BreezeCOM and Floware unite

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License Exempt Spectrum and Advanced Technologies

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InnoWave joins Alvarion

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Contents

- BWA Market trends
- Power & Spectral Ingredients for Successful BWA Deployments
- Are regulations a limit for new radio technologies? Do they enable “spectrum mess” ?
- LE vision - new regulatory rules
- Conclusions

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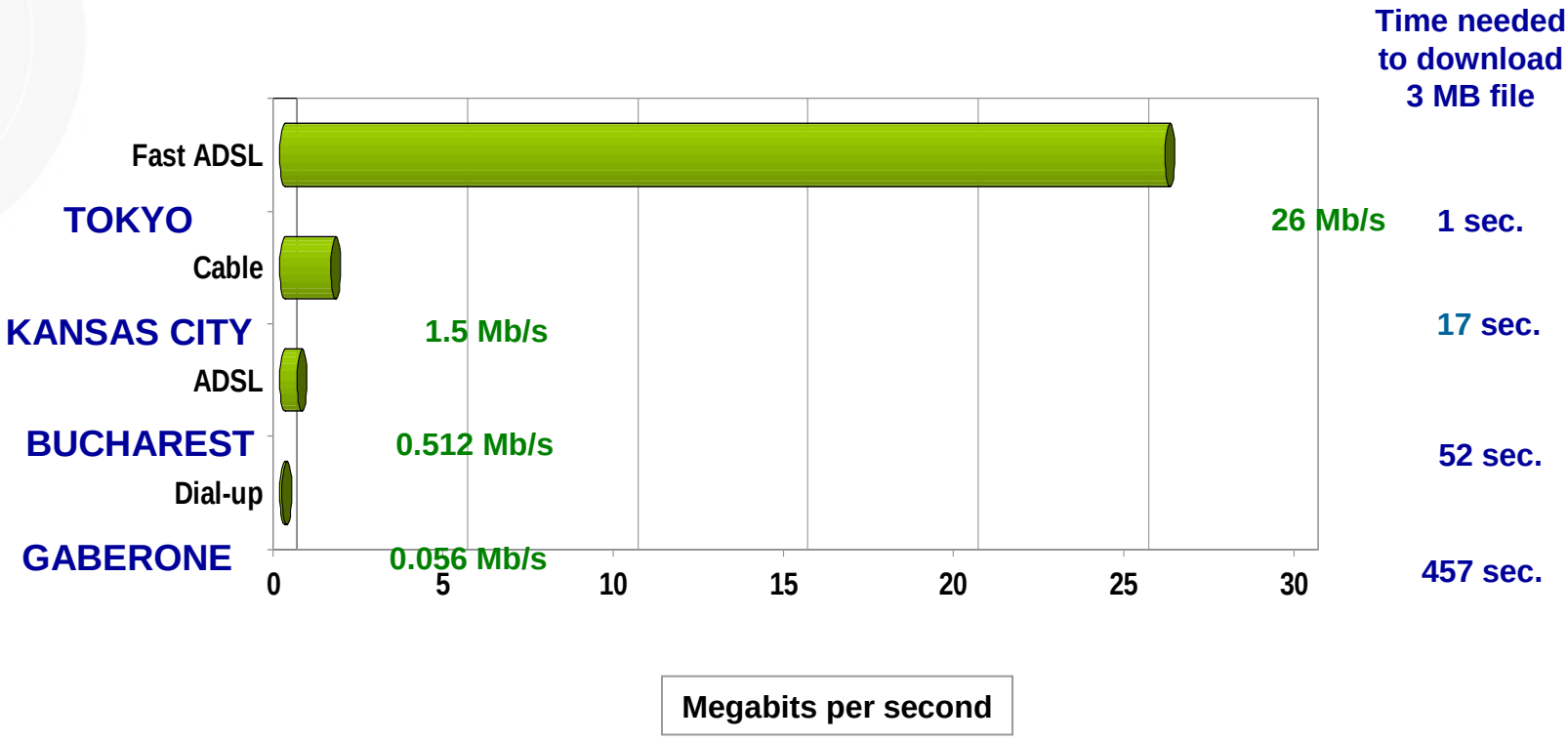
Definition of Broadband Depends on Geography



Source: Pyramid Research

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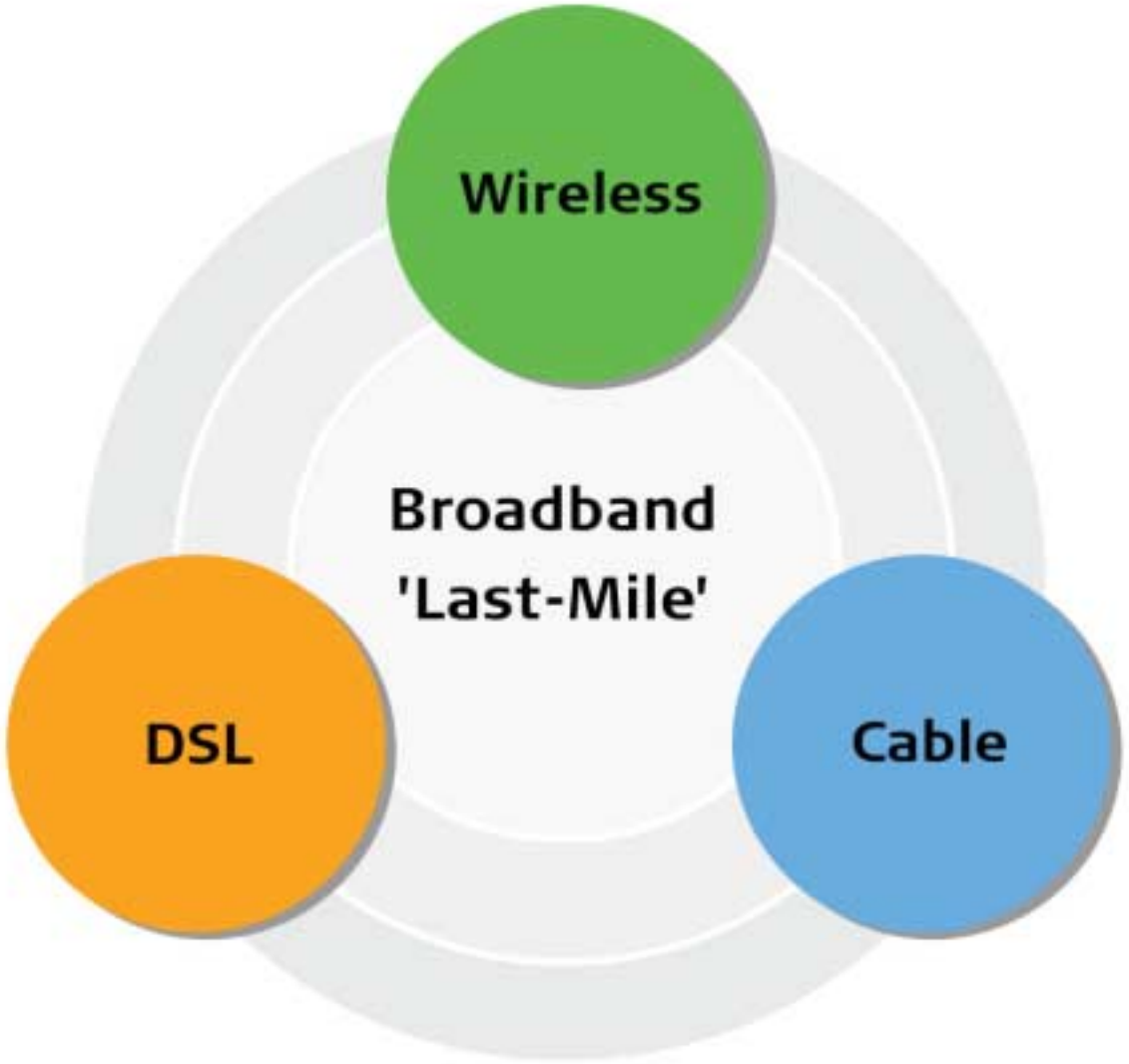
Broadband Revolution



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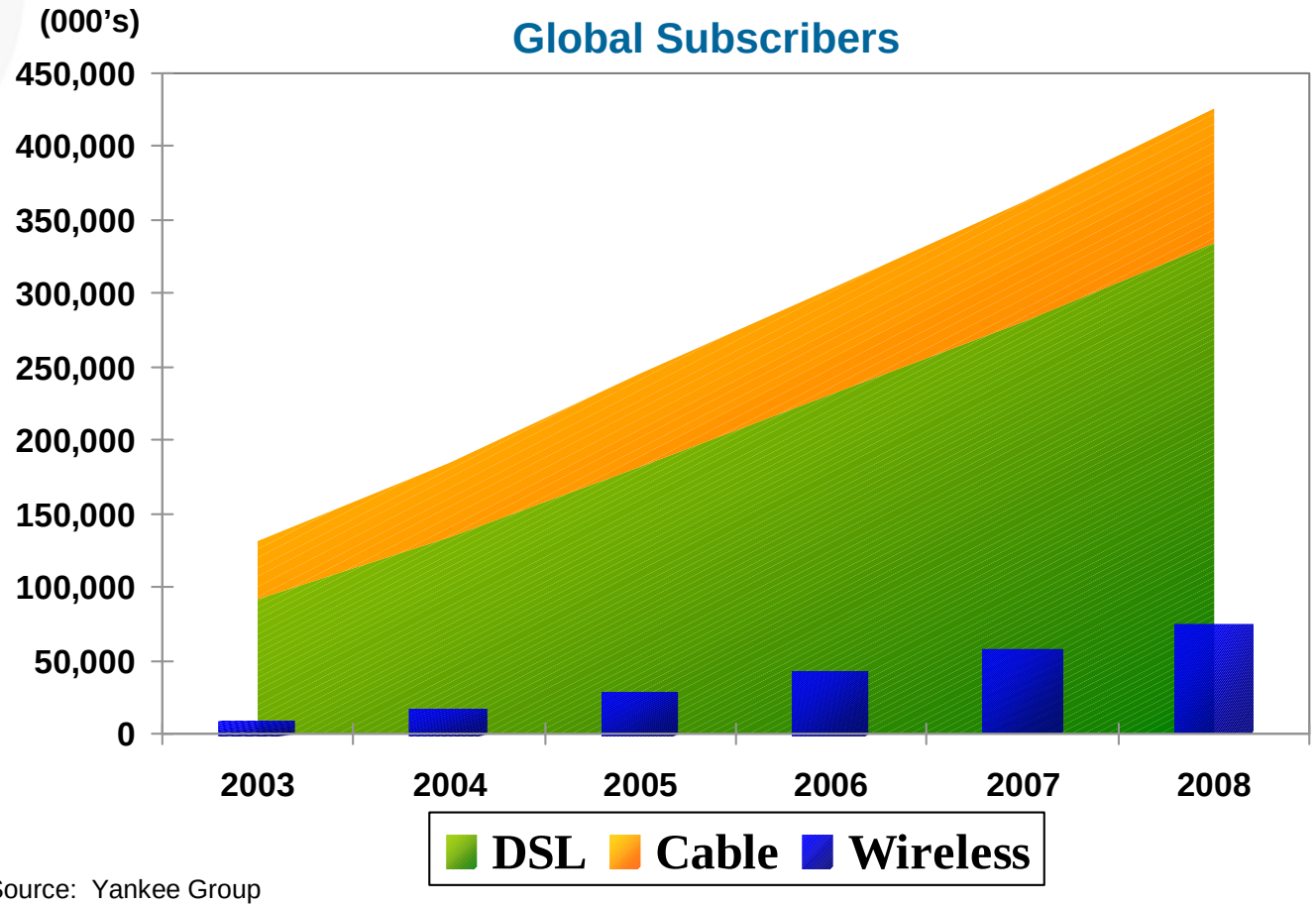
BWA Follows DSL Trend



Source: Yankee Group

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License Exempt Broadband by Country Type

Developing Countries	Developed Countries
Service Provider Types ▪ ILECs ▪ CLECs ▪ Large (Nationwide) ISPs	**Service Provider Types** ▪ Large ISPs ▪ small WISPs ▪ ILECs (limited deployment)
Region ▪ Urban ▪ Sub Urban	**Region** ▪ Sub Urban ▪ Rural
Types of Service ▪ Business Data & Voice ▪ Residential Data	**Types of Service** ▪ Residential Data ▪ Business Data

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Power & Spectral Ingredients for Successful BWA Deployments

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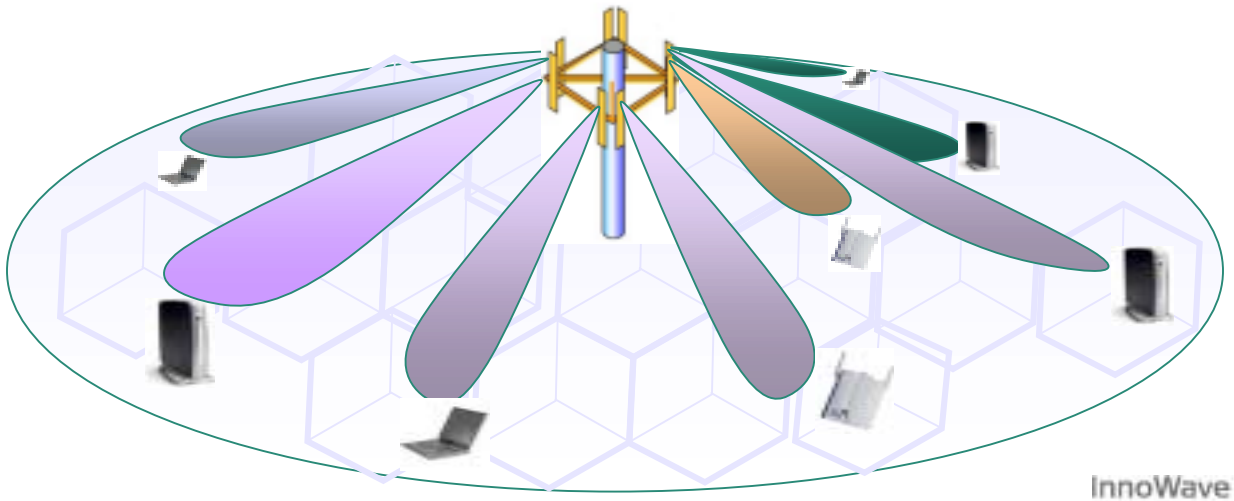
High Power for Positive Business Case

- Efficient and high quality BWA requires **higher** power transmissions than WLAN:
  - Larger cell size
  - Outdoor-to-indoor penetration (**NEW!**)
  - Higher sustained aggregated throughput
  - Increased overall cell performance



High Power, Advanced Technologies for Positive Business Case - Example

- Covered area: 225 Mile^2
- Penetration Rate – 18% @ 5Yr
-

Year 1	Year 2	Year 3	Year 4	Year 5
0.80%	1.80%	4.80%	6.60%	4.00%

- Household Density:
  - Sub urban high density - 4500 HH/mi^2
  - Sub urban low density- 1500 HH/mi^2
  - Rural -500 HH/mi^2

BreezeMAX using 5.8GHz, FCC ISM rules, TDD, 5MHz channels						
Area	**Configuration**	**No. Of BST's**	**BST Range [Km]**	**Total SU per BS**	**Price Per Line**	**ROI**
Rural High	**Macro 4 ways, 6 sectors**	16	4.0	1300	$360	36 Months
	Macro 2 ways, 3 sectors	31	3.0	650	$370	36 Months
Suburban Low	**Macro 4 ways, 6 sectors**	34	3	1800	$330	36 Months
Suburban High	**Macro 4 ways, 4 sectors**	350	1.0	500	$450	40 Months

High Power for Positive Business Case (contd.)

- Operator Benefits:
  - More subscribers in each cell reduce the base station CAPEX and OPEX load on each subscriber.
  - Increased subscriber throughput (higher modulation states can be used) allows for higher subscription rates for lucrative services.
  - Faster ROI, Higher NPV
- Subscriber Benefits:
  - Affordable subscription rates.
  - High throughput

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Present and near future

License Exempt Spectrum Allocations

- **Lack of spectrum**
- **2.4GHz**
  - Interference in 2.4GHz ISM band is driving service providers and equipment vendors **away** from this band.
  - **Europe: limited power, almost no use for access**
- **5GHz**
  - US: U-NII and upper ISM bands (5.15 – 5.85 GHz)
    - FWA applications using mainly roof-top antennae - **High cost / line**
  - **No 5.8GHz European allocation yet; CEPT studies consider less power than allowed by FCC**
- **Needed allocation of LE spectrum below 3GHz!**
  - Better coping with high distances and NLOS conditions

Standards and the “mess” in LE bands

- IEEE 802.11
  - Define “listen before send”
  - Does not work with FWA (stations are “hidden”, due to directional antennae)
  - Does not work in NLOS:
    - most of the stations are “hidden” due to “shadowing” and wall isolation effects
- IEEE 802.15
  - Frequency hopping!
- IEEE 802.16
  - Does not resolve the adjacent channel interference
- IEEE 802.11a, 802.16
  - Dynamic channel selection
    - **With 20MHz channels, may work only in 5GHz!**

BWA and interference mitigation with higher power allowance

- **Statistical approach**
  - Reduce interference levels
    - Beam forming / switching – **new FCC proposal**
    - Limited time occupancy – **new FCC proposal**
    - Frequency Hopping
      - Not suitable for broadband (channel no. limitation)
      - Not suitable for QoS
  - Pros: fast solution to allow higher e.I.r.p. levels
  - Contras: no QoS guarantee
- **BW Reservation approach**
  - Technology independent
    - Inter-system communication – **why not?**
  - Pros: suitable to new traffic types, requiring QoS
  - Not defined yet !

BWA: down-link cell-size limitation paradox

- **802.16a / ETSI HiperMAN / WiMAX define up-link OFDMA**
  - The Subscriber Terminal (ST) power may be concentrated on sub-channels
  - Up to 12dB up/link gain for 16 sub-channels
- **System gain**
  - Up-link: Tx(ts) + AG(ts) + AG(bs) - RSL(bs) + OFDMA(gain)
  - Down-link: Tx(bs) + AG(bs) + AG(ts) - RSL(ts)
- **Example for FWA, max. e.I.r.p = 36dBm (4W):**
  - AG(bs) = 14dBi; AG(ts) = 17dBi; Tx (bs) = 22dBm; Tx(ts) = 19dBm;
  - RSL (bs) = RSL(ts) = -88dBm; OFDMA(gain) = 12dB

    Results:
  - Down-link system gain = 22+14+17-(-88) = 141dB
  - Up-link system gain = 19 +17 +14 –(-88) + 12 = 150dB

- **Existing regulations limit the cell size due to downlink max. power limitation!**
- **Higher downlink power allowance is needed!**

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BW reservation in LE bands

-vision-

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New regulations – wish list

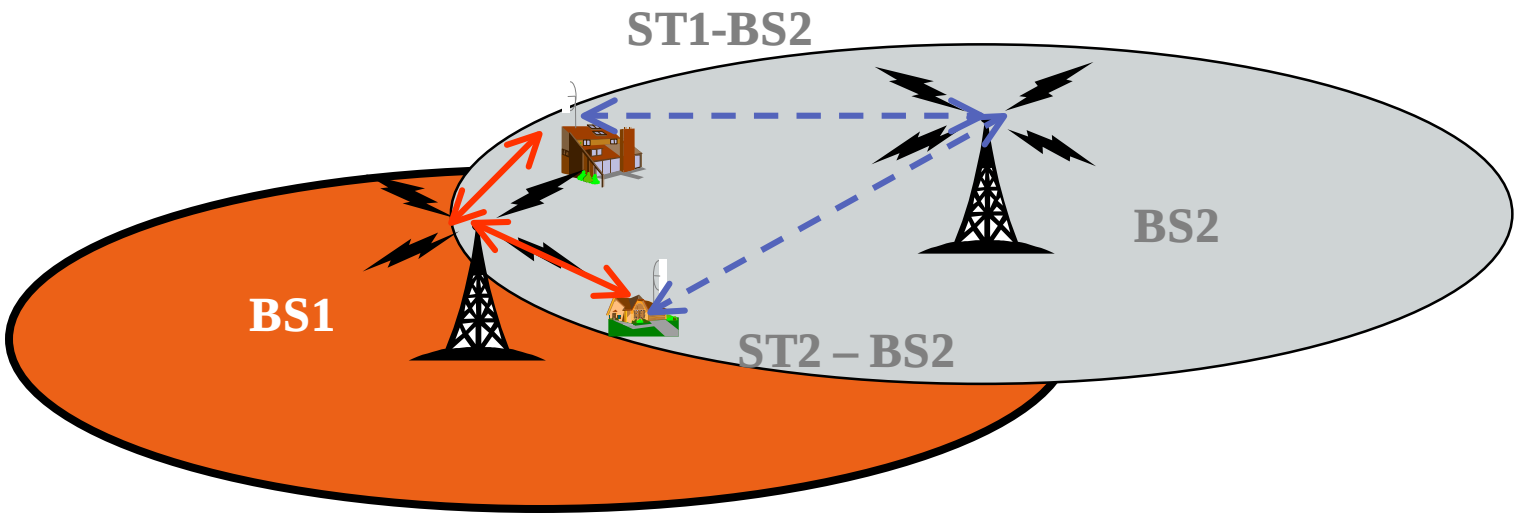
- Enforce **bandwidth reservation** rules
  - Provide a QoS environment for Access and LAN
  - PANs (FH and Ultra-wideband) to be kept outside new bands
- **Split capacity** between systems according to fairness criteria
- **Increase** allowed **down-link power**
  - Let new access technologies, as up-link OFDMA, to work

Dynamic Channel Selection

- **Co-channel co-existence in frequency domain**
  - **Define a grid of allowed channel centers**
  - **Define 1-2 allowed channel widths**
  - **Make Dynamic Channel Selection a mandatory mechanism**
    - Define thresholds for channel selection
    - **Define the channel bandwidth consistently with allocated spectrum**
      - Min. 12 ? Channels
  - **Limit the transmitted e.I.r.p. as function of co-existence behavior**

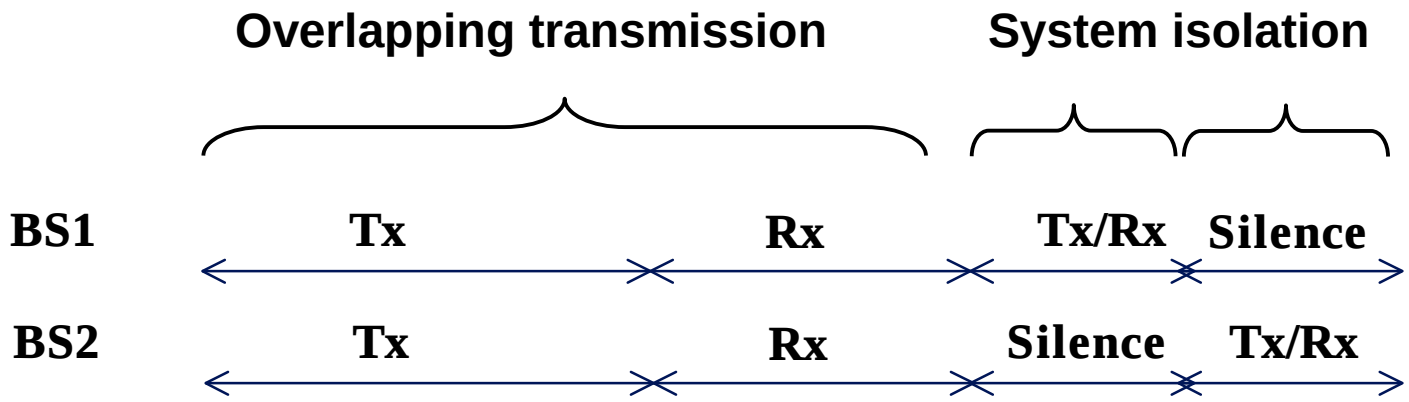
Adjacent channel interference problem

- TDD systems need a guard band equal with 2 channel widths
- An interference-avoidance mechanism is necessary



Ideal spectrum use

- Transmission that do not create interference
  - use same time, same or different frequencies
- In case of interference
  - time isolation



Co-existence in TDD

- **Same MAC frame duration – regulatory defined**
  - GPS synchronization of MAC frame start
  - “listening” synchronization of MAC frame start
- **Synchronization of Tx and Rx intervals**
  - works for “almost co-located” systems
- **Reservation of time-domain resources**
  - best interference avoidance
  - allows QoS
- **Use at least 3 sectors**
  - good frequency reuse
  - interference avoidance
- **Avoid interfering during Rx intervals**

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Inter-system communication

- Communication “puzzle words”
  - PCM, SC, OFDM, SC-FFT EQ., CDMA, DS, CCK, WCDMA, MC-CDMA, etc!

- Technology independent approach
    - enforce the **RESERVATION** approach
    - provide **fairness** between systems
  - Basic form of modulation / coding
  - **Minimal communication protocol**
    - **to be mandatory**
  - To be **defined** by regulatory rules
    - Radar detection algorithms are now defined for 5GHz

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Proposed new regulatory principles: Equipment classes

- Function of co-existence capabilities

	Class 4	Class 3	Class 2	Class 1
Sync MAC frames with GPS	yes			
Sync Tx period to other systems	yes	yes	yes	yes
Advanced inter-system communication	yes	yes	yes	
Synchronize both Tx and Rx intervals	yes	yes		
> 3 sectors	yes			

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Proposed new regulatory principles: Allowed power - example

- **Allowed_power(dBm) = k(coexistence_behavior) + min_power (dBm)**
  - **Min. power (e.I.r.p) = 20dBm (100mW)**
  - **Class 1**
    - **K = 0dB**
    - **Potential systems: WLAN**
  - **Class 2**
    - **k=6dB**
    - **Potential systems: WLAN**
  - **Class 3**
    - **k=20dB**
    - **Potential systems: MAN (Metropolitan Area Network)**
  - **Class 4**
    - **k=30dB**
    - **Potential systems: MAN**

Conclusion - what should be done

- Identify new harmonized LE spectrum in lower frequencies
  - Rural: below 1GHz
  - Mobile: below 3GHz
  - Administrations: press for moving P-P links above 7GHz
- Create a Question for defining the new Regulatory rules
  - Implement the **Resource RESERVATION** principle
  - Study co-existence of different equipment classes and **define the allowed power levels**
  - **Define technology-independent inter-system communication**
    - Simple protocol
    - Involve relevant standard bodies