

Cognitive Radio Messaging for 802.16h Applications

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Purpose:

Present Cognitive Radio Messaging for 802.16h Applications

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Cognitive Radio Messaging for 802.16h

Applications

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A LE Wireless LAN creates a physical coverage area in:

>space: By EIRP, antenna radiation pattern, direction of radiation, polarization of radiation, propagation conditions.

>time: duty cycle, offset wrt to a reference clock.

>frequency: Channel Bandwidth, Centre Frequency

These 3 fundamental qualities delineate Co-Existence.
Co-existing systems can negotiate their use.





What independent co-existing wireless networks can do with each other:

- > Avoid each other
- > Inform each other of local conditions, including CCI and spectral occupancy (altruism)
- > Respond to each other's presence
- > negotiate on the basis of equivalency


But they can't control each other.....






Proposed Co-existence solution:

All network entities, both base stations and subscriber stations periodically transmit a RF Emission packet (a MAC PDU) that can be demodulated by all others...including co-channel receiver/interferers.

- > The packet would contain emission information relating to the space, time, frequency, & identity attributes of the emitter.
 - > It would contain all the information necessary to drive a CR co-existence algorithm, if one were to be applied.
- 



Messaging Proposal:


- > Will work with both FDD and TDD
 - > Requires a fixed channel bandwidth and demodulation (propose 10 MHz & 3.5 MHz)
 - > 8 messages in total in this proposal: all that is needed for CCI control.
- 

MAC PDUs

- > Insert MAC PDU either in DL Burst # 1 or UL Burst #1
- > Mandatory BPSK - 1/2 @link EIRP
- > BW of operation:
 - 1) 10 MHz & 3.5 MHz @ 5 GHz
 - 2) 7 MHz & 3.5 @ 2.4 GHz & 3.5 GHz
- > periodicity ~ 1/sec



MAC PDUs

- > One uplink and one downlink MAC PDU
 - > Contains immediate emission characteristics of radiator
 - > Identifies radiator in terms of IP and Geographical coordinates.
 - > Specifies timing and frequency occupancy characteristics of the emitter.
 - > Attached to every downlink and uplink frame but can be considerably reduced in content most of the time to reduce overhead.
- 

SS_MEM MAC PDU.

BS_ID	Sector_ID	BS IP add	DL EIRP	Uplink RF	FS#	NMS IP	Timing
-------	-----------	-----------	---------	-----------	-----	--------	--------

ST_MEM broadcast every 1 second (in full form) on downlink by the BS

Some of its Parameters:

- BS_ID: Identifies the base station (sector) broadcasting the SS_MEM message.
- Sector ID: GPS location, beam width, direction, antenna height...etc.
- BS_IP; Base station IP address
- DL EIRP of burst
- Uplink RF: Uplink RF channels in this sector
- FS#: Frame sequence number
- NMS IP: IP address of network management system
- Timing Stamp: Duty cycle, ref clock of TDD DL frame/ TDD UP frame
- Etc

SSURF MAC PDU

BS_ID	Sector ID	Fr Seq#	APL	EIRP	GeoPl	NMS IP	Ch _Statre
-------	-----------	---------	-----	------	-------	--------	------------

SSURF is sent by the SS every ~ 1 sec (in full form)

Some of its Parameters:

- BS_ID: Identifies the base station (sector) of the SS_MEM message.
- Sector ID: GPS location, beam width, direction, antenna height...etc.
- Of Sector
- FrSeq#: frame seq numbe
- APL: Parameters of SS antenna, BW, direction, gain, etc.
- EIRP: Uplink EIRP of this burst
- GeoPL: GPS of SS, Range, height, etc
- NMS IP: IP address of network management system
- Ch_State: link condition, mean fade rate, mean sign strength, etc.
- Etc

SNMP Messages

The assumption is made that all LE emission devices are IP addressable. This is a fundamental assumption for the co-existence mechanism proposed herein.

Six SNMP control messages are proposed. These are generated and received by the SS, the BS, and the Network Management System (CR-NMS).

SNMP Trap and Set Messages

- 4 Messages.
- Act as interference information carriers and BS/SS reconfiguration messages.
- Trap messages directed to the CR-NMS by the BS and SS; which can in turn re-address them to a foreign CR-NMS.
- Set messages directed sent by a CR-NMS only to its BSs & SSs.
- Trap messages can act as annoyance or spamming messages; reiterating a victimized systems' RF interference state via the IP route....annoying the victimizing transmitter

SNMP Trap and Set Messages

- **BS_CCID_IND**
- This is a SNMP trap message sent by a BS to CR-NMS when co-channel interference is detected at BS.
- · SS_NUM: total number of subscriber stations for which interference events were noted.
- · SS_ID: the subscriber stations ID that causes the co-channel interference
- · Sector_ID: the sector ID of the subscriber stations that cause interference
- · Source base station ID: the BS ID that sent this trap message.
- · Source sector_ID: the antenna sector that detects the co-channel interference.

- The CR-NMS can reformat this message and send it to the CR-NMS associated with the SS causing the interference in cases where the second CR-NMS is not associated with the first.

SNMP Trap and Set Messages

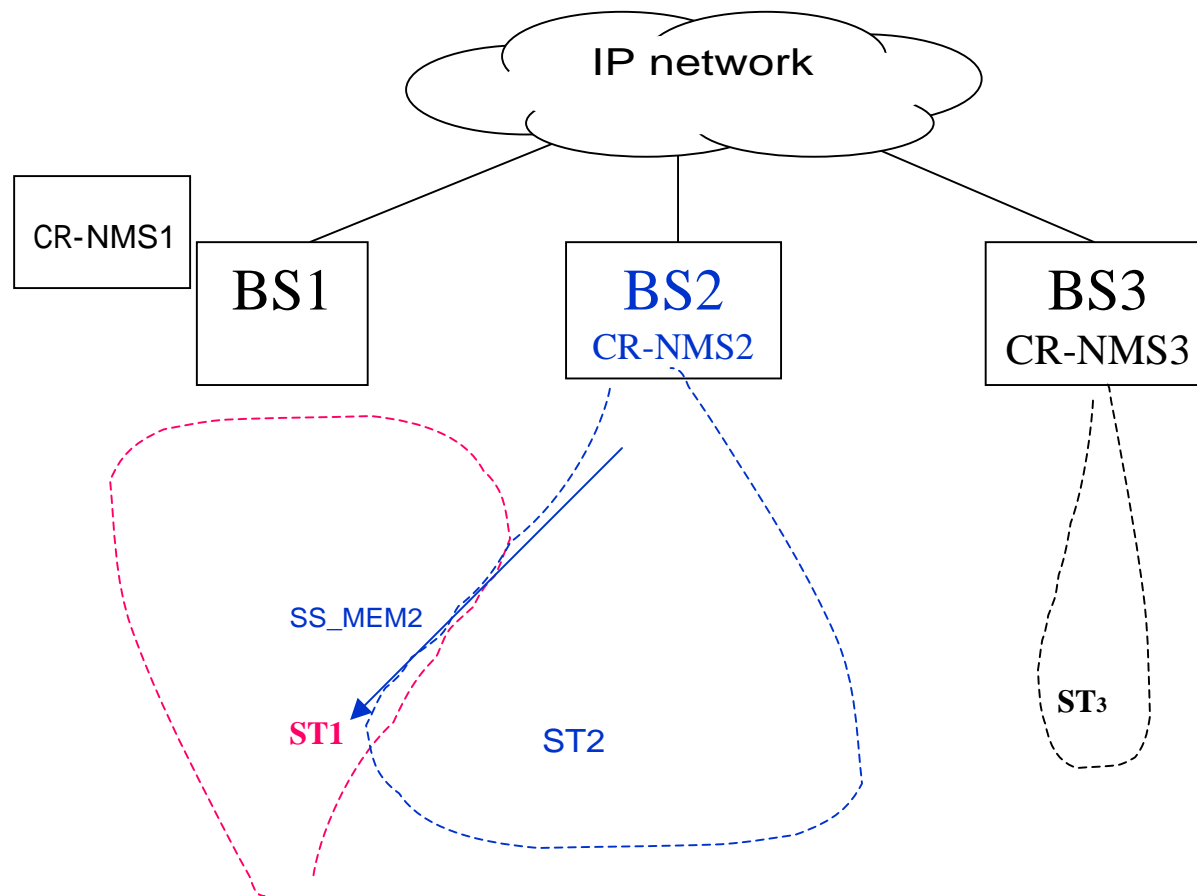
- **SS_CCID_IND**

- This is a SNMP trap message sent by a SS to CR-NMS when co-channel interference is detected at SS.
- BS_NUM: total number of base stations from which CCI interference is detected.
- · BS_ID: the base station IDs causing CCI
- BS_IP: the IP address of the BS causing CCI
- · Sector_ID: the sector IDs of the base stations causing CCI
- · SS_ID: the SS that sent this trap.

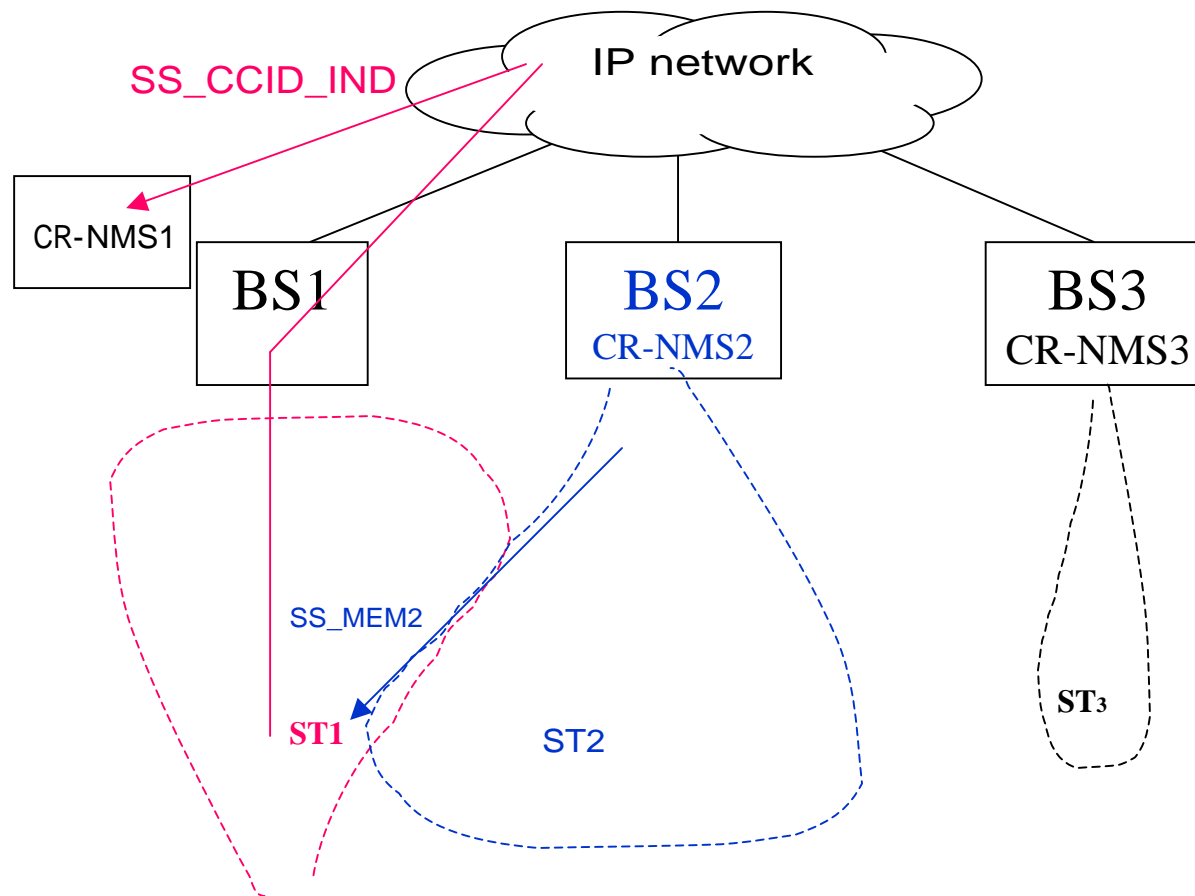
SNMP Trap and Set Messages

- **SS_CCID_RSP**
- **BS_CCID_RSP**
- Execute change SNMP command: CR-NMS directive to BS and SS
 - EIRP for the specified SS. This is a reduced/increased EIRP value for this SS based on cognitive radio algorithm.
 - Downlink/uplink frequency change.
 - Re-registration request to a new BS
 - Specification of allowable uplink timing slots.
 - Adaptive antenna configuration parameters for reception/transmission.
 - EIRP for the specified BS

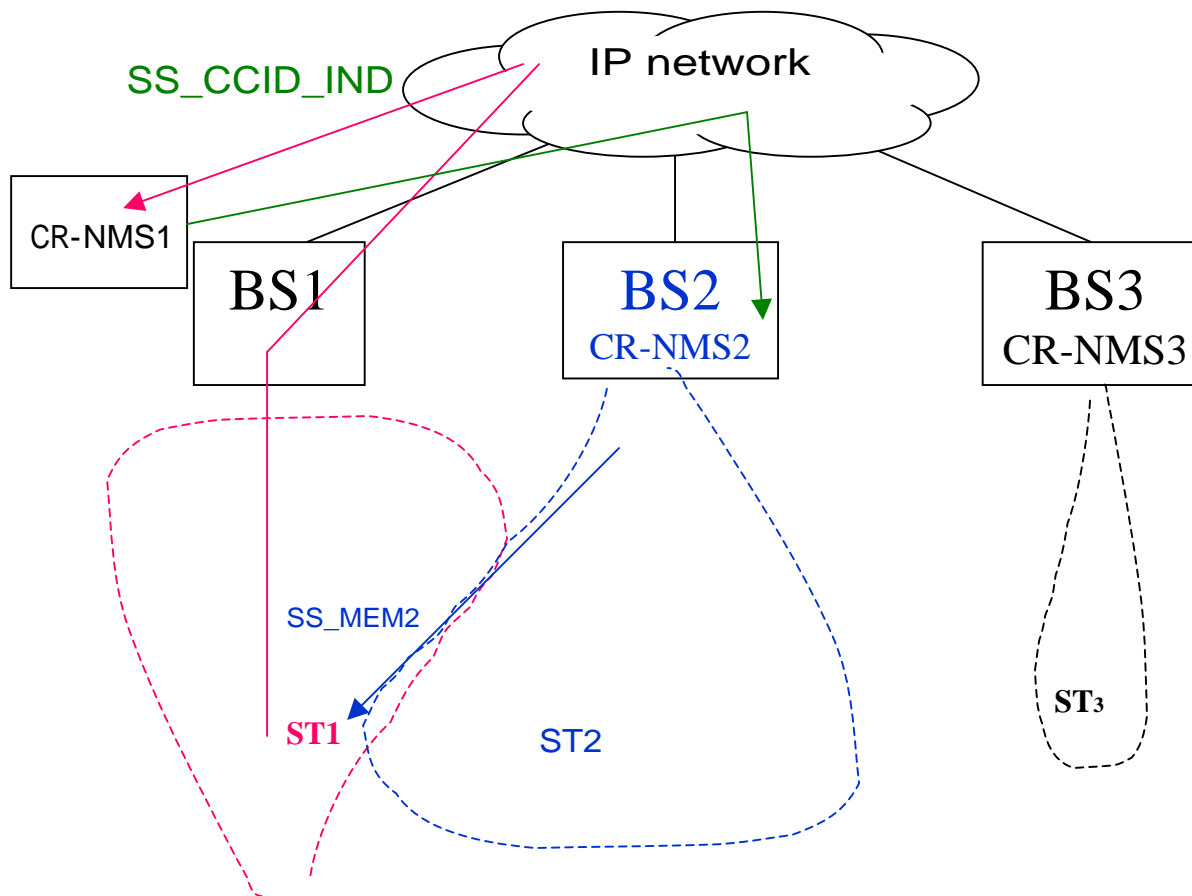
BS2 Downlink **SS_MEM2** received by ST1



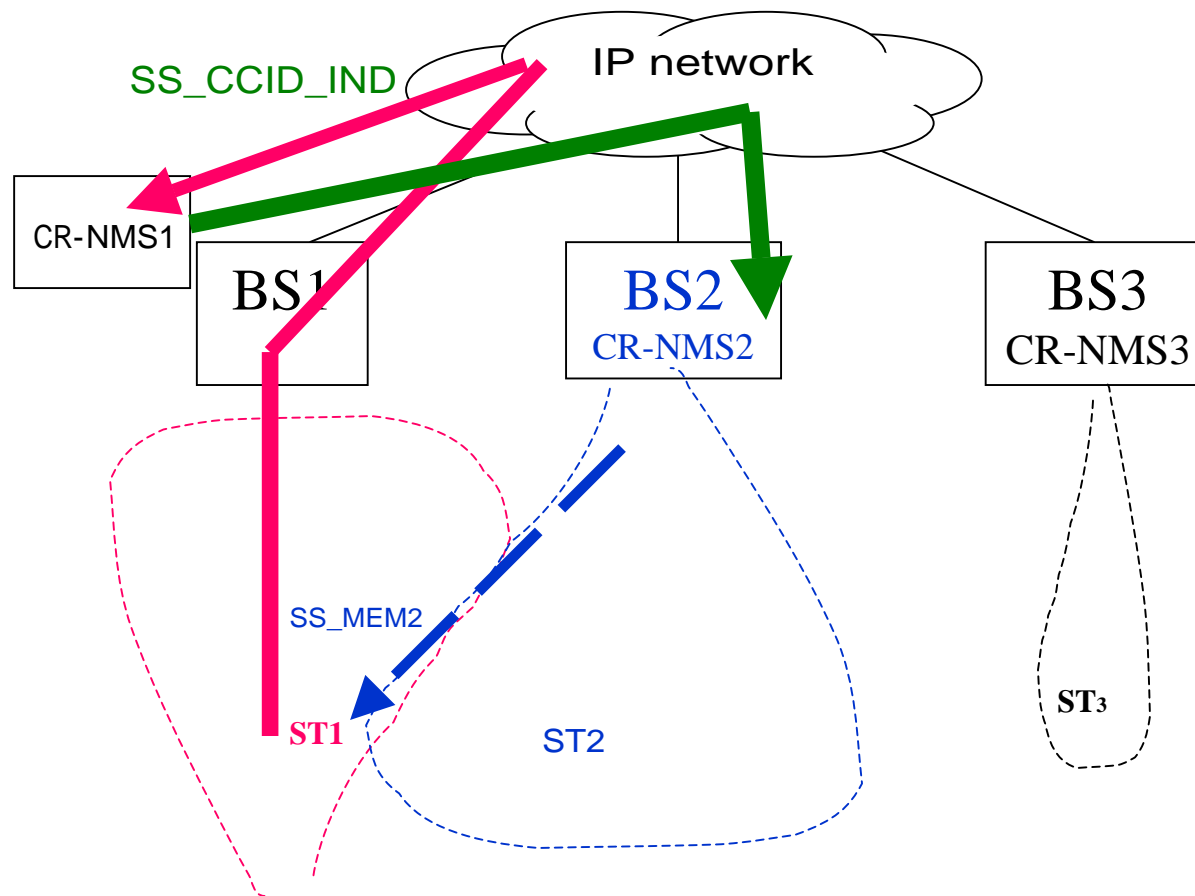
ST1 generates a **SS_CCID_IND** SNMP message and sends it to CR-NMS1



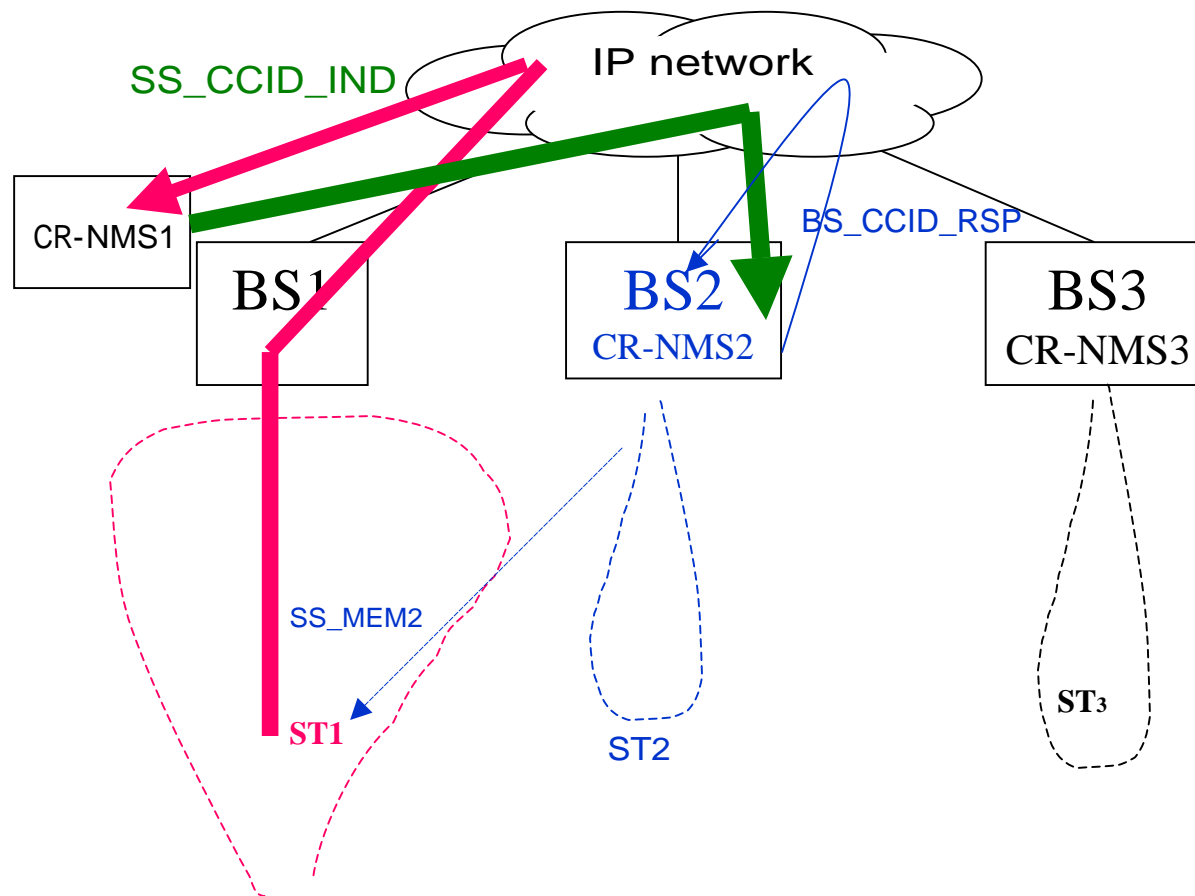
CR-NMS1 generates and **SS_CCID_IND** SNMP message and sends to CR-NMS2



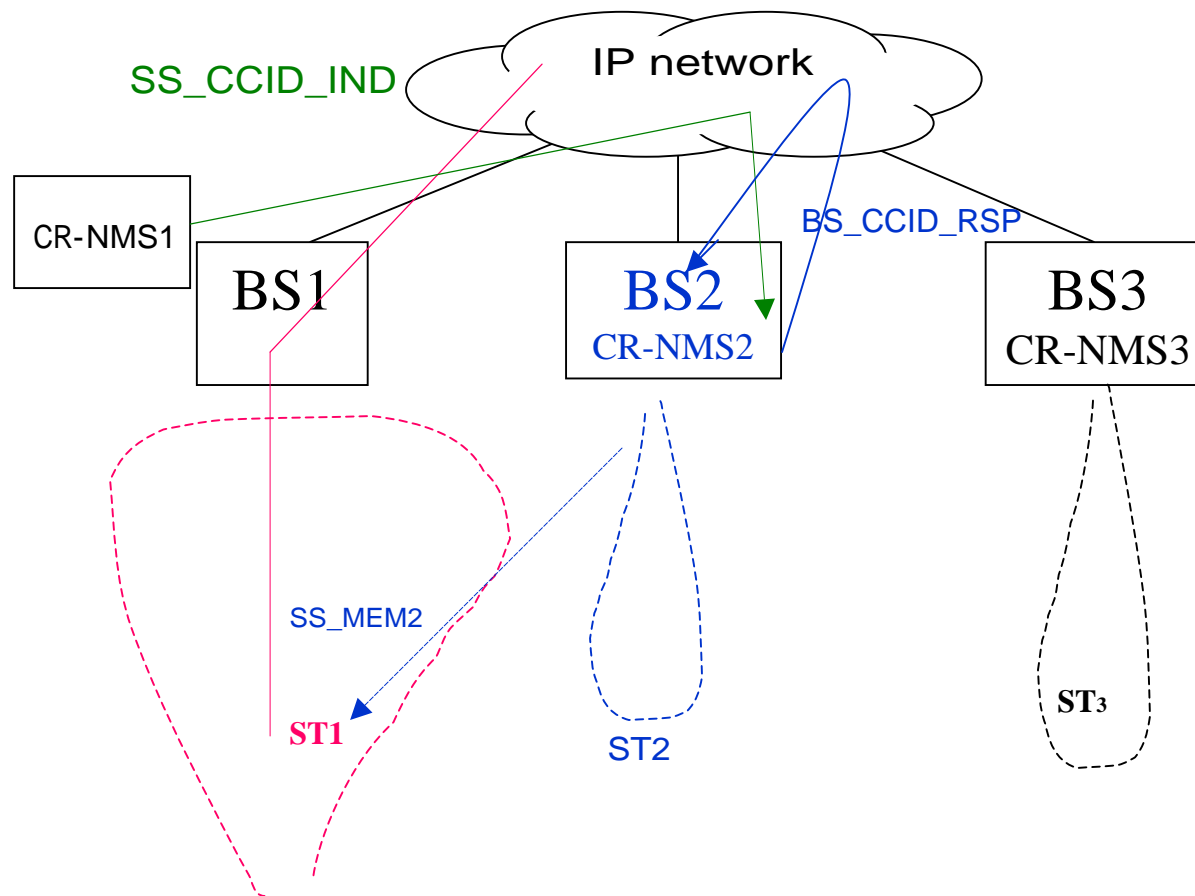
CR-NMS2 may take no action, as interference increases, so does SNMP messaging level from CR-NMS1



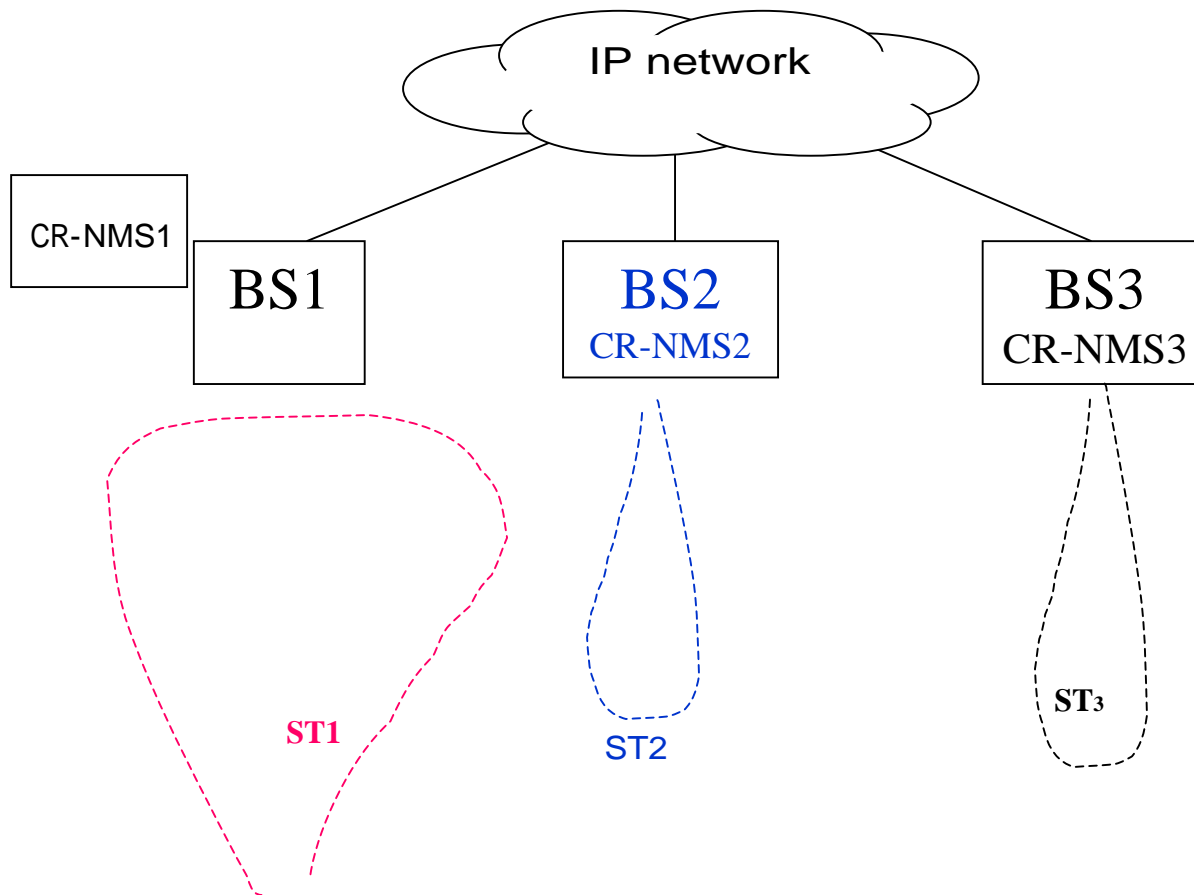
CR-NMS2 now receives high SNMP level of SS_CCID_IND “SNMP interference” such that functioning of BS2 is compromised. CR-NMS2 reconfigures emission of BS2, lowering SS_MEM2 levels to ST1. This is done by sending a BS_CCID_RSP message to BS2.



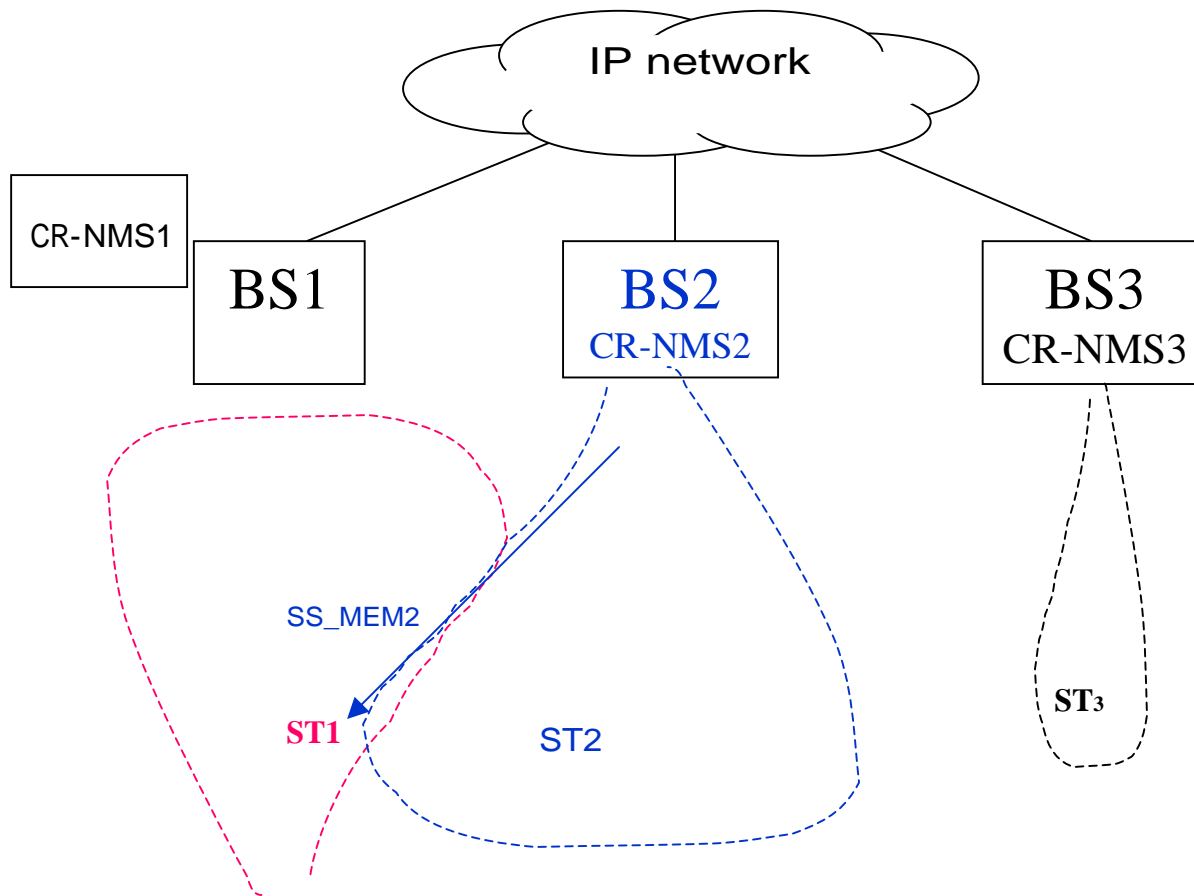
SNMP annoyance messaging decreases when RF interference decreases and a co-existence level is achieved.



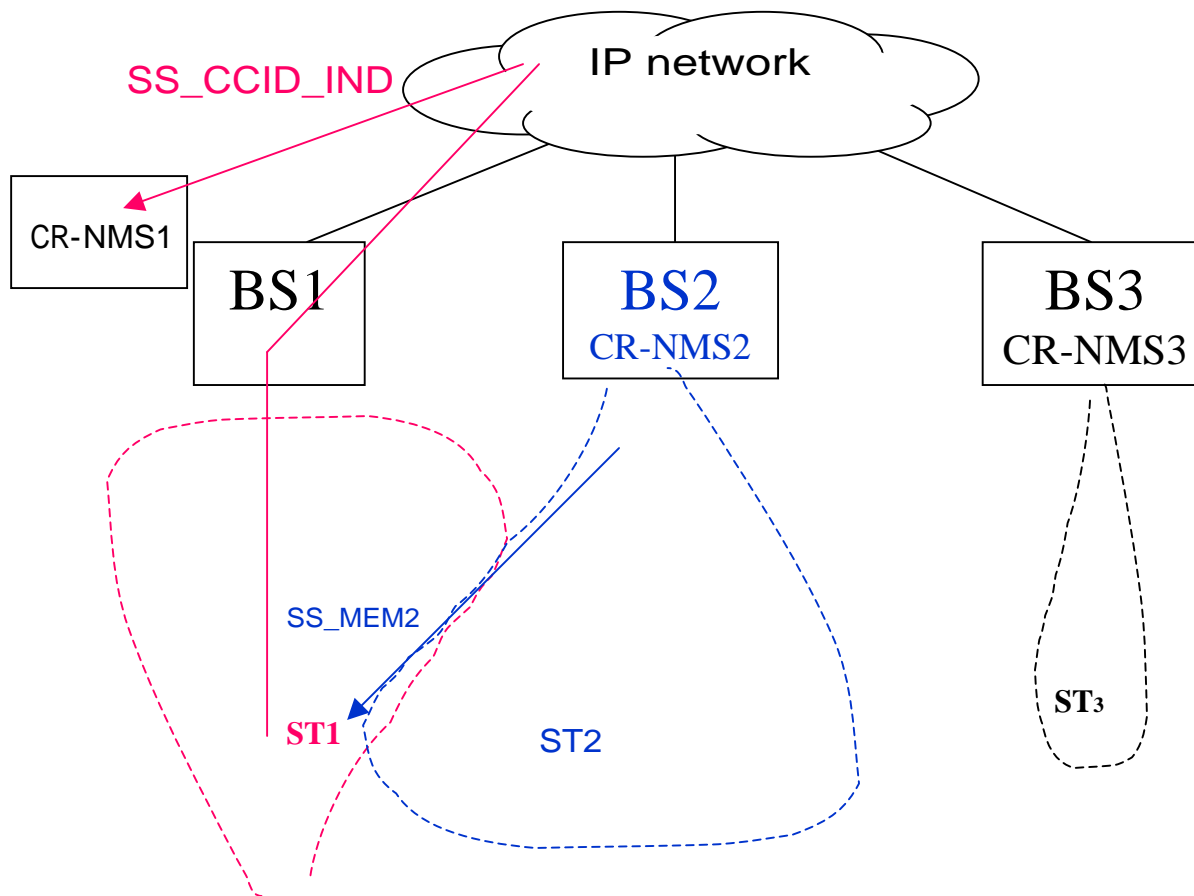
With no RF interference, SNMP messaging drops as well



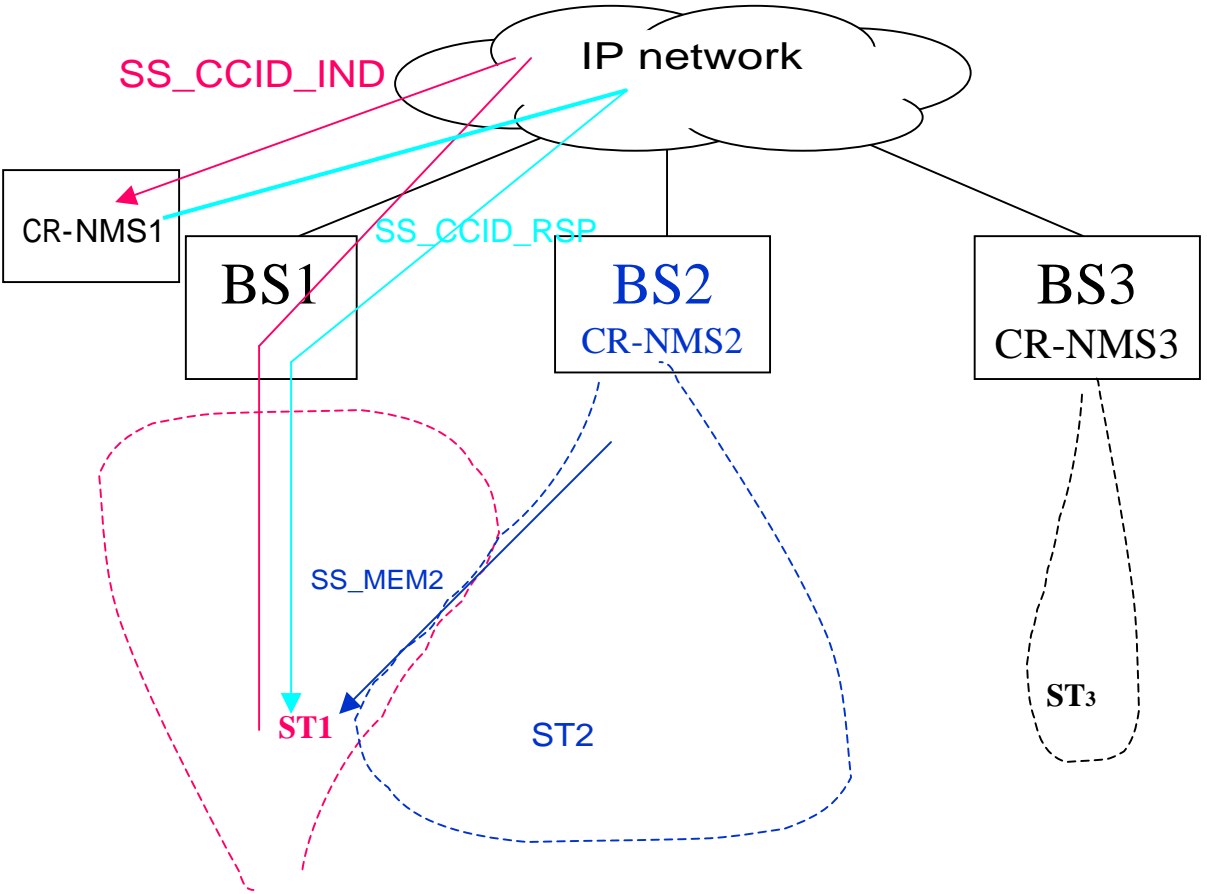
Alternatively when BS2 Downlink **SS_MEM2** received by ST1.....



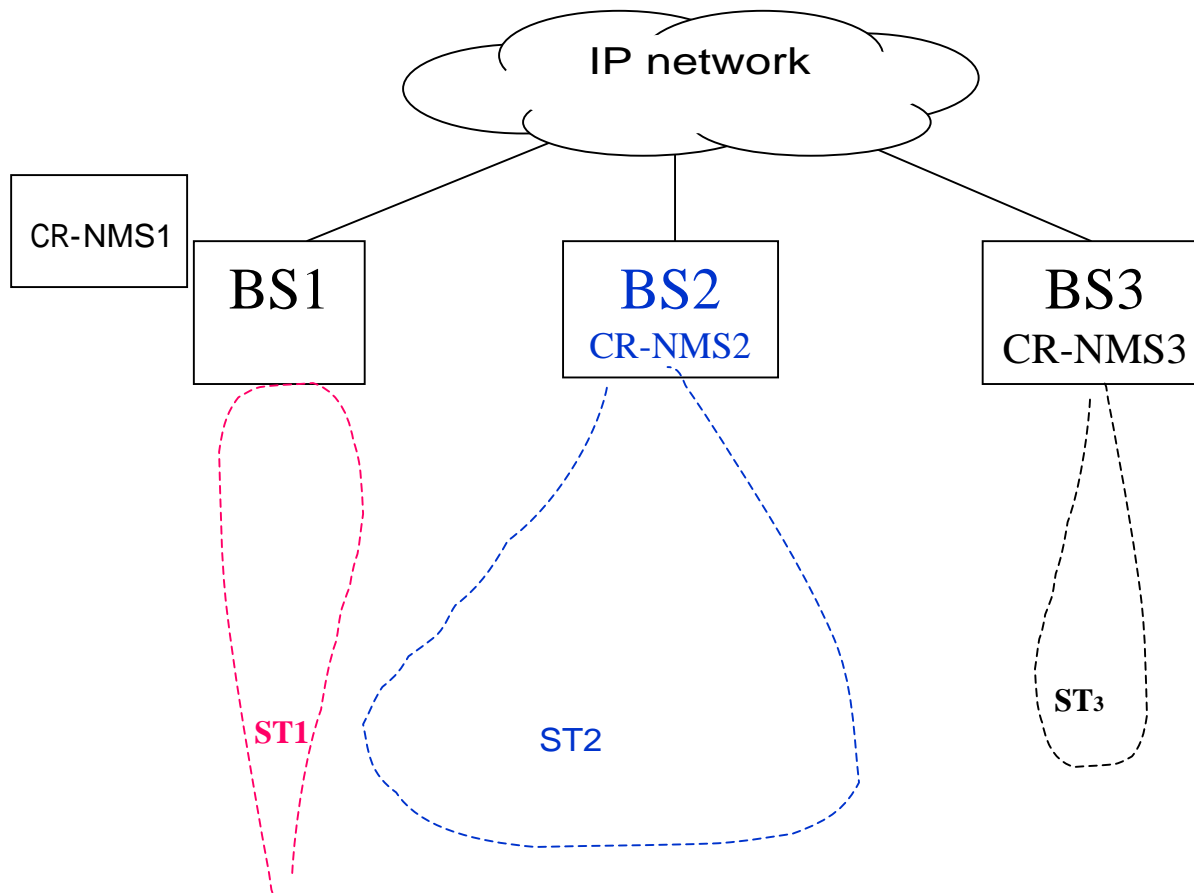
We can still have ST1 generate a **SS_CCID_IND** SNMP message and send it to CR-NMS1... but



CR-NMS1 generates a **SS_CCID_RSP** SNMP message and sends to ST1 instructing it to change its beam pattern to eliminate SS-MEM2



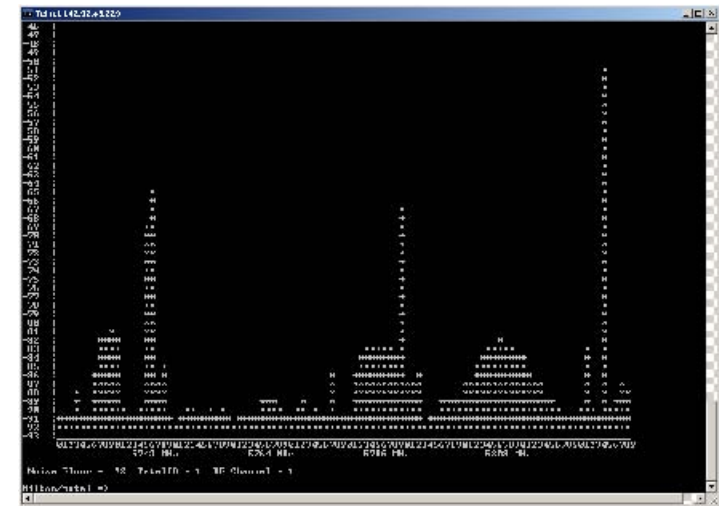
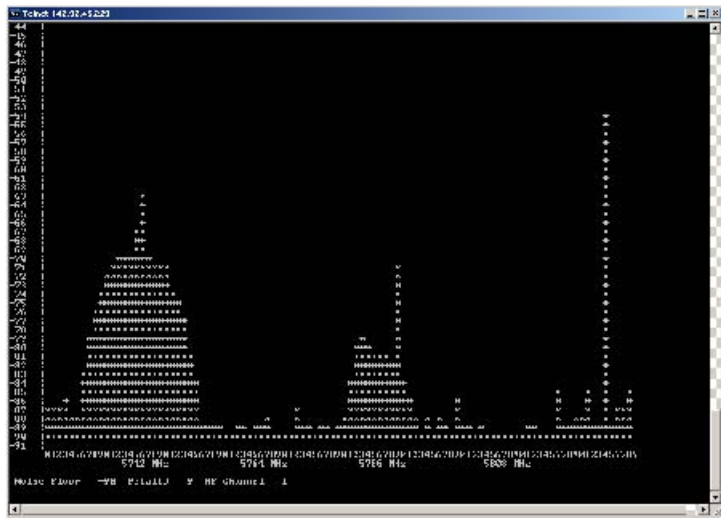
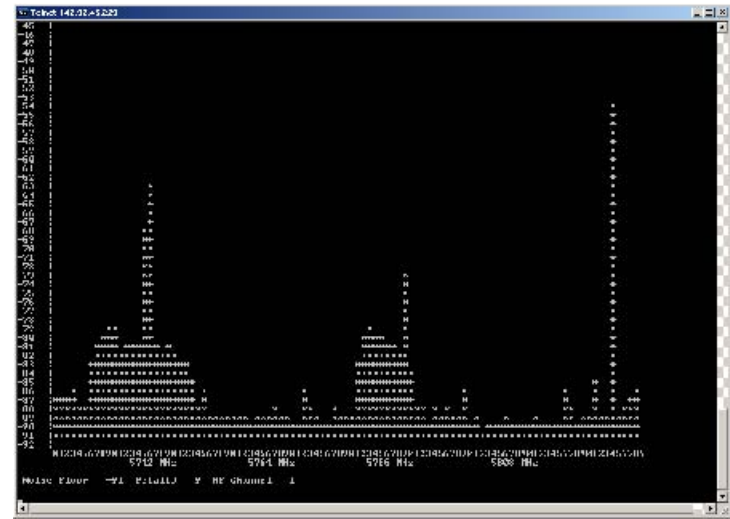
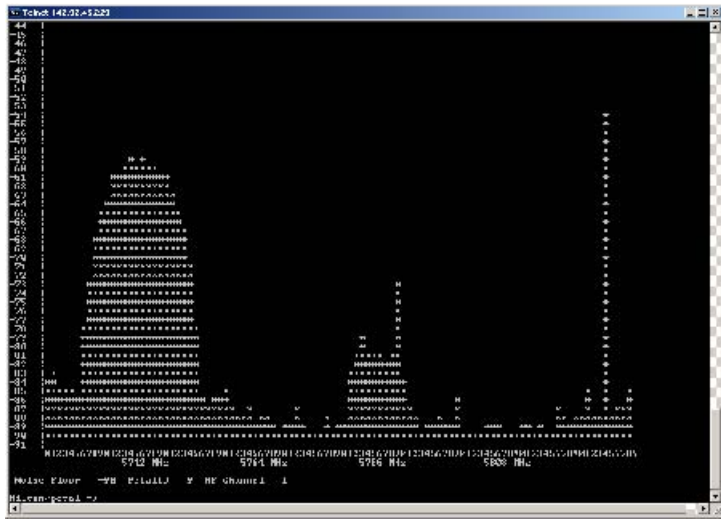
Again creating a situation of co-existence



SNMP PSD Messages

PSD needs to be taken to determine level of interference that is below detection threshold of terminals and to identify white spaces, occupancy, non-IEEE 802.16 interference, etc...

- **PSD_REQ** : Request a PSD to be taken by a SS or BS
- **PSD_RSP** : PSD Data field sent by the SS or BS to the CR-NMS



PHY Layer Sensed Info: PSD snapshot as undertaken by CRC CR System in 5725-5825 MHz, CCK signal -80 to -60 dBm & Interference on 5808 shown



Issues

- >Symmetry: Uplink and Downlinks of interfered with terminals will likely be mutually interfering.
- >Spatial Claim: how do we resolve the coverage area claimed by two interfering networks...unfairness issues?
- > Trade-off between changing one's emission characteristics and requesting a change to another network.
- >Etiquette? Is the time now?
- >First come/First Claim

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Summary

- > Space, Time, and Frequency will be the currency of Co-existence... LE systems negotiate for this.
- > Identity of all LE negotiators must be known.
- > Negotiating LE systems must have a common knowledge base...this is created with the first incidence of interference by using proposed Tagged Headers as MAC PDUs in 802.16h.
- > This proposal introduces the concept of a RF to IP information feedback path that forces negotiation.
- > Co-existence becomes achieved by negotiations between cognitive radio entities residing in the NMS.

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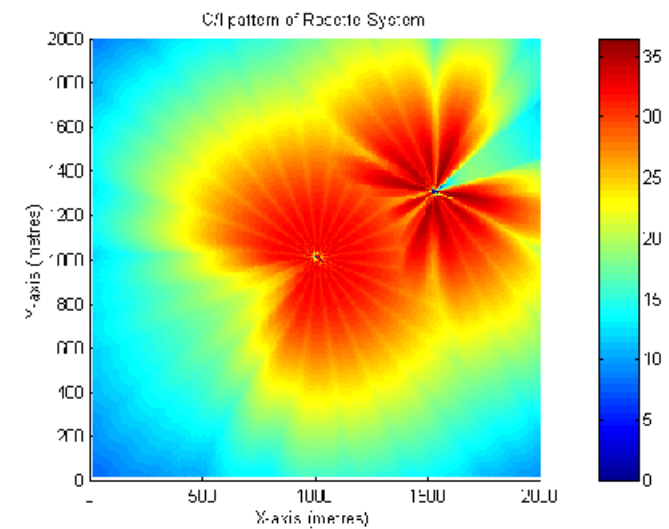
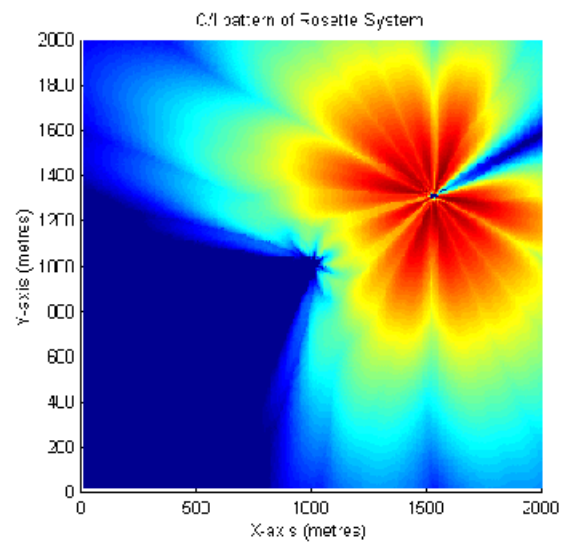
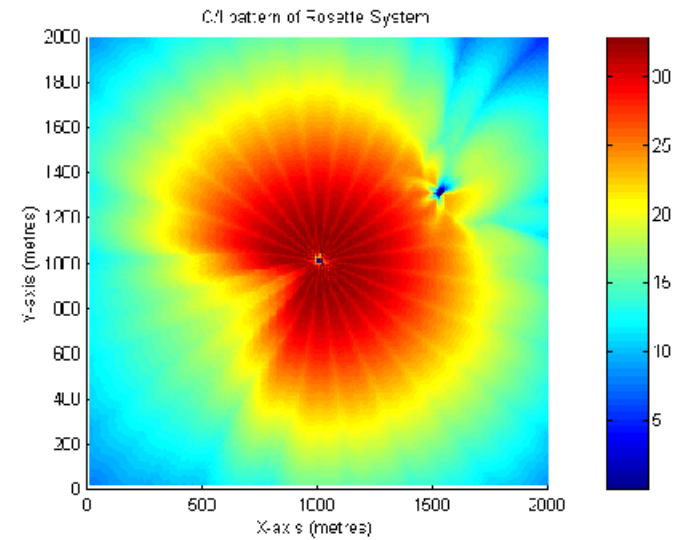
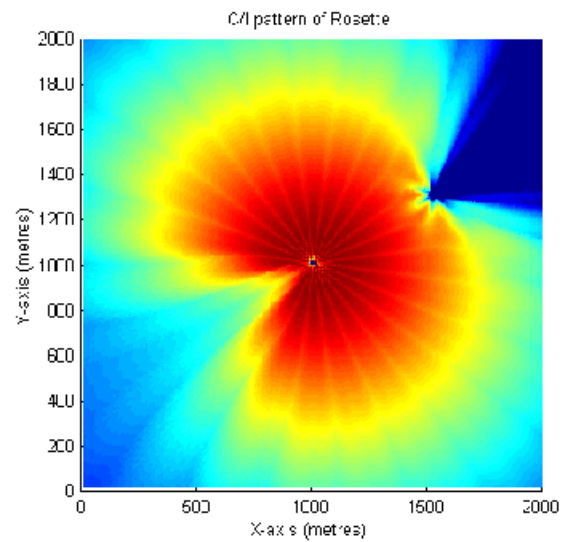


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Simulation of overlap of 2 CRC CR Rosette Systems to achieve increased capacity over a common area





Thank You

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