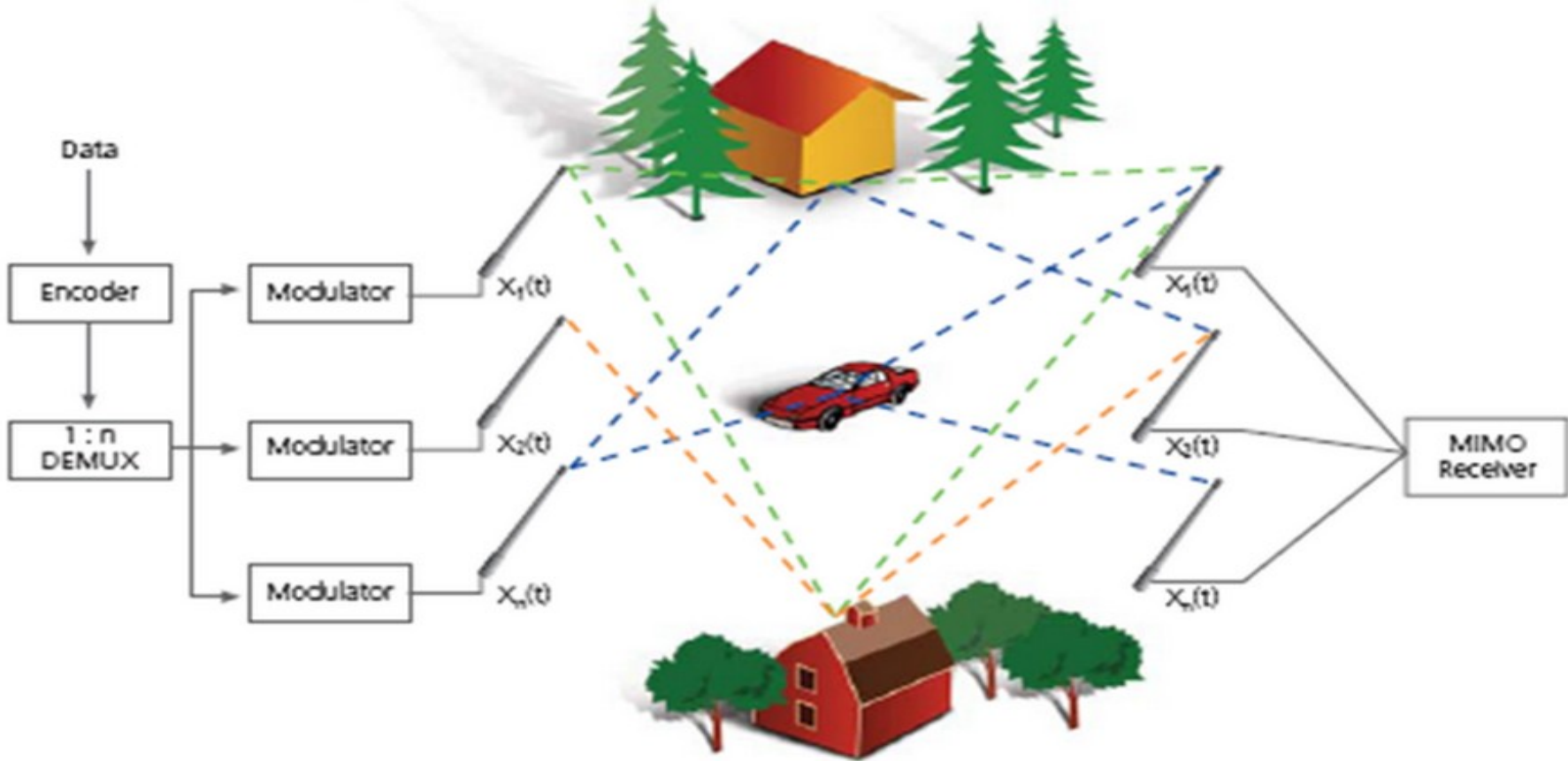


# WiMax Technology

## Multiple-In and Multiple-Out

### MIMO

n x n MIMO Antenna System

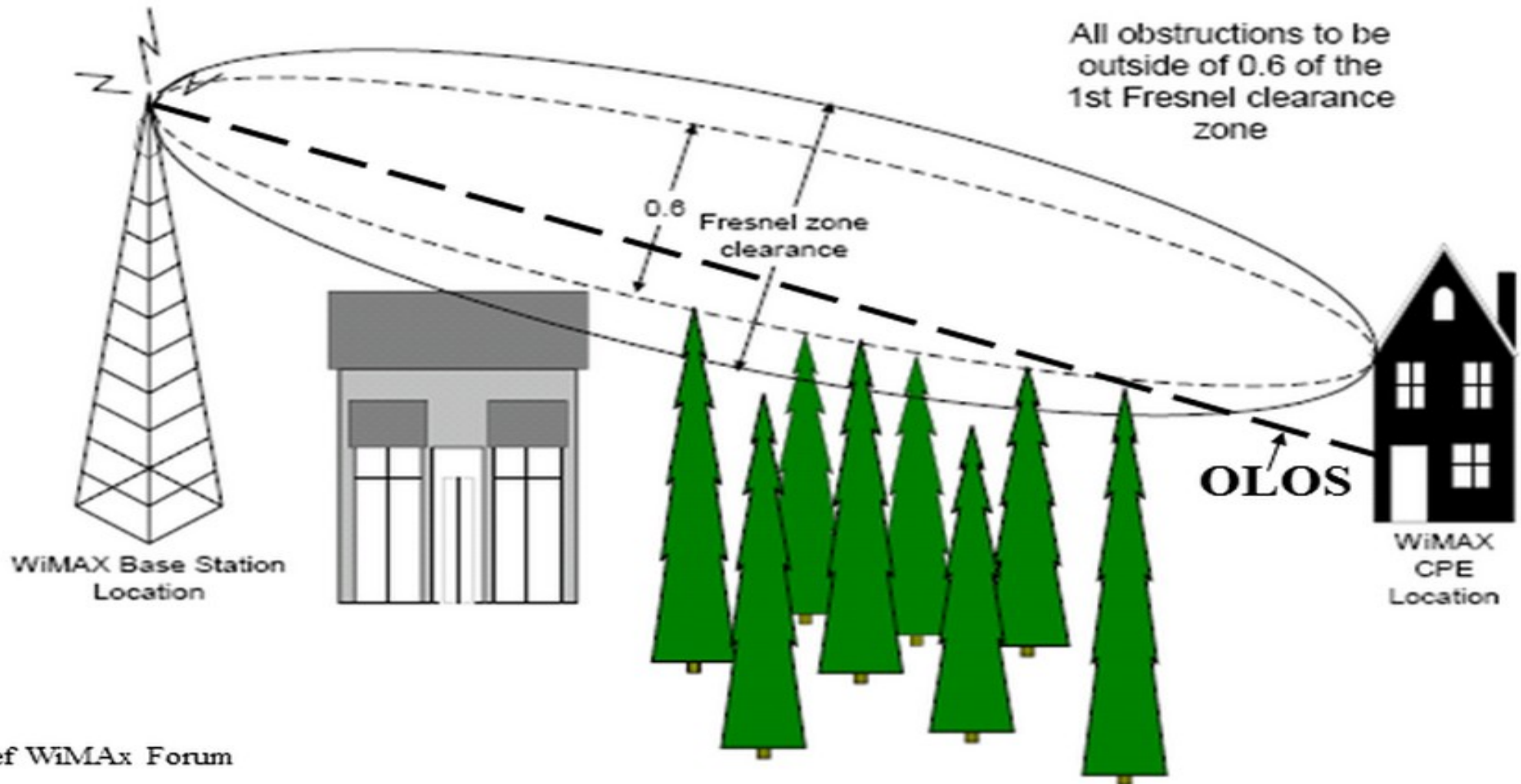


$$\text{Where: } r_n(t) = h_{n1}x_1(t) + h_{n2}x_2(t) + \dots + h_{nn}x_n(t)$$



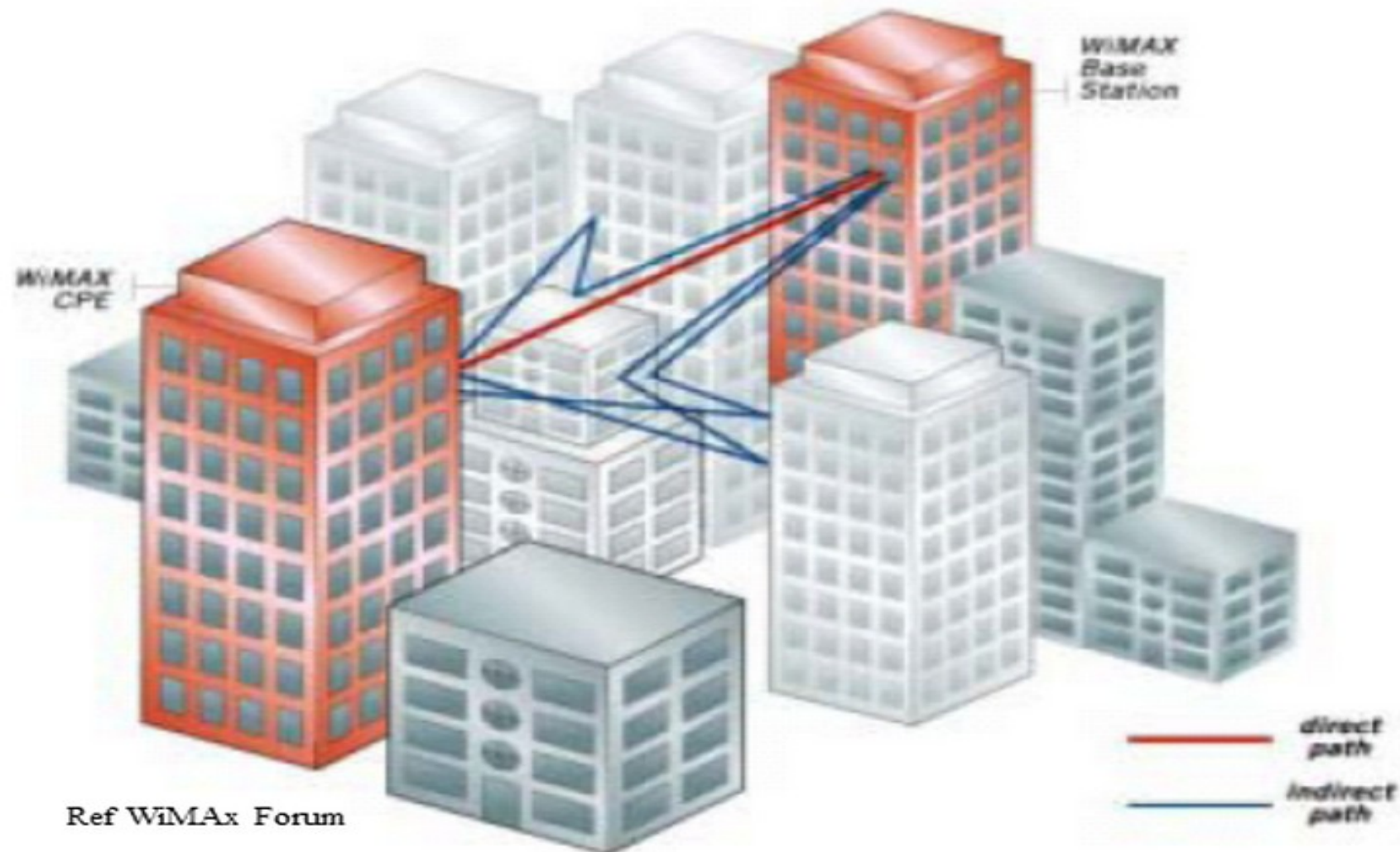
# WiMax Technology Line of Sight

## LOS - Line Of Sight



# *WiMax Technology Non Line of Sight*

## NLOS Non Line Of Sight -Urban



# *WiMax Technology* *Non Line of Sight*

## NLOS Non Line Of Sight Rural



# WiMax Technology

## Base Station Ranges with 90° sector antenna

### Rekkevidde med BS 90° sektor-antenne

Utstyr	Propagasjons- modus	BPSK modulasjo n inkl. koding  (1 Mbit/s)	QPSK modulasjo n inkl. koding  (2,5 Mbit/s)	16QAM modulasjo n inkl. koding  (6 Mbit/s)	64QAM modulasjo n inkl. koding  (10 Mbit/s)
Standard BS med utendørs CPE	LOS OLOS NLOS Rural NLOS Urban	216,7 km 68,5 km 21,7 km 8,6 km	153,4 km 48,5 km 15,3 km 6,1 km	<u>68,5 km</u> <u>21,7 km</u> <u>6,9 km</u> <u>2,7 km</u>	34,4 km 10,9 km 3,4 km 1,4 km
Standard BS med innendørs CPE	LOS OLOS NLOS Rural NLOS Urban	21,7 km 6,9 km 2,2 km 0,9 km	15,3 km 4,9 km 1,5 km 0,61 km	<u>6,9 km</u> <u>2,2 km</u> <u>0,69 km</u> <u>0,27 km</u>	3,4 km 1,1 km 0,34 km 0,14 km
Lav-effekt BS med utendørs CPE  CPE UL	LOS OLOS NLOS Rural NLOS Urban	68,5 km <u>21,7 km</u> <u>6,9 km</u> 2,7 km	48,5 km 15,3 km 4,9 km 1,9 km	<u>21,7 km</u> <u>6,9 km</u> <u>2,2 km</u> <u>0,9 km</u>	10,9 km 3,4 km 1,1 km 0,43 km
Lav-effekt BS med innendørs CPE	LOS OLOS NLOS Rural NLOS Urban	6,9 km 2,2 km 0,69 km 0,27 km	4,9 km 1,5 km 0,49 km 0,19 km	<u>2,2 km</u> <u>0,69 km</u> <u>0,22 km</u> <u>0,09 km</u>	1,1 km 0,34 km 0,11 km 0,04 km

NB! For avstander mindre enn ca. 1 km gir bruk av de vanlige propagasjons-modellene i bebygde områder (NLOS Urban) for korte rekkevidder. De angitte avstandene må derfor betraktes som nedre grenseverdier.

# WiMax Technology

## Base Station Ranges with omni antenna

### Rekkevidde med BS omni-antenne


Utstyr	Propagasjonsmodus	BPSK modulasjon inkl. koding (1 Mbit/s)	QPSK modulasjon inkl. koding (2,5 Mbit/s)	16QAM modulasjon inkl. koding (6 Mbit/s)	64QAM modulasjon inkl. koding (10 Mbit/s)
$P_t = 27 \text{ dBm}$ $60^\circ$ antenne		SNR > 6 dB	9	16	22 dB
Standard BS med utendørs CPE	LOS OLOS NLOS Rural NLOS Urban	153,4 km 48,5 km 15,3 km 6,1 km	108,6 km 34,4 km 10,9 km 4,3 km	48,5 km <u>15,3 km</u> <u>4,9 km</u> <u>1,9 km</u>	24,3 km 7,7 km 2,4 km 1,0 km
Standard BS med innendørs CPE	LOS OLOS NLOS Rural NLOS Urban	15,3 km 4,9 km 1,5 km 0,6 km	10,9 km 3,4 km 1,1 km 0,43 km	4,9 km <u>1,5 km</u> <u>0,49 km</u> <u>0,19 km</u>	2,4 km 0,8 km 0,24 km 0,10 km
Lav-effekt BS med utendørs CPE	LOS OLOS NLOS Rural NLOS Urban	48,5 km <b>15,3 km</b> <b>4,9 km</b> 1,9 km	34,4 km 10,9 km 3,4 km 1,4 km	<u>15,3 km</u> <u>4,9 km</u> <u>1,5 km</u> <u>0,6 km</u>	7,7 km 2,4 km 0,8 km 0,31 km
Lav-effekt BS med innendørs CPE	LOS OLOS NLOS Rural NLOS Urban	4,9 km 1,5 km 0,49 km 0,19 km	3,4 km 1,1 km 0,34 km 0,14 km	<u>1,5 km</u> <u>0,49 km</u> <u>0,15 km</u> <u>0,08 km</u>	0,8 km 0,24 km 0,08 km 0,03 km

NB! For avstander mindre enn ca. 1 km gir bruk av de vanlige propagasjons-modellene i bebygde områder (NLOS Urban) for korte rekkevidder. De angitte avstandene må derfor betraktes som nedre grenseverdier.

# WiMax Technology

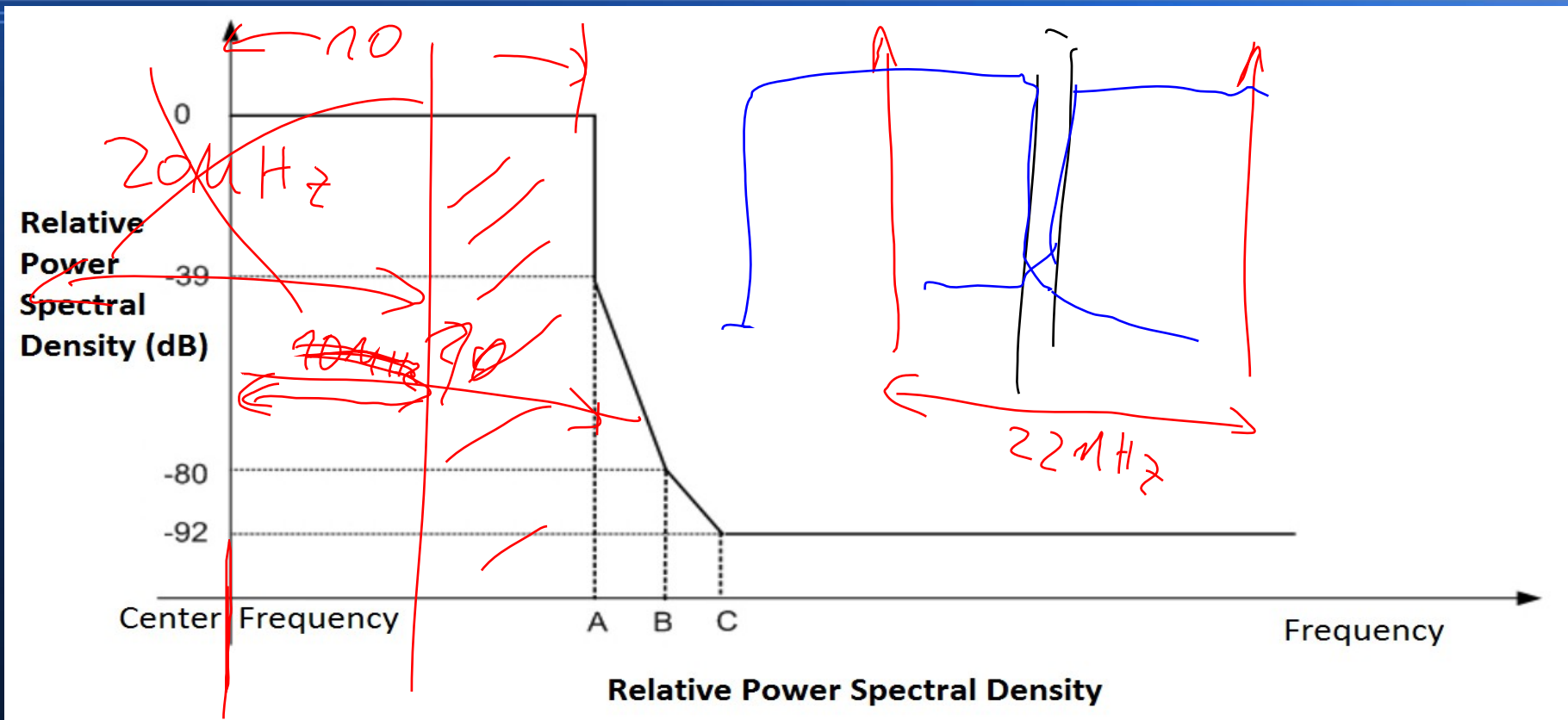
## Range example (Telenor)

Equipment	Propagation Mode	16QAM modulation included coding (6 Mbit/s)
Standard Base Station (90° sector antenna) with outdoor CPE (Consumer Premises Equipment)	LOS	48.5 km
	OLOS	15.3 km
	NLOS Rural	4.9 km
	NLOS Urban	1.9 km



# WiMax Technology

## Post and Teletilsynets restrictions in 2.3 GHz Band



Channel Distance (MHz)	Point A (MHz)	Point B (MHz)	Point C (MHz)
22 MHz	-39 dB	-80 dB	-92 dB
	10 MHz	12 MHz	13.5 MHz

Break Points in the Spectrum Mask

# WiMax Technology

## Data from antennas used by Telenor

Antenna	Frequency	Effect (W)	Effect (dB)	Gain
Integrated BS Antenna	3.5 GHz	0.5 W	27 dBm	14 dBi
Integrated Consumer Antenna	3.5 GHz			17 dBi
Gapfiller Link Antenna	5.8 GHz	0.08 W	19 dBm	23 dBi

Handwritten notes in red:

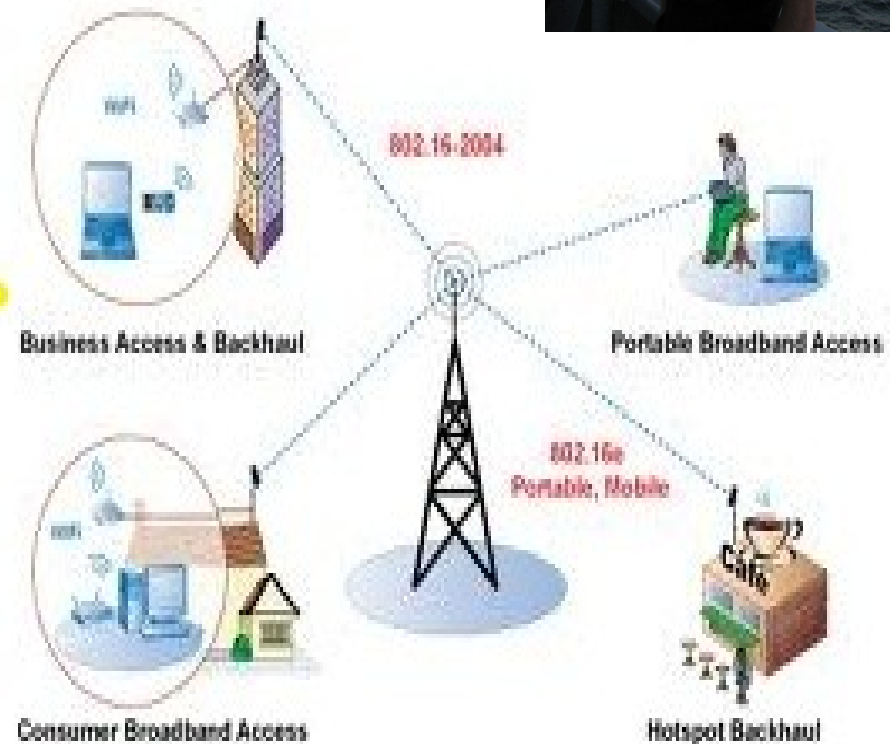
- Next to "Integrated BS Antenna":  $60^\circ$  (circled),  $20^\circ$  vertical opening
- Next to "Integrated Consumer Antenna":  $10^\circ$  vert. & horiz beamwidth (with arrow pointing to the 17 dBi gain)
- Next to "Gapfiller Link Antenna":  $0.08$  W (circled),  $23 + 23 = 46$  dB (with arrow pointing to the 23 dBi gain)
- Next to "Integrated BS Antenna" Gain:  $14 + 17 = 31$  dB



# Getting close to the end... Personal Experience with WiMax

Fridtjof Nansen-klasse fregattar  
SPY-1F Radar - S-bånd

WiMax  
2.3 & 3.5 GHz



# *WiMax*

## *Acknowledgements*

- Thank you very much for the information
  - Trond Berrefjord at Telenor
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  - Rune Bøe at Post og Teletilsynet
- Sources:
  - Wikipedia, Google, Wimax Forum
- Questions and Comments?