A Proposal for a 5.2/5.8 GHz License-Exempt (LE) WirelessHUMAN™ Network Standard Based on Modified IEEE 802.11a PHY and IEEE 802.16.1 MAC Standards

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John Sydor
CRC
3701 Carling Ave
Ottowa, ONT, CA

Voice: 613-998-2388
Fax: 613-990-8369
E-mail: john.sydor@crc.ca

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A Proposal for a 5.2/5.8 GHz License-Exempt (LE) WirelessHUMAN™ Network Standard Based on Modified IEEE 802.11a PHY and IEEE 802.16.1 MAC Standards

John Sydor

Communications Research Center, Ottawa, Canada

Octavian Sarca

Redline Communications Inc, Toronto, Canada.

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Introduction

- A proposal for a system of autonomous/adaptive Base Stations containing multiple (24-35) microcells.
- A WirelessHUMAN solution that can easily interface with urban Fiber Optic backhaul networks.
- Designed for growth by allowing multiple independent service providers who would directly benefit from neighbourhood siting privileges.
- Based on the IEEE 802.11a MAC
- IEEE TDD/TDM (802.16.1)
- Discussion herein considers the “RF Management Sublayer”, which uses the MAC and PHY layers…..but only mediates the transfer of information for control of the PHY…..and only the RF characteristics of the PHY on a Base Station, Subscriber Station, and Network Level.

References

- http://www.crc.ca/milton/

  For propagation data, simulations, descriptions, etc.
- http://www.ieee802.org/16/tg4/contrib/802164c-01_15.pdf This Proposal
- http://grouper.ieee.org/groups/802/16/tg3/contrib/802163c-00_46.pdf A Proposal to Standardize Directive Antennas and Highly Sectored Cellular Hub Systems for Outdoor Point to Multipoint Communications.

Core Attributes of Proposal

- Antennas for outdoor WirelessHUMAN should have directivity and sidelobe constraints for Point-to-Multipont oblong microcells (petals)
- Microcells are arranged concentrically around a hub (Rosettes)

- First come…..first claim to a Space and Frequency defined service area.

- All additional base stations subscribe to a common set of rules governing:
  - Dynamic Spectrum Selection
  - EIRP control
  - Assignment of channels to a service space

Fundamental Physical Constraints on WirelessHUMAN

- Low UNII EIRP limits range in the MAN operational environment : 750-7000 Meters; ~1000 meters typically;
- 5250-5350 MHz Band is low power (17 dBm/MHz) and needs emission considerations re Satellite Imaging and the ITU
- 5725-5825 MHz Band may contain high power (40 dBm/MHz)
- Propagation environment is not homogenous or stationary which is good and bad;
- Co-Interference from other users of the spectrum is to be expected.
- Co-Channel users will be our own system in the form of intracell and intercell co-channel interference.

Operational Constraints on WirelessHUMAN

- Location of Hub Base Stations: real estate is expensive on tall buildings.
- Many base stations must be built.
- Will the capacity WirelessHUMAN delivers warrant interest from the subscriber: how fast is the link, is it better than conventional wireline? Is it worth it?
- Can a prospective service provider see a business case for WirelessHUMAN?

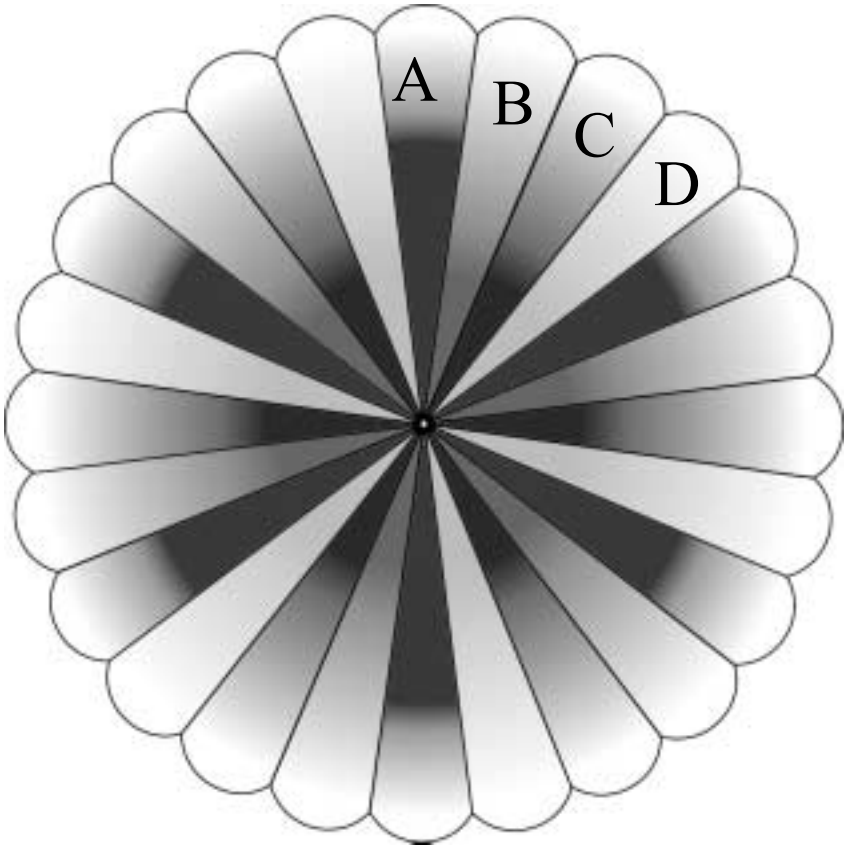
Macro-RF/PHY Attributes

- Beamwidth of 10-15 Degrees for base station and subscriber terminals (~50 nsec delay spread)=>oblong microcell or “petal”
- Sidelobe level @ -35 dBC at 60 degrees {see proposed mask}
- Linear Polarization with X-POL at –35 dB on Boresite.
- EIRP Control 23 to –7 dBm/MHz (Base Station)
- Channel Plan of 5 (preferred) or 4 IEEE 802.11a OFDM carriers per 100 MHz of Bandwidth.
- Channel distribution sequence spatially periodic around the hub;

  ie: reused frequencies repeated at the same angular separation.
- Overlapping petals usually allowing the choice of 2 or 3 channels.
- TDD operation with Tx/Rx duty cycles fixed (or slowly varying);

  with all base stations (petals) synchronized.

24 Petal Rosette with a Spatial Frequency Sequence Code for Petal Assignments



Frequency Sequence ABCD

Intermediate RF/PHY Attributes(base station)

- On power-up: monitoring of each petal on all 5 (4) channels for non-WirelessHUMAN activity at 5 GHz
- Data exchange from existing adjacent hubs containing:

- GPS Location
- Height
- Number of Beams
- Frequency Sequence Code
- EIRP per Channel
- Bearing of Beam #1
- Range of each SS, and
- Mean RSSI, C/I of each SS

Intermediate RF/PHY Attributes (Subscriber)

(Alignment assumed complete)

- Monitor all 4 (5) channels
- Collects and store mean RSSI; Interference Levels;
- Sends this information to host base station

Microscopic RF/PHY Attributes (Base Station)

- Monitoring of power in each 20 MHz Channel slot for each petal; Calculation of Noise Floor (RF Hardware function)=> RF Hub Control Computer
- Monitoring for other Rosettes on each channel on each petal for Hub/Base Station RF Management Messages {HBS/RFMM} =>RF Hub Control Computer or:
- Retrieves HBS/RFMM from a URL=>RF Hub Control Computer

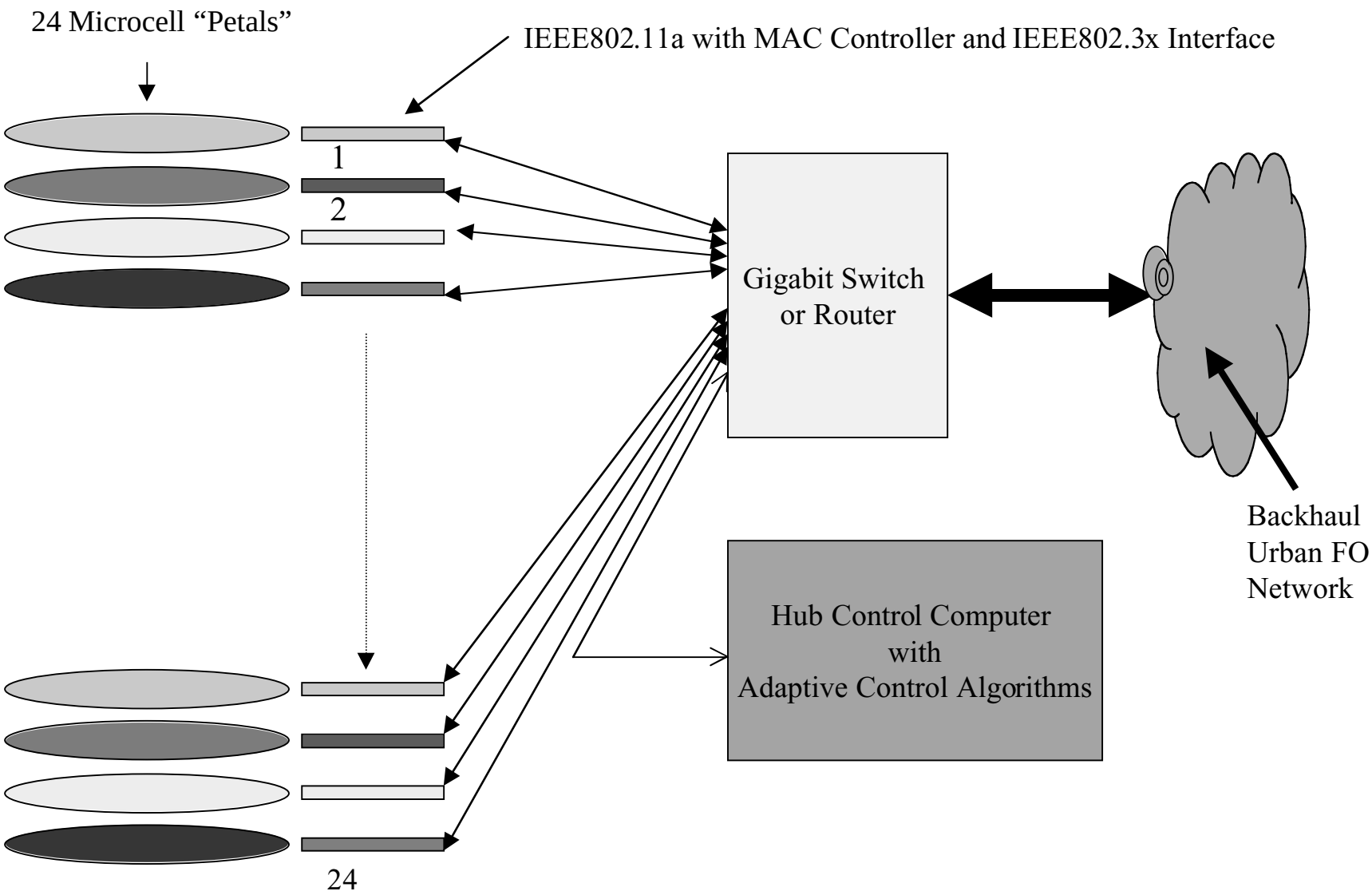
Hub Control Computer Attributes

- Creates a full azimuth map of other-system co-channel interference.
- Compares interference to acceptable threshold limits (Supplied by service provider)
- Uses data from HBS/RFMM
- Requires information on its own location, height, and direction of Petal #1 (service provider data)

  ==========➔ Runs a propagation path loss simulation algorithm with a co-channel interference calculator.

- ➢ Determines its Frequency Sequence Code
- ➢ Determines EIRP of Petals
- ➢ Generates it own HBS/RFMM
- ➢ Assigns terminals to petals based on SS/RFMM data
- ➢ Polls subscriber terminals to update RFMM

Hub Base Station Block Layout



HBS/RFMM

- Broadcast by a Rosette on all petals every 2-4 seconds
  or as continual stream embedded within the DL control frames.
- Filtered by MAC controller of Base Station and directed to the Hub Control Computer.
- Gives complete radiation characteristic of rosette and its subscriber terminals.

HBS/RFMM Message

- BSID: 2 bytes
- Height: 1 byte
- GPS: 10 bytes
- FSC: 1 byte
- Mag Bearing :2 bytes
- EIRPs : 4 bytes

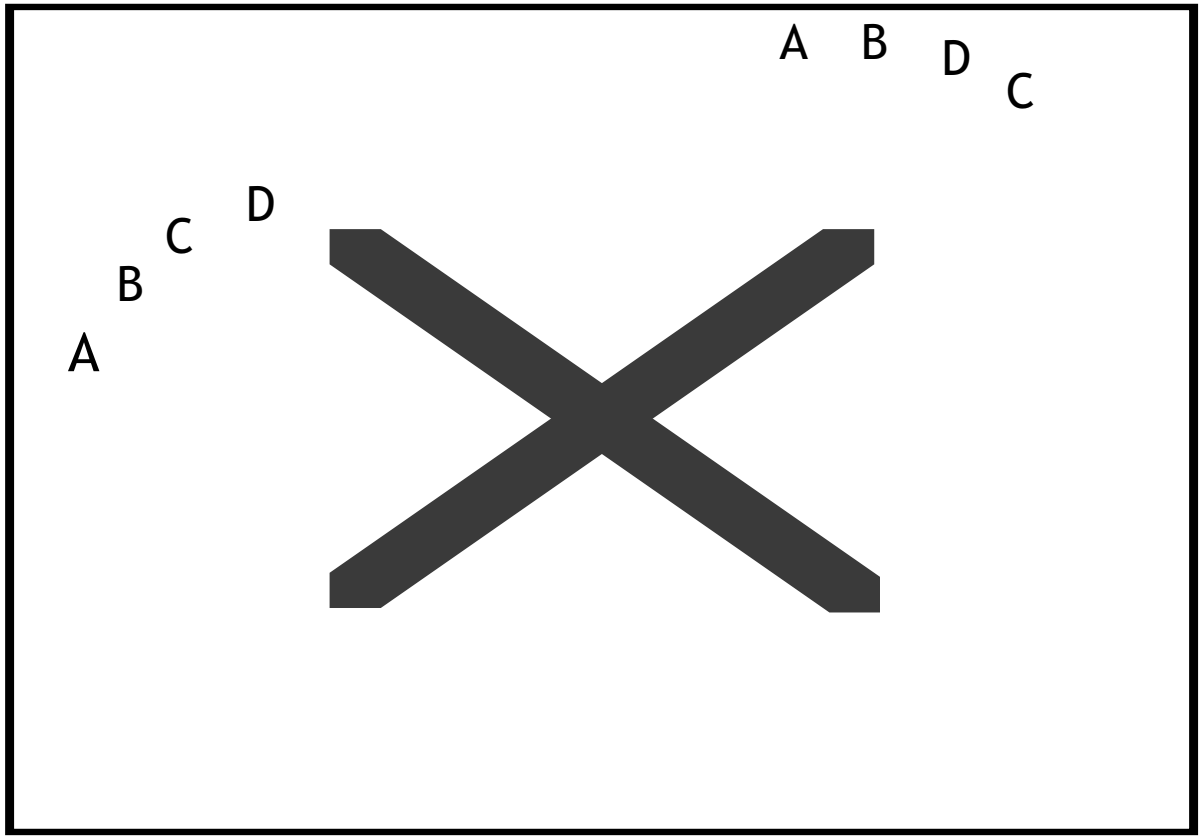
- Beam 1-24 SS data: 3 bytes per terminal
- Up to 36 Kilobits;
- Resolution of SS range is 100 meters.

Microscopic RF Attributes (Subscriber Station)

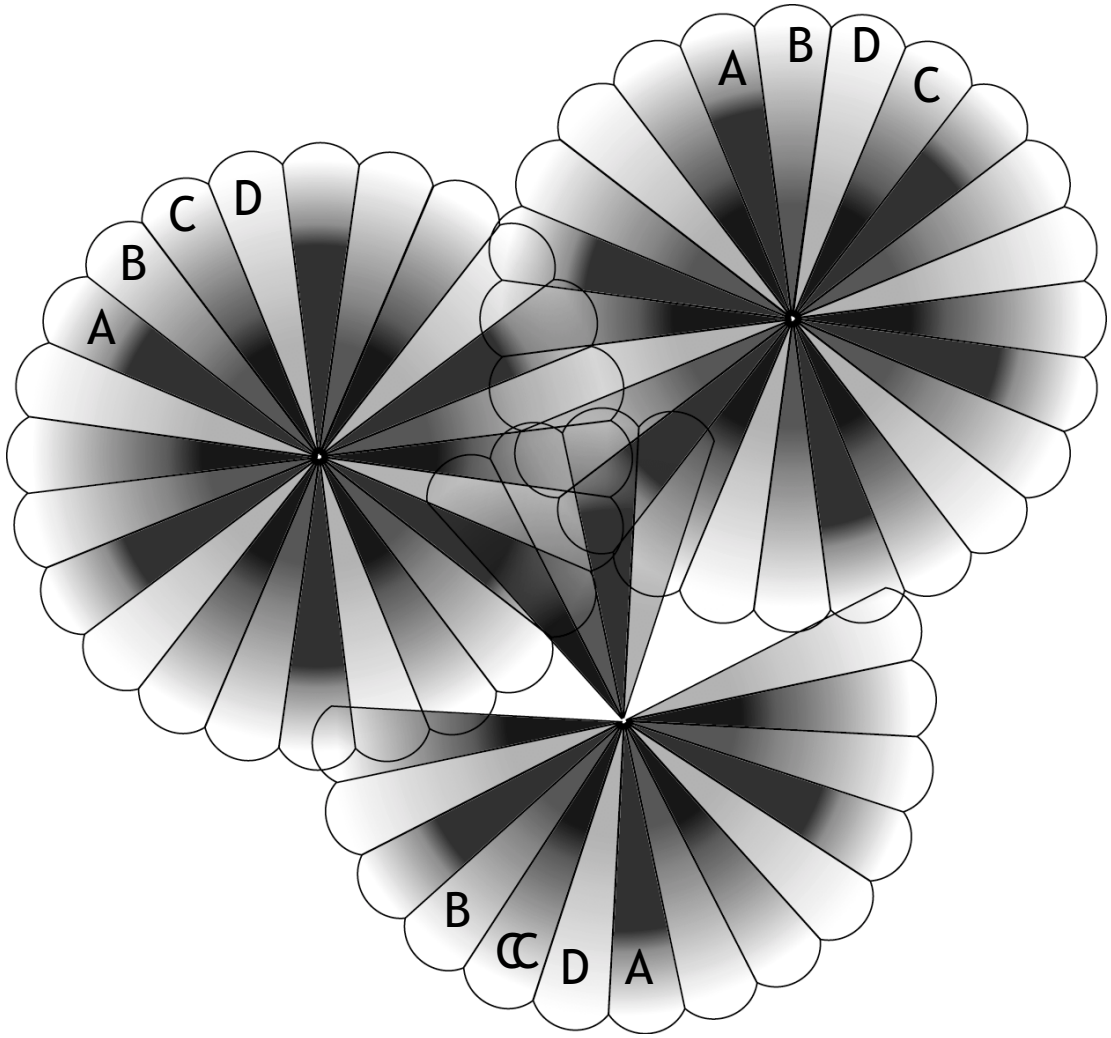
- Monitoring of power in each 20 MHz Channel slot for each petal; Calculation of Noise Floor (RF Hardware function)=> Subscriber Station microprocessor.
- Monitors downlink Petals on all 4 channels and creates a mean RSSI and C/I table for each channel.
- May be able to collect other useful data such a fading statistics
- Time Stamps data.

Subscriber Station Microprocessor

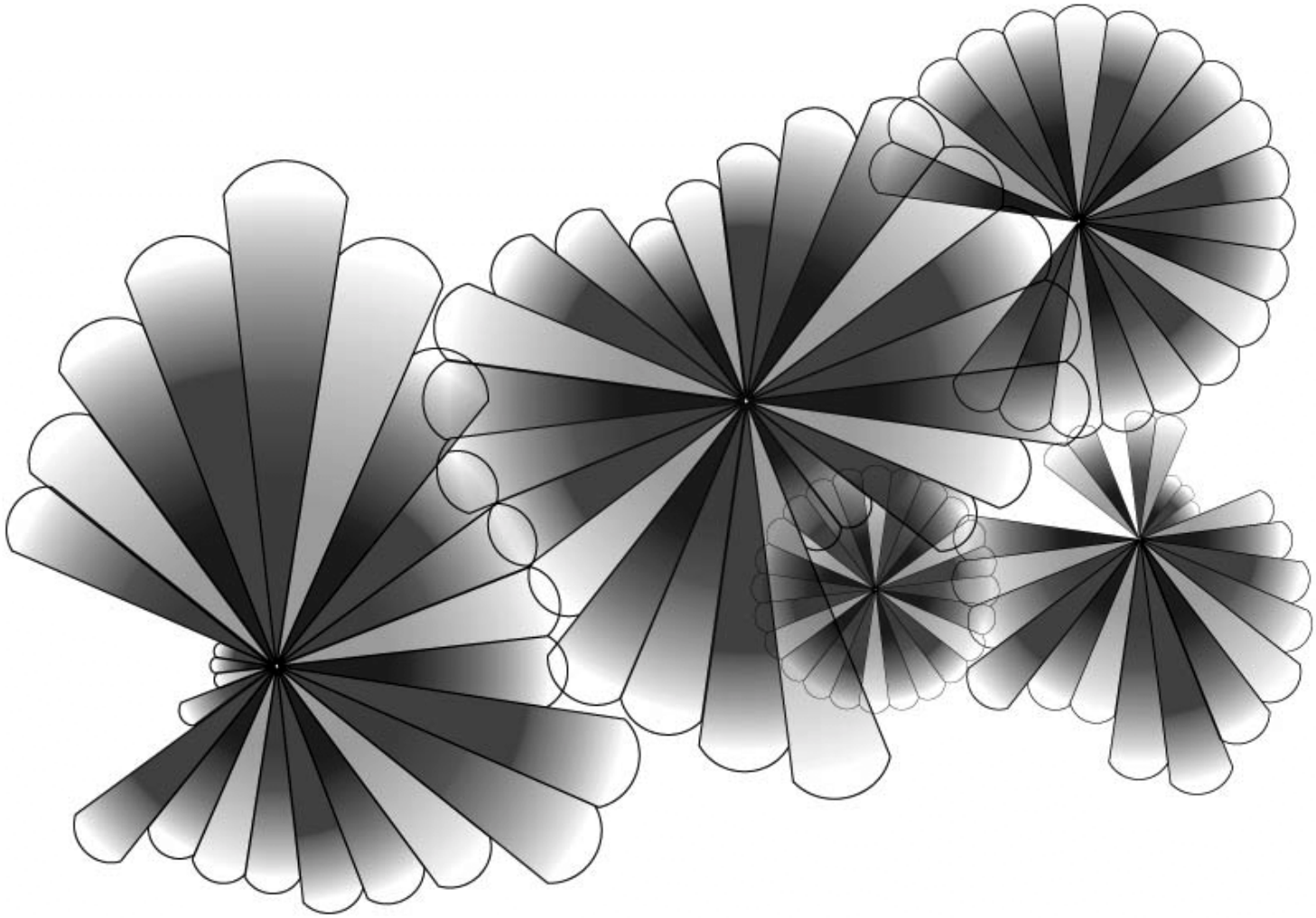
- Creates SS/RFMM which contains statistical data.
- Sends SS/RFMM as part of log-on instruction set.
- Updates SS/RFMM during dormant periods (eg: no activity for 1 hour)
- Responds to Hub Control Computer polled request for updated SS/RFMM



Two adjacent rosettes with differing FSC



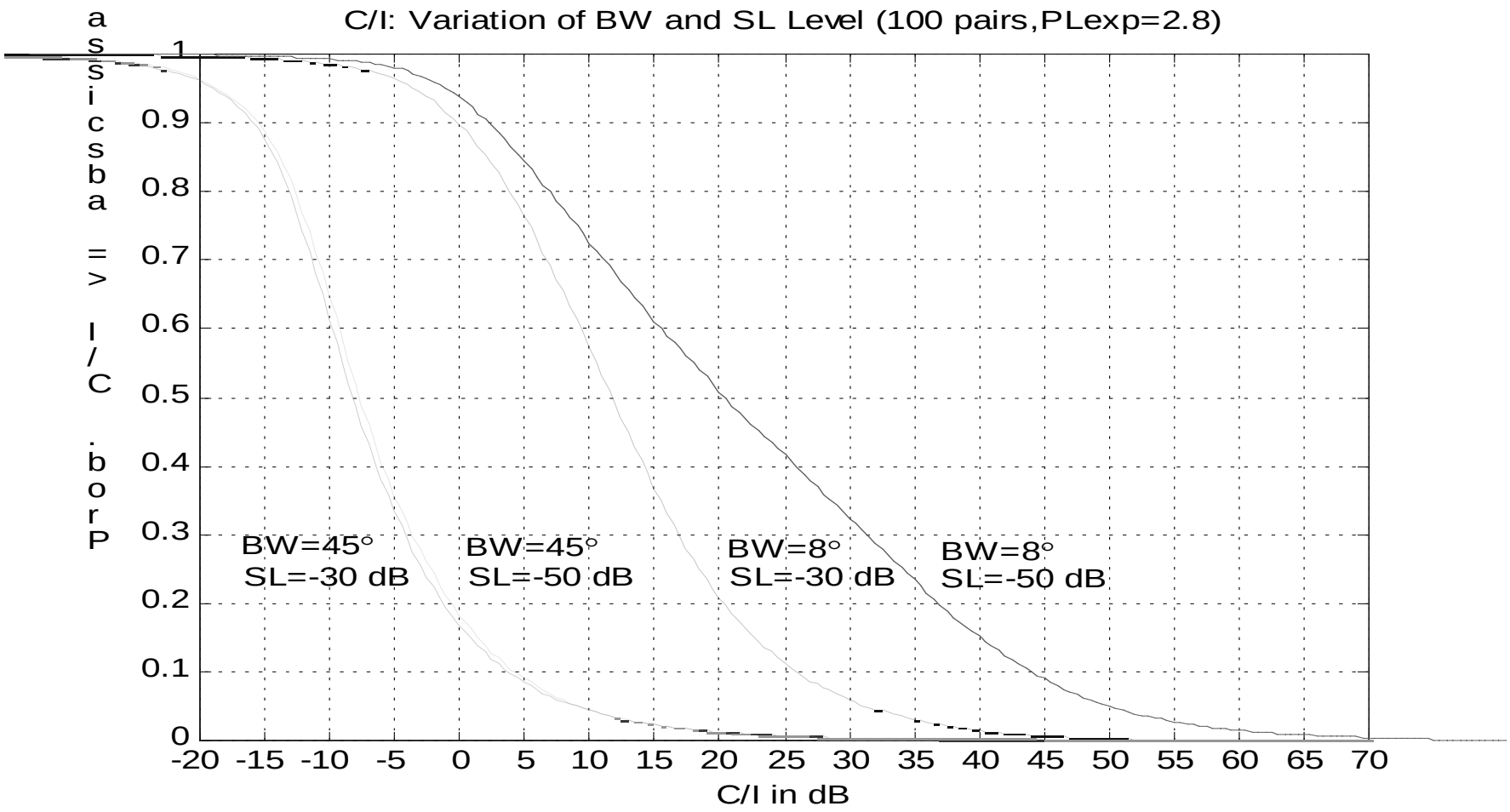
3 Rosettes with different FSC; Petal deactivation shown



Likely scenario with coverage over zones of varying path loss & blockage
Showing EIRP reduction, FSC variation, and Petal de-activation

Antennas

- 15 degree Beamwidth maximum
- 60 degree reuse spacing
- Beam Spreading occurs which can increase co-channel interference
- Side-lobe levels of –35 dB; front to back of –40 dB
- Small apertures: 25-35 cms.


C/I: Variation of BW and SL Level (100 pairs,PLexp=2.8)
Pr obability => C/I
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
C/I in dB
BW=45°
SL=-30 dB
BW=45°
SL=-50 dB
BW=8°
SL=-30 dB
BW=8°
SL=-50 dB

Deployment

- Hubs are independent entities.
- Service providers do not require coordination of installations…..they just have to be aware of the constraints.
- Prediction on coverage can be determined prior to installation….simply by monitoring with a test hub.
- Highest placement will not claim the largest service area.
- Billing information available from the Hub Control Computer.

Other Attributes

- TDD/TDM operation
- Downlink data capacity should be multi-megabit per second…..possibly as high as 400 Mbps downstream.
- Adaptive Bit Rate
- Limit number of users to 64 per petal
- Expect number of active users to be small thereby facilitating polling.
- Ethernet switches at hub; 802.3x interfaces

Satellite Spectrum Sharing
Preserving Spectrum for Terrestrial LE Applications

- Directivity has been recognized by co-channel satellite users as an acceptable method of controlling co-channel inteference.
- In Canada through the RABC forums, both ICO and Globalstar (users of 5150-5250 MHz Uplink Spectrum) have gone on record…..acknowleding that 27 dBm/MHz for outdoor point-multipoint MANs using directivity will be tolerable.
- Hub stations according to this proposal would:

➢ Negate the possibility of the worst case scenario that satellite users site

➢ Lower the EIRP into orbital SAR arc

➢ Significantly lower the spurious RF due to scattering

➢ On a per terminal basis, be less problematic than current 802.11a

Conclusion

- **Directivity and Side-lobe level need to be standardized for outdoor LE applications.**
- **A base station or hub must broadcast the equivalent of a HBS/RFMM.**
- **A subscriber terminal must broadcast the equivalent of a SS/RFMM**
- **RF monitoring capability must be identified and included at the PHY level.**
- **TDD operation**
- **EIRP Control of base station and subscribers**
- **First come……first claim on spectrum and microcell area.**
- **All additional base stations subscribe to a common set of rules governing:**
  - **Dynamic Spectrum Selection**
  - **EIRP control**
  - **Assignment of channels to a service space**