Cognitive Radio Messaging for 802.16h Applications

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Purpose:

Present Cognitive Radio Messaging for 802.16h Applications

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 or 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**

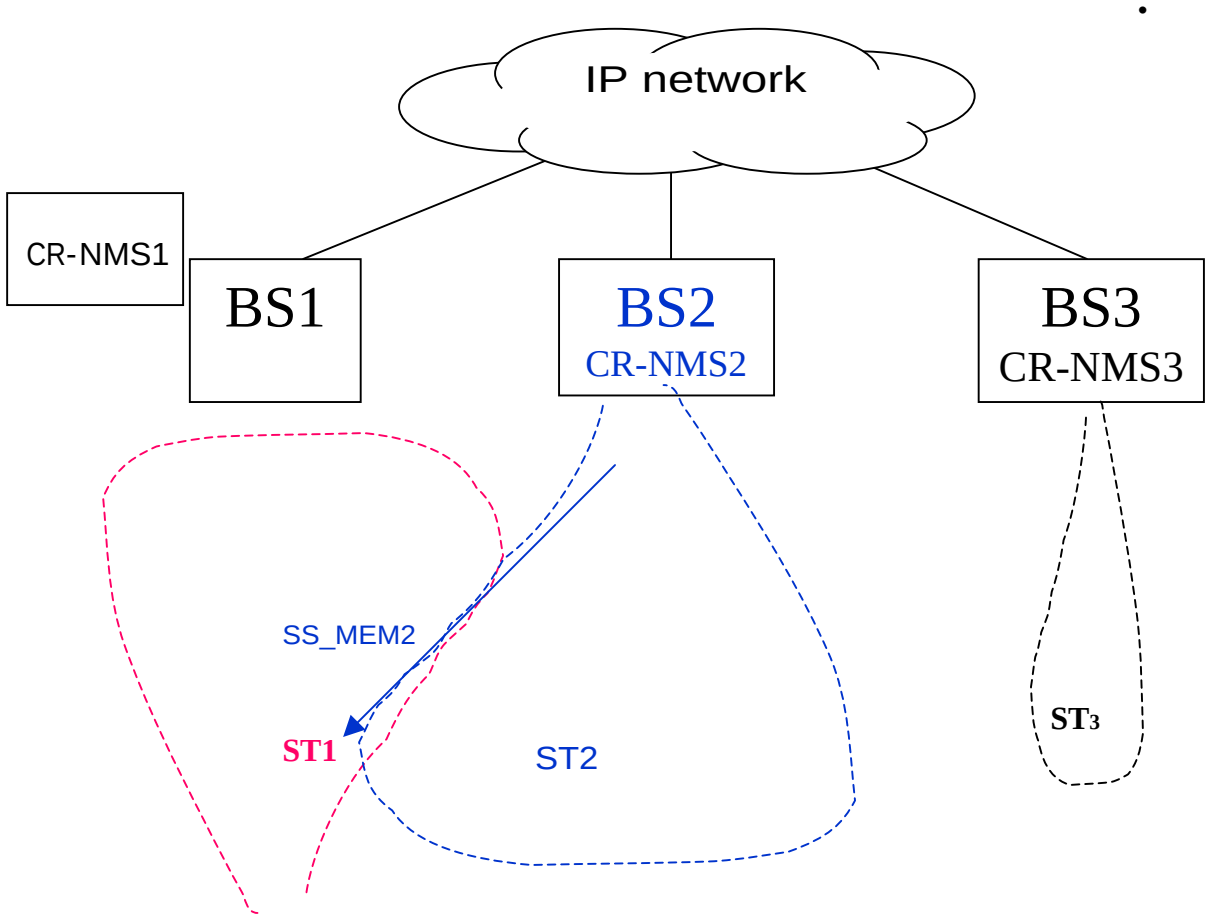
- This is a SNMP trap message sent by a SS to CR-NMS when co-channel interference is detected at SS.
- BS_NUM: total number of base stations from which CCI interference is detected.
- · BS_ID: the base station IDs causing CCI
- BS_IP: the IP address of the BS causing CCI
- · Sector_ID: the sector IDs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

SNMP Trap and Set Messages

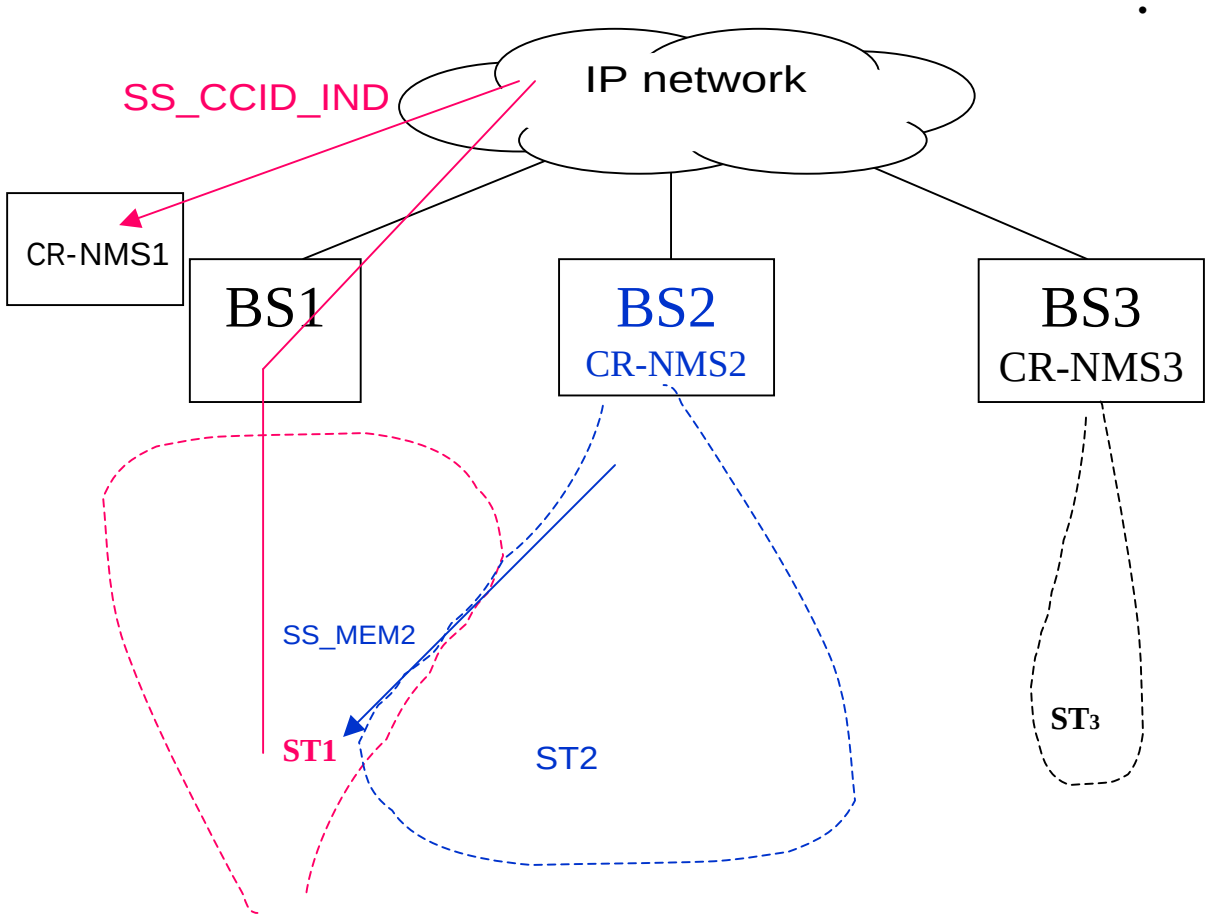
- **SS_CCID_RSP**
- **BS_CCID_RSP**
- Execute change SNMP command: CR-NMS directive to BS and SS

- 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

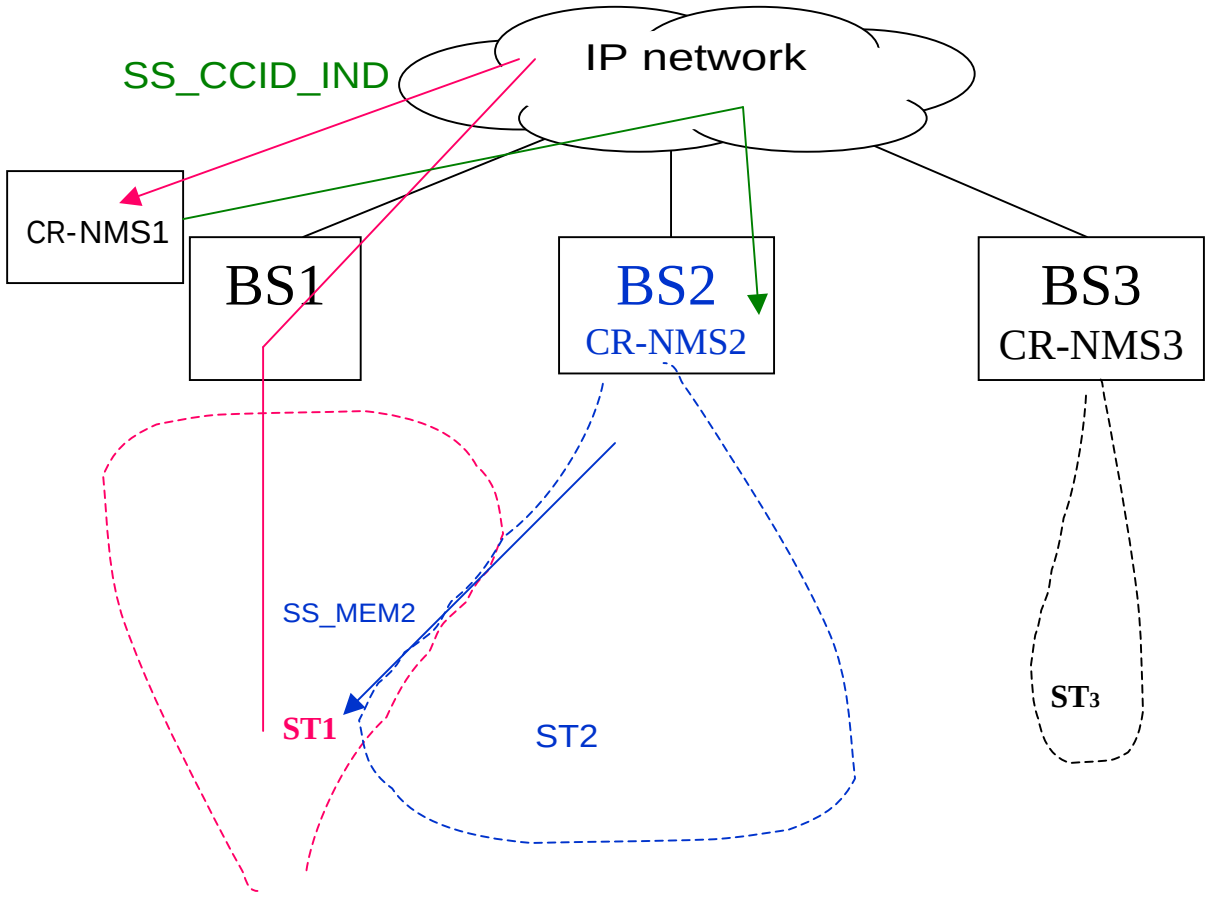
BS2 Downlink SS_MEM2 received by ST1



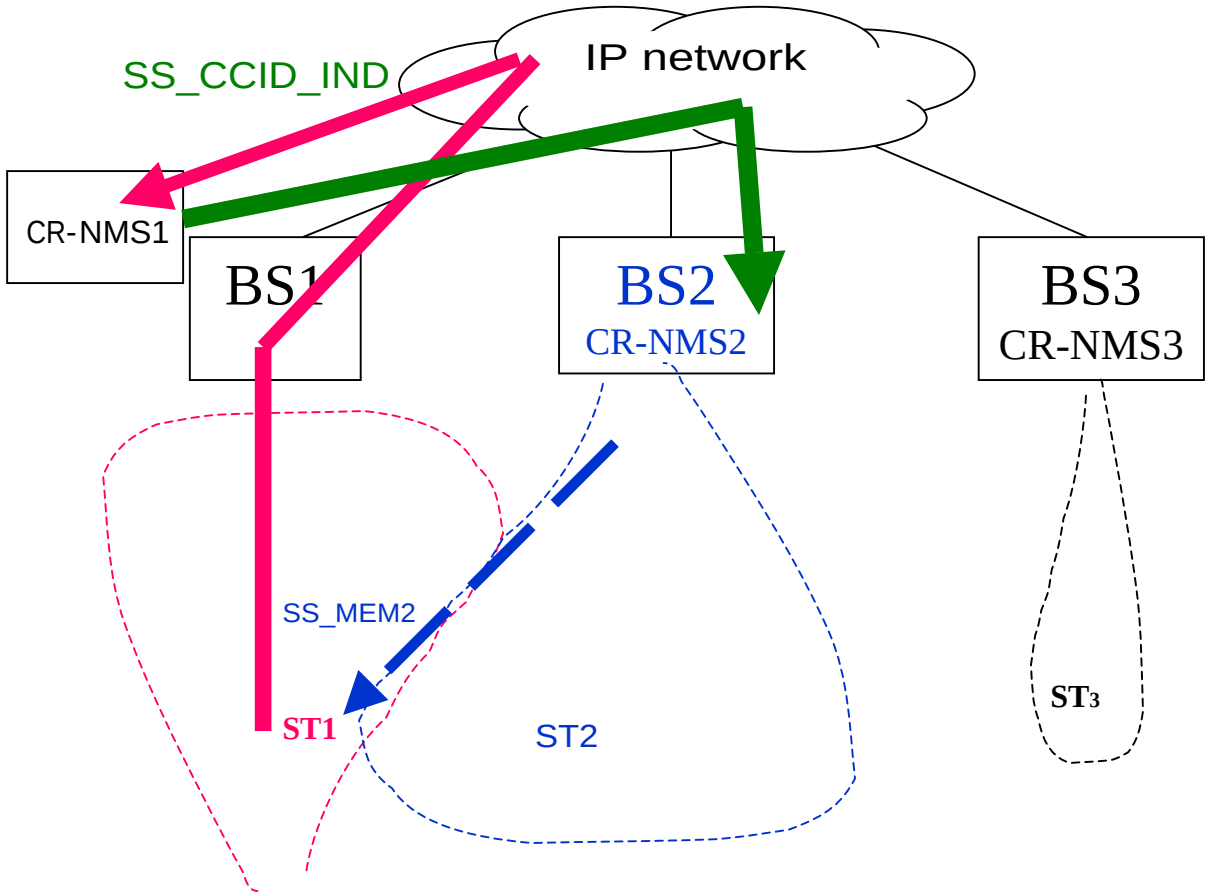
ST1 generates a SS_CCID_IND SNMP message and sends it to CR-NMS1



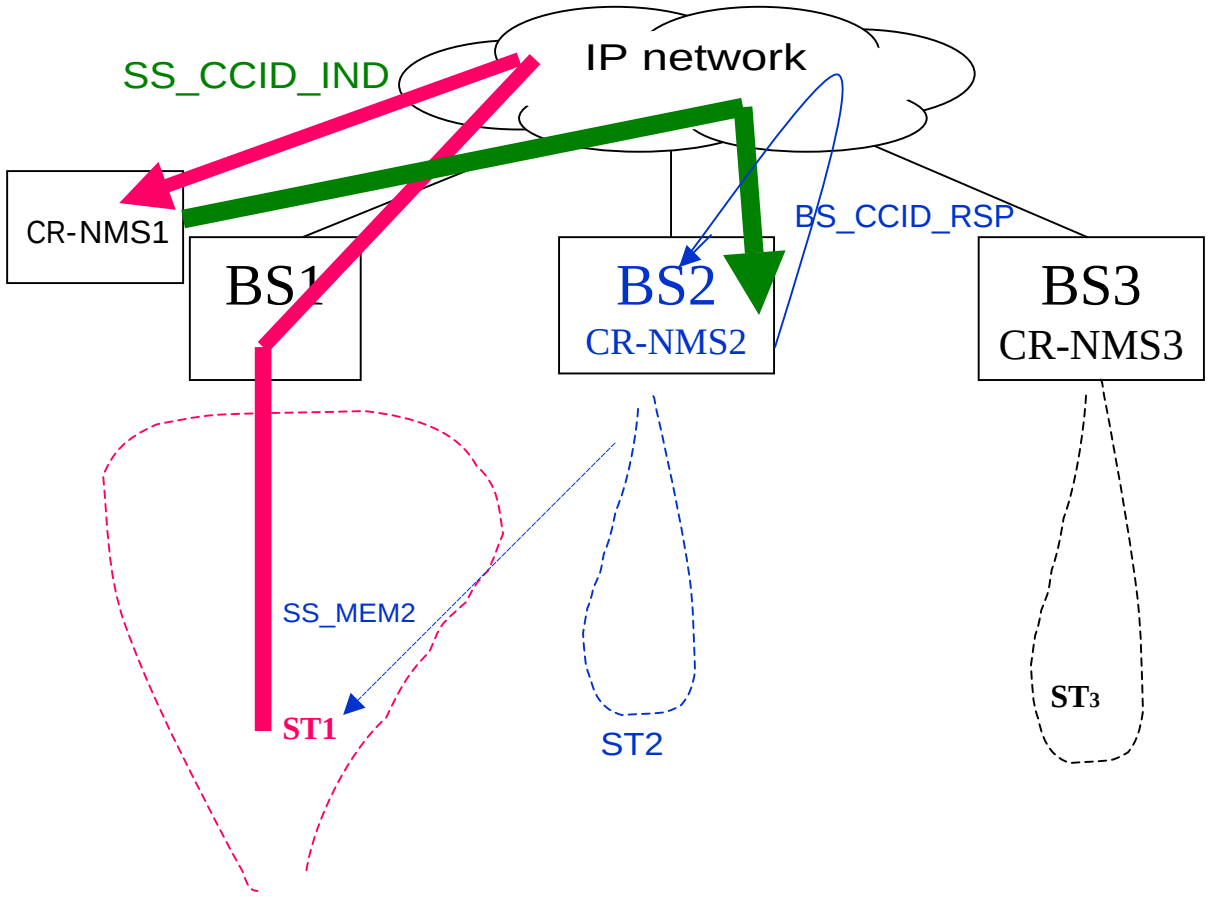
CR-NMS1 generates and SS_CCID_IND SNMP message and sends to CR-NMS2



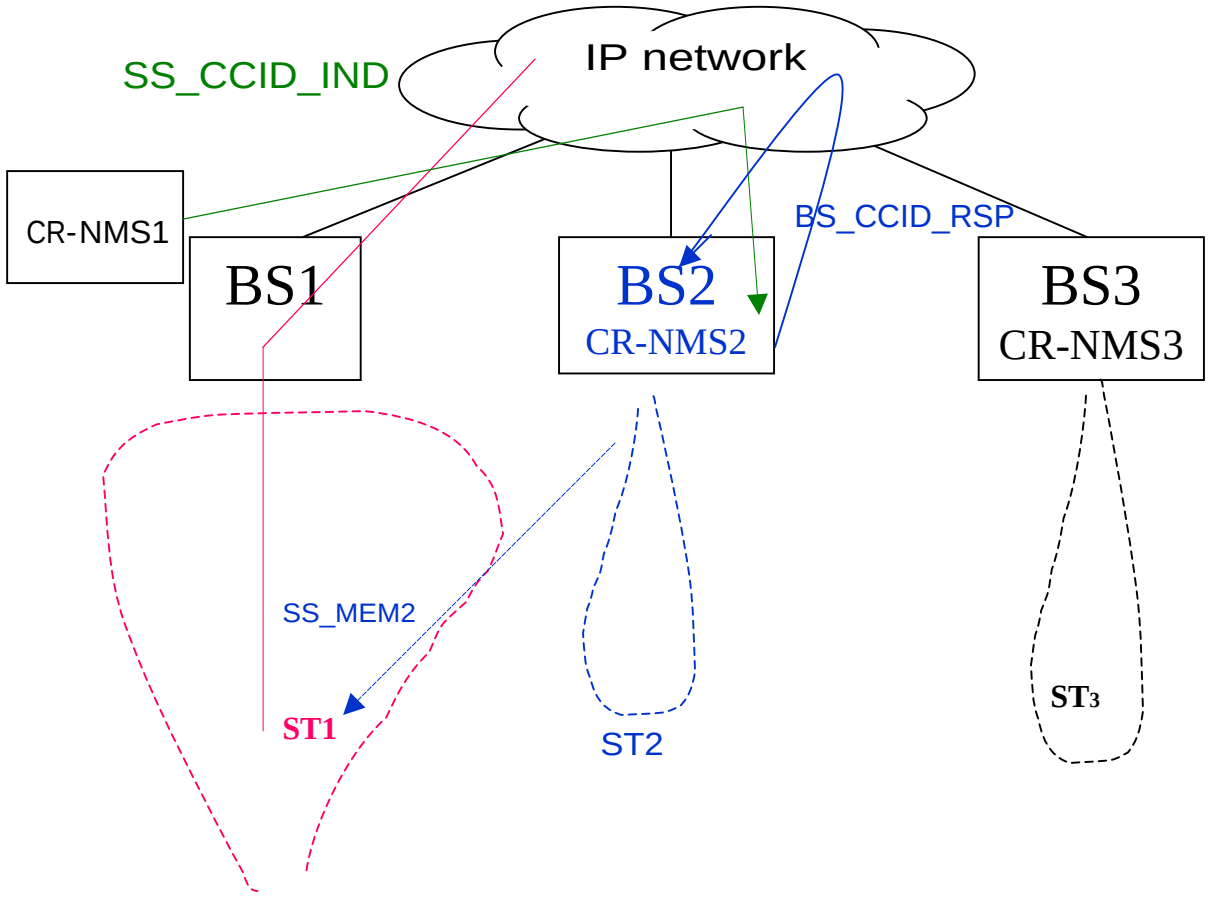
CR-NMS2 may take no action, as interference increases, so does SNMP messaging level from CR-NMS1



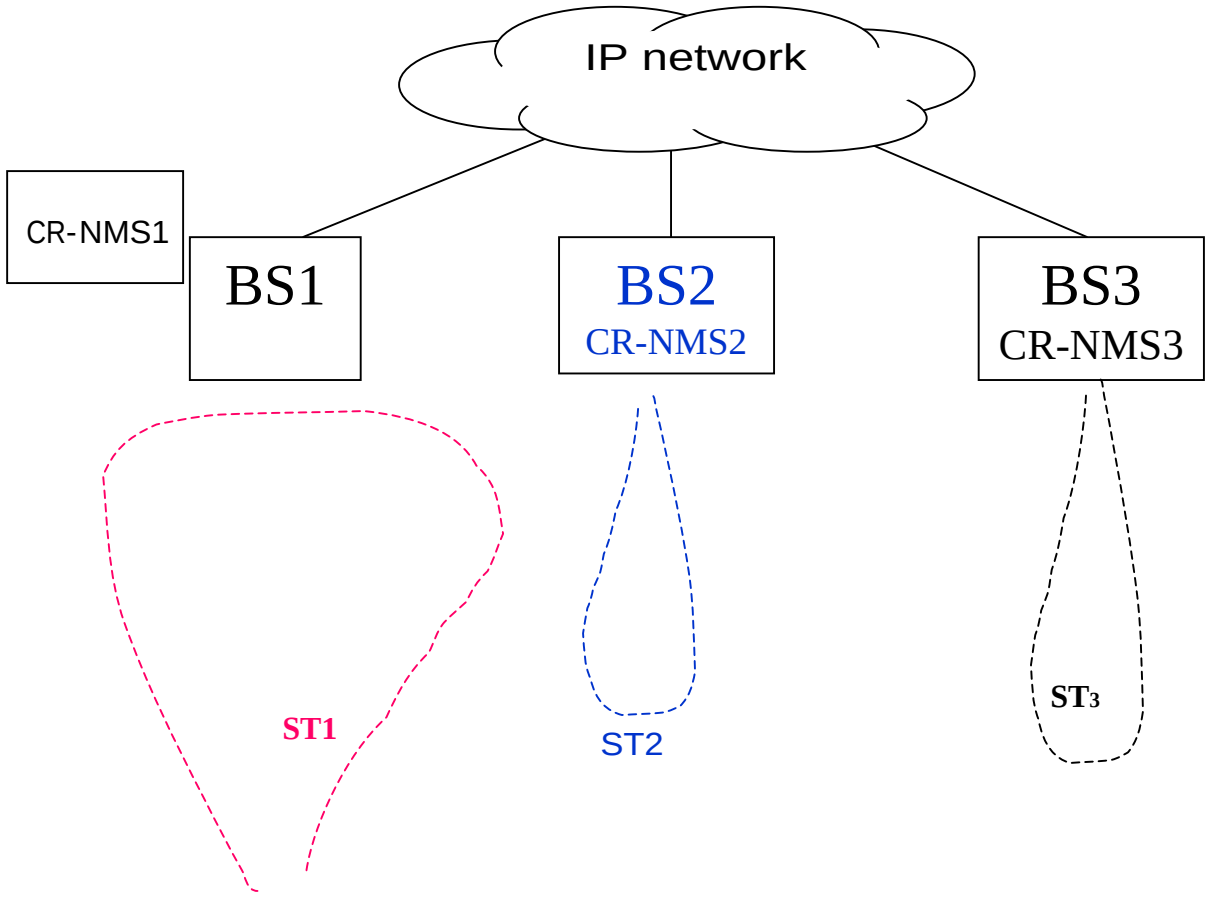
CR-NMS2 now receives high SNMP level of SS_CCID_IND “SNMP interference” such that functioning of BS2 is compromised. CR-NMS2 reconfigures emission of BS2, lowering SS_MEM2 levels to ST1
This is done by sending a BS_CCID_RSP message to BS2



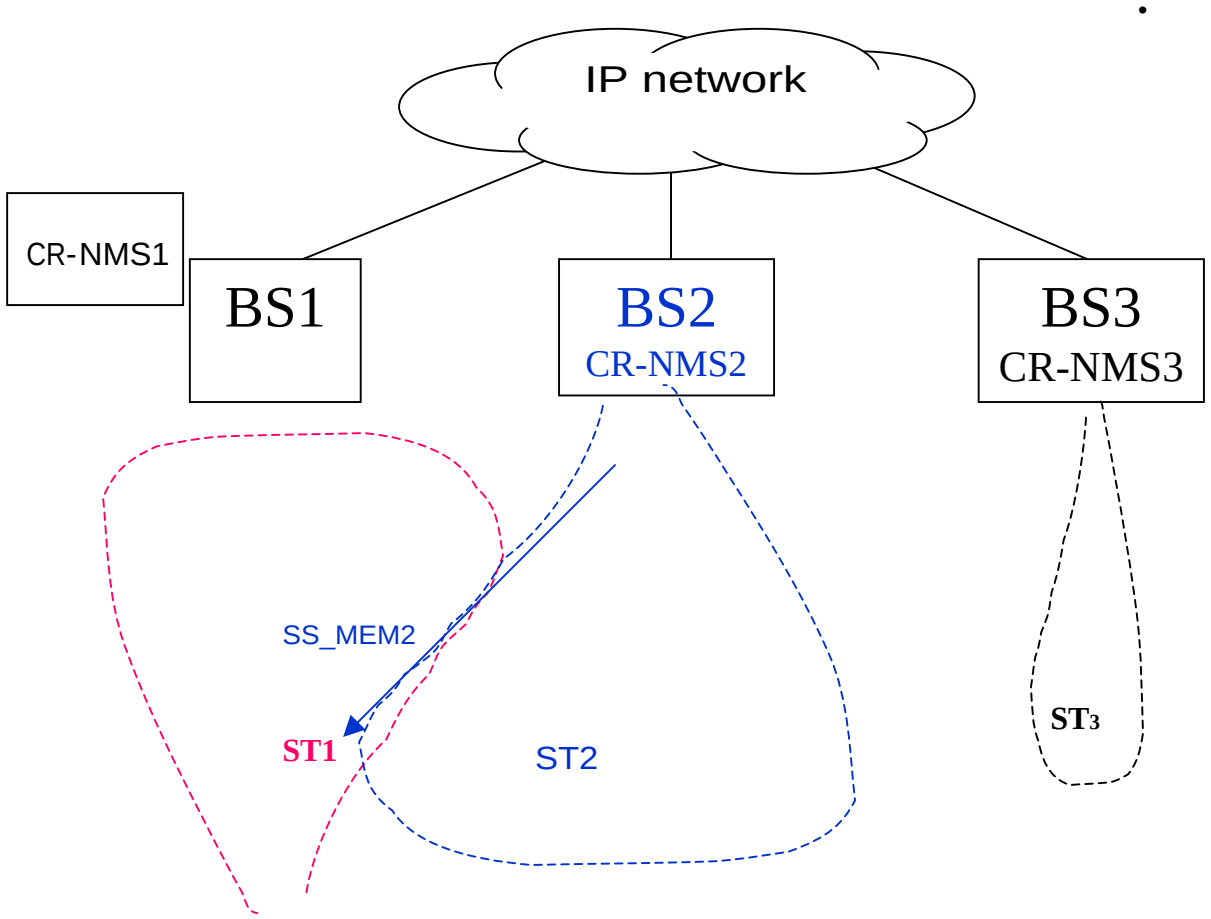
SNMP annoyance messaging decreases when RF interference decreases and a co-existence level is achieved.



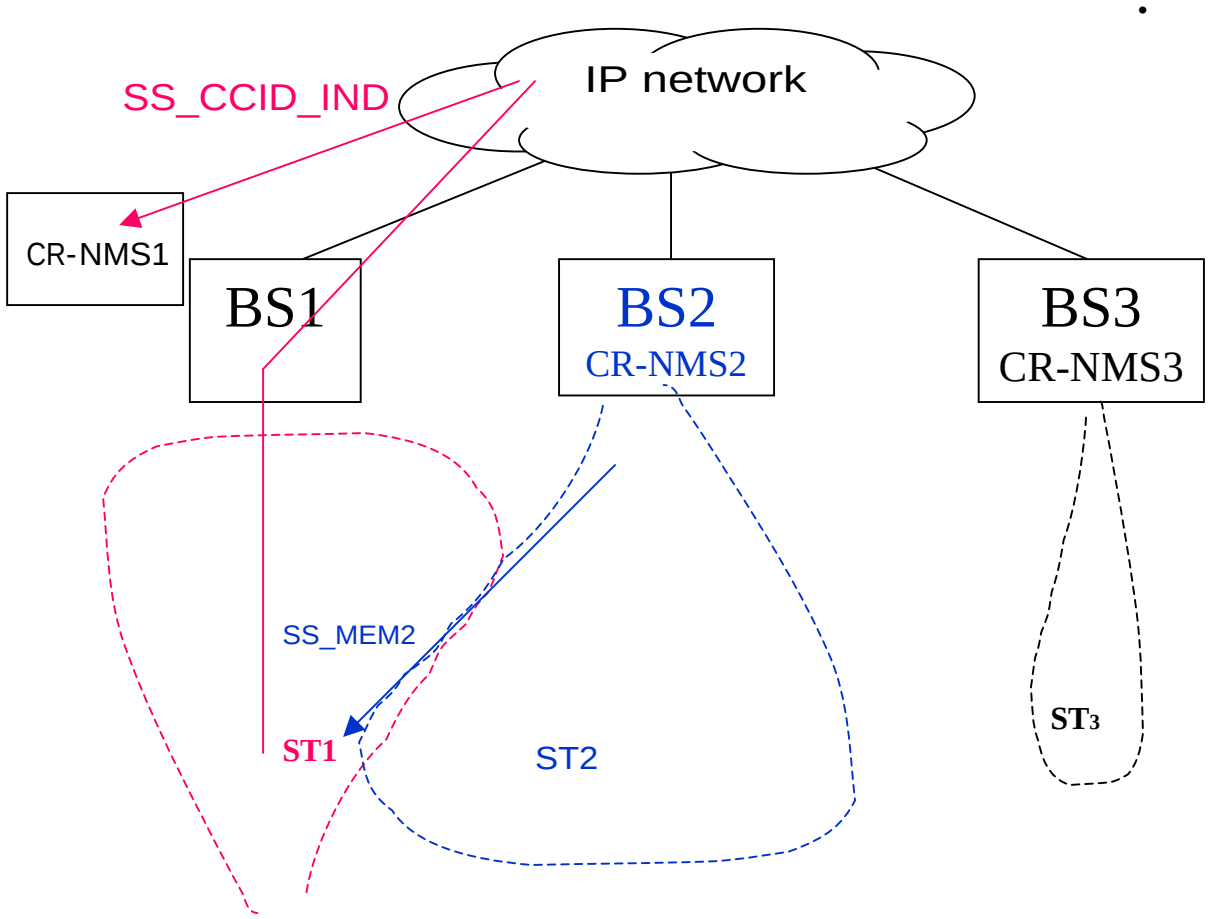
With no RF interference, SNMP messaging drops as well



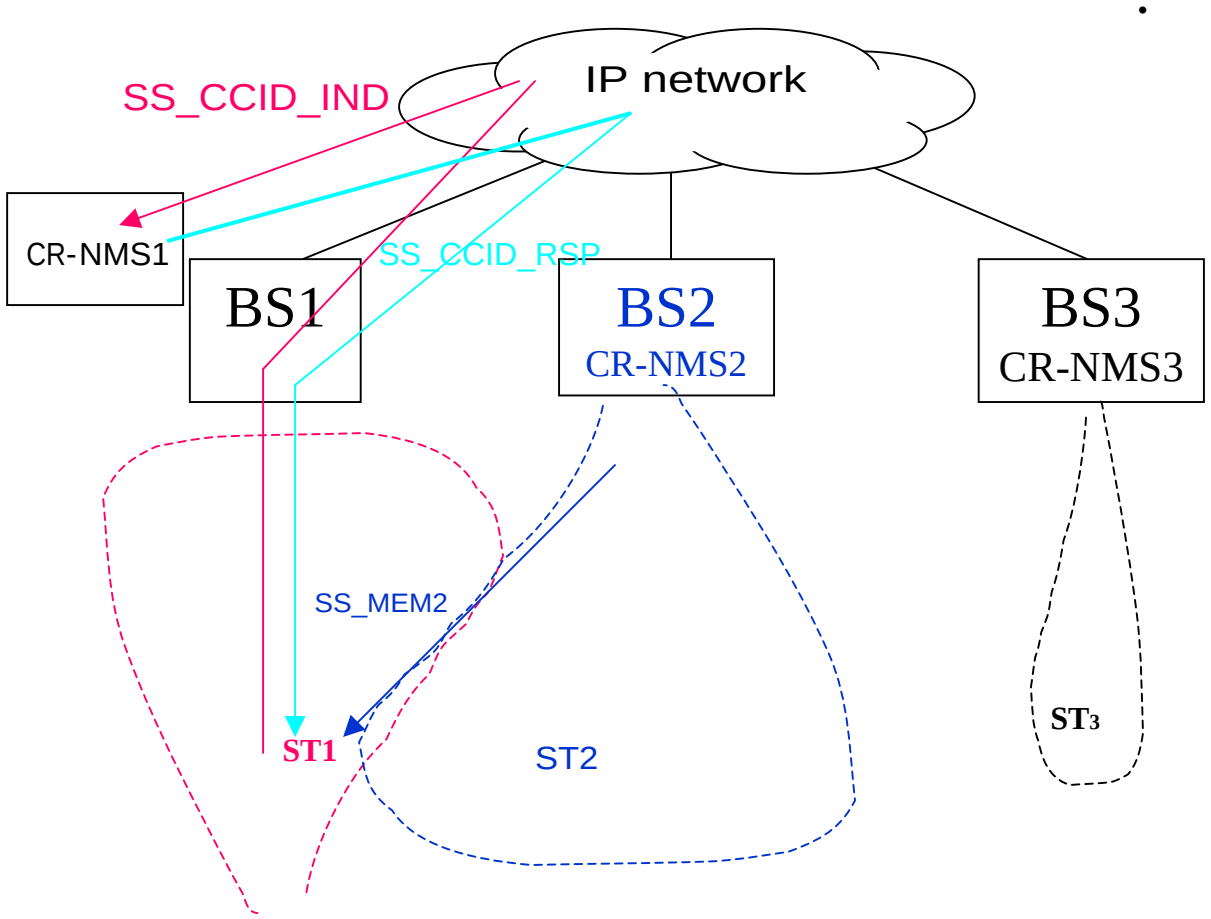
Alternatively when BS2 Downlink SS_MEM2 received by ST1……



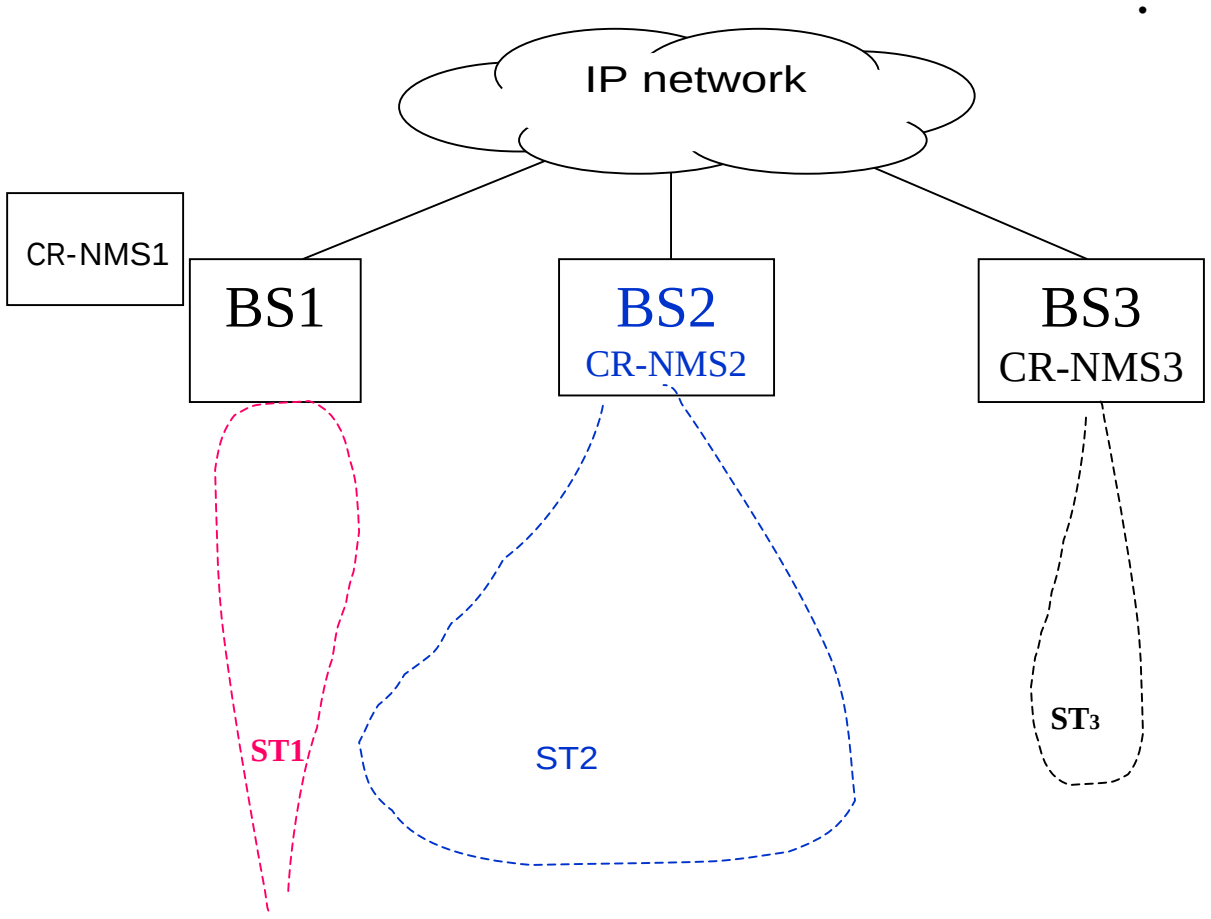
We can still have ST1 generate a SS_CCID_IND SNMP message and send it to
CR-NMS1… but



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



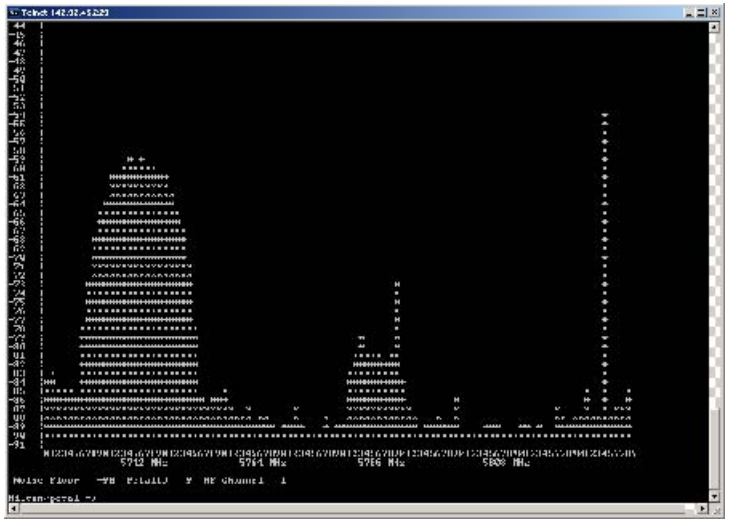
Again creating a situation of co-existence

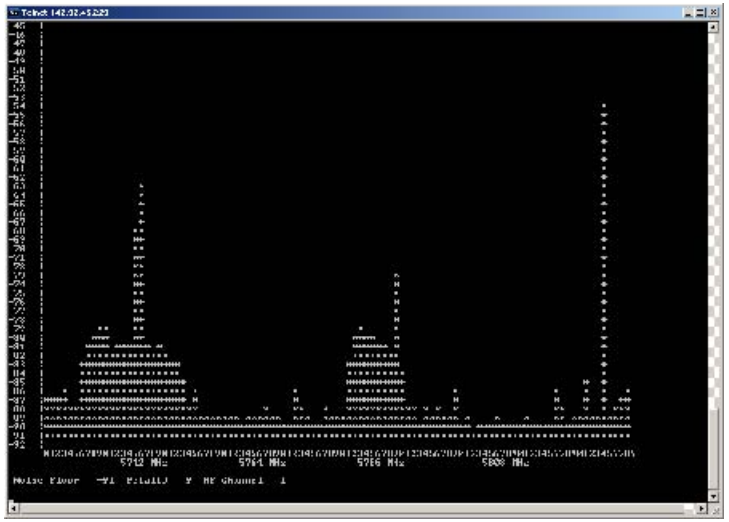


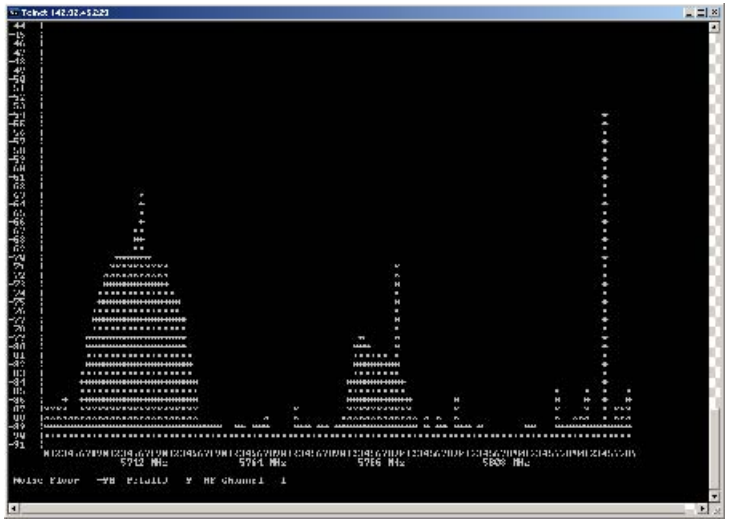
SNMP PSD Messages

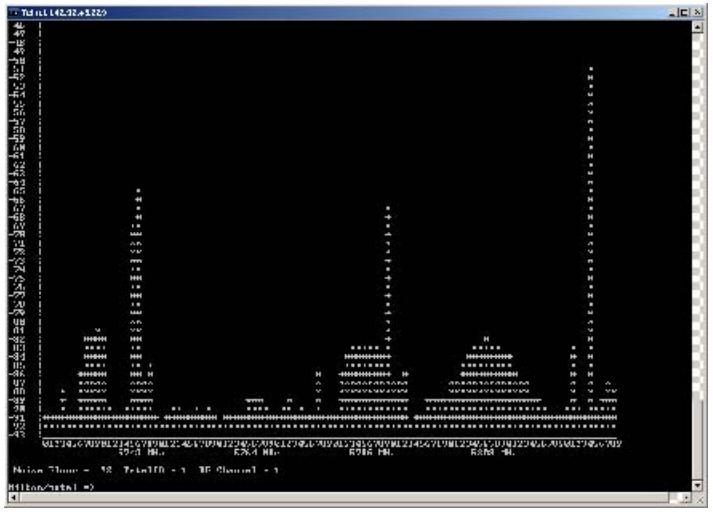
PSD needs to be taken to determine level of interference that is below detection threshold of terminals and to identify white spaces, occupancy, non-IEEE 802.16 interference, etc…

- 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

Summary

>Space, Time, and Frequency will be the currency of Co-existence… LE systems negotiate for this.

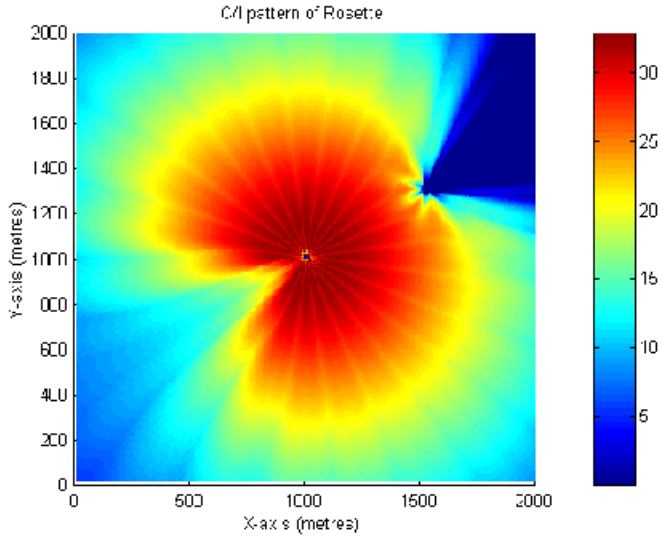
>Identity of all LE negotiators must be known.

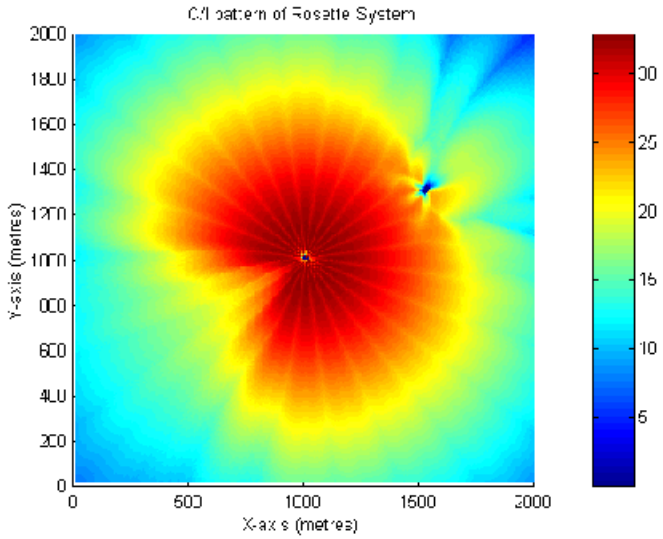
>Negotiating LE systems must have a common knowledge base...this is created with the first incidence of interference by using proposedTagged Headers as MAC PDUs in 802.16h.

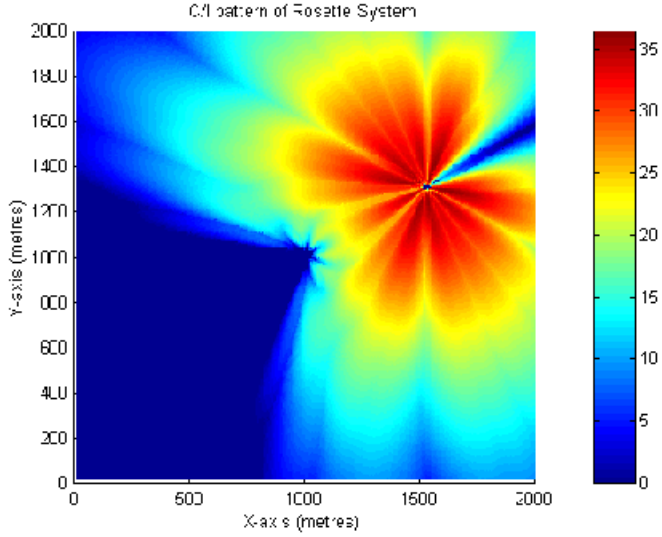
>This proposal introduces the concept ofa RF to IP information feedback path that forces negotiation.

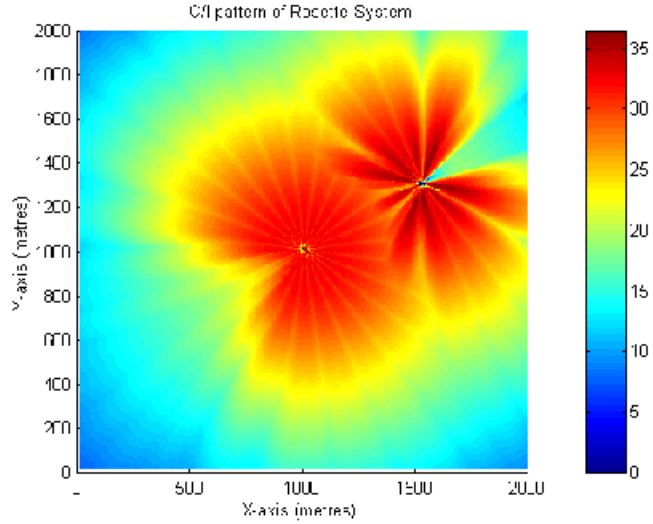
>Co-existence becomes achieved by negotiations between cognitive radio entities residing in the NMS.

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









Thank You