The Geographic Electromagnetic Radiation Domain Control System (GERDCS_{TM})

IEEE P802.22 Wireless RANs Date: 2008-07-12

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Abstract

The Geographic **Electromagnetic Radiation Domain Control System (GERDCS**_m)

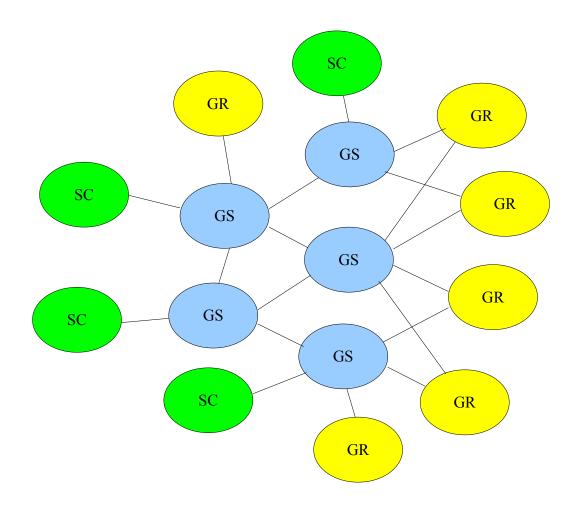
This system was seeded from the need to promote frequency reuse, plan for coexistence between licensed and license-exempt spectrum users, determine spectrum availability and

efficiently convey needed information in a timely manner. It consists of a web of client, server and resolver computers

GERDCS Defined

- Is a web of on-line networked computers
- It consist of
 - Spectral Clients
 - Geographic Servers
 - Geographic Resolvers
- Is similar in nature to
 - The Internet Domain Name System (DNS)
 - That resolves names (URLs) to IP addresses
- Intends to comply with the needs expressed in
 - 22-06-0242-09-0002-draft-recommended-practice.doc
 - With alterations avoiding what WISPs perceive as unacceptable pitfalls

GERDCS Defined



GERDCS Audience



- Regulators
- Transmitter operators
 - Licensed incumbents
 - License-exempt
- Network planners
- Emergency response personnel



Goals



- Help in resolving coexistence issues
 - Help to protect licensed operators
 - Inform license-exempt operators



- Provide an efficient communication system
- Proactive and effective
- · At quickly disseminating notifications and
- Propagating data in a scalable fashion
- With multiple interfaces
 - machine to machine
 - human-machine

Scope

- GERDCS is not
 - A coexistence assurance system
 - A dispute resolution system



• GERDCS allows uniform communication

enhancing operator awareness



Security

- GERDCS devices communicate
 - Over secured links (SSH or HTTPS)
 - Between registered devices/operators



Awareness





- Helps to avoid and resolve coexistence issues
 - Between license-exempt operators
- Help to protect licensed operators
 - From license-exempt operators

Regulatory Compliance Assurance

- Operation in compliance to
 - Regulator requirements
 - GERDCS requirements
- Is and remains the sole responsibility of
 - Transmitter operators

Function

• GERDCS receives, validates, conveys and disseminates

- data pertaining to the maximum radiation levels
- a license-exempt transmitter or
- an array of Same Frequency Network transmitters
- should be allowed to impress on a victim receiver
- at a given time and location
- before such radiation starts to cause
- significant degradation to the receiver's ability
- to receive and decode another signal



GERDCS

Is designed from the ground up to

- Allow for enhanced coexistence
- Subjugate license-exempt services to
 - Regulatory requirements
 - Licensed incumbents
- Provide for voluntary coordination
 - Between transmitter operators
- Protect information confidentiality
- Provide usage logs and audit trails
- Provide information source identity





GERDCS Concern for Privacy

Clients may request information

- For whatever reason
- For entire geographical areas
- Irrespective of whether they actually have
 - Transmitters or receivers in that area
- Without divulging
 - How many they may have or where they are

As the request covers a geographical area

- It does not divulge
 - Quantities or location of transmitters and receivers
 - Circumventing WISP operator objections
 - Of divulging their network topology and BS locations

- A Geographic Resolver (GR) is a GERDCS client device
- It runs under the exclusive supervision of an operator
 - Of a transmitter
 - Of a network of transmitters
- May be used by a network designer
 - Seeking for optimum future transmitter locations
 - In the potential evaluation of available sites

Requests

- Secure GERDCS client-server connections
- Queries GERDCS servers
- Receives responses and notifications

Transmitter operators

- who want to operate and coexist
- use a resolver to assess
- if a channel is cleared for use and available



One of its tasks and responsibilities is

- To receive and analyze
- Specific bandwidth allocation requests
- Made by the transmitter operator

It analyzes and resolves

- local transmitter geographic electromagnetic radiation coexistence issues
- in a given geographic reception area
- based on
 - available data
 - established rules and agreements



- The result of this analysis is
 - A matrix of maximum allowable field strength vectors
- This time-bound matrix covers the entire geographic area the transmitted field may reach
 - Including direct paths, reflection, etc...
- This multi-dimensional matrix has indexes of
 - Time
 - Position
 - Polarization
 - Incident arrival angle



Antennas

- Transmitter and receiver antennas
- Have complex multi-dimensional free-space radiation patterns



- The resolver as a cognitive system device
- Knows a-priori about
 - The transmitter's antenna properties
 - Surrounding terrain propagation characteristics
- It considers all these factors and determines the maximum allowable EIRP and field strengths emanating from the transmitting antenna in the determination of the maximum allowable radiated power a given transmitter may emit



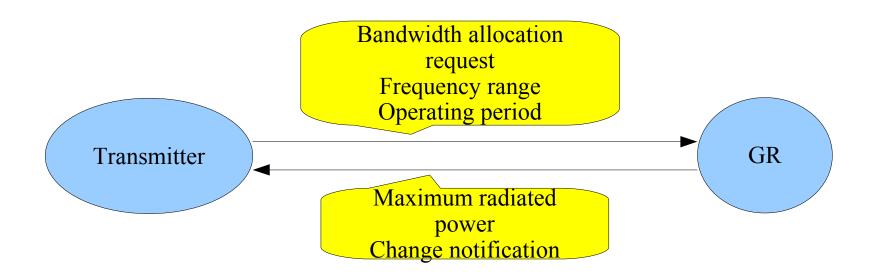
- The output of the resolver is the maximum allowable output power in dBm over a requested frequency range and operating period
- The resolver, requesting and maintaining active connections also receives and reacts to pro-active GERDCS environmental change notifications







<u>Transmitter – Resolver relationship</u>



Geographic Server



The Geographic Server (GS)

- Receives secure connection requests
- From registered GERDCS clients
- Grants secure client-server
 - connection sessions



- Information
- Notifications





Geographic Server

- Receives and responds to client queries
- Issues update notifications
- Validates requests for given
 - Geographical areas
 - Regulatory domains

Acts as

- Authoritative information cache
- Network information forwarder

Answers

- About a given domain
- Or how to get "closer" to another GS
 - With authoritative information about the domain



Spectral Client

- Is also a GERDCS client
- It runs under the exclusive supervision and control of
- The operator of
 - A transmitter or
 - A network of transmitters
- Or under the control of a regulator

Spectral Client

- It requests secure client-server connections
- Feeds and queries servers
- Issues notifications
- Receives responses

Spectral Client

- Is used by transmitter operators
- Who want to
 - Announce their license-protected domains and claims or
 - Signal their license-exempt domains
 - To improve controlled sharing
 - To help avoid coexistence issues
- The Spectral Client is used to
 - Create, edit, delete and register domains
 - Make claims about these domains



Domain Definition

- A GERDCS Domain is
 - A collection of bubbles where each bubble has
 - A Name with a root GS URL
 - An Author
 - A Time to Live
- A domain may for example represent a broadcaster's designated market area
- It may also represent a protection area around an event covered by a group of microphones
- A temporary area to be protected for emergency services





Domain Attributes

- The Domain name is a metaphore used to
 - Identify the domain
 - Provide a root GS URL and regulator
 - Example: MyDomain.AuthoritativeServer.GERDCS.us
- The Author is the name of the domain claimant
 - Used to allow others to contact to the claimant
 - Allow traceability toward domain claims
- · Claims describe the authority over the domain
 - Possible values at this time are
 - license # ...
 - license-exempt



Domain Attributes

• Time To Live (TTL)

- Is a domain data validation specification used to force periodic updates
- Allows a resolver to select and favor the most recent data available amongst multiple sources
- Allows for domain cancellation

Domain Attributes

Number Of Bubbles

- The Number Of Bubbles (NOB) attribute
- enumerates the quantity of bubbles
- forming the domain that intersect a specified area

Bubble Definition

- A GERDCS bubble is a 7 dimension construct describing the particulars of the domain claim
- The bubble dimensions are
 - Three dimension geographic space bound by
 - Altitude, Latitude and Longitude ranges
 - Direction of arrivals bound by
 - Azimuth and Elevation ranges
 - A spectral space bound by
 - Frequency range and polarization
- Bubbles can be understood as
 - elements of 22-06-0242-09-0002-draft-recommendedpractice.doc 2.1.1.3.1.2 polygons
- Bubbles allow for the creation of "swiss cheese" contours.

Bubble Definition (cont.)

- Bubbles allow for broad spectral coverage, such as
 - Sideband protection
 - Swiss cheese coverage
 - Receiver weaknesses
 - Taboo channels
- Protection of transmitter arrays
 - Multiple microphones on multiple frequencies
- Protection of designated market areas
 - Protected area shape is arbitrary
- Protection exceptions
 - Licensed point-to-point and point-to-multipoint links
- Squelched transmitters
 - Need protection but may go off-air while idle

Bubble Data

The Spectral Limit Record (SLR)

- Contain all the data describing a specific bubble
- With a signal amplitude level (microvolts/meter)
- That can not be exceeded without causing
- Significant harm to the domain author's service

SLR Resolution

- SLR Latitude, Longitude and Altitude attributes
- Have a resolution of .00001 degrees
- Equivalent to worst case of ~1 meter

GC Protocol Elements

Registration Request

- Sent by GC to GS
- Used to establish or maintain
- A virtual client-server connection
- Is periodically issued to signal continued presence
- Indicates continued interest in notifications

GERDCS GC Protocol Elements

- Spectral Limit Queries (SLQ)
 - Issued by GC or GS
 - Received by GS
 - Specifies an interest in
 - A domain or class of domains
 - A geographical area
 - A spectrum range

GERDCS GC Protocol Elements

- When a GS receives an SLQ
 - It may respond with
 - An array of SLRs
 - An alternate GS (to allow scaling and load management)
 - One or more URLs closer to the most authoritative GS
- When the GS responds with a URL, the GC
 - Abandons the query with this GS
 - Makes the same SLQ to the indicated GS

SC Protocol Elements

- SC protocol elements are used to
 - Request additions, deletions and edits to SLRs
- The GS returns
 - an ACK if it abides by the request
 - A NAK if it refuses the request
 - NAK is followed by textual description of refusal cause
 - Example: NAK:outside regulatory bounds
- GS internal validation policies
 - are beyond the scope of this presentation

GERDCS

- Using domain name definitions
- Along with multiple SLRs
- The SC can define irregularly shaped
 - Coverage areas or Designated Market Areas
- Allow for sideband protection claims such as
 - Adjacent channels
 - Taboo channels
- Preempt for the possible use of fail-over channels

USE

- · A transmitter or transmitter network operator
 - Typically queries a resolver for a set of receivers
 - With a time range (date & time)
 - With a spacial target (long, lat,alt range)
 - With a expected angle of arrival range
- The resolver, consults it's cache and known GS
- Responds in correspondence with
 - the maximum allowable received radiation level

USE (cont.)

- Many such request will be made
- The transmitter should cap its output power
- To comply with
 - All the returned requirements
 - Taking into account its antenna pattern
 - Terrain topography & propagation models
- And dynamically react to notifications

GERDCS

- GERDCS is like a dynamic road sign
- In itself, it does not enforce or ensure rule enforcement



- It disseminates information
- Allowing law-abiding citizens to make informed decisions to comply with complex requirements
- Negates ignorance as a plea or excuse for noncompliance
- Its an evolutionary system which will doubtlessly evolve with time



GERDCS

Transmitter operators are responsible

- To limit claims sensibly to and only to their legal rights
 - With traceability and recorded audit trails
- To be courteous bandwidth sharers
- To comply to regulatory requirements



Cost Reductions

If a MAC enforces GERDCS compliance

- Products may operate with far less hardware and complexity
- There is no need to embed the resolver in the product hardware
- Resolver functionality may reside in a host driver (PC or other)
- Greater control and centralized upgrades are possible
 - Without user knowledge, intervention and hassles
- Products may be simplified as a large portion of
 - cognitive functions may be offloaded to network-based resolver support
- The system may be more amenable to local regulator requirements
 - because standard CPE and BS do not need to be modified
 - to adopt behaviors in compliance to local regulator requirements
 - or to modify the behavior as regulators modify rules from time to time

Cost Reductions (cont.)

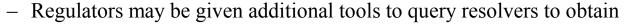
• If a MAC enforces GERDCS compliance

- Sensors, which can only react to and cannot preempt situations
 - May no longer be required
- The MAC no longer needs to know about and understand
 - complex cognitive rules
 - implemented by the Geographic Resolver
 - Examples: Taboo channels, sideband protection, location vs incumbent protected contour or designated market areas, etc...
- BS products therefore may end up
 - simpler, easier to implement, faster to market and costing less
 - more appealing to the general public, incumbents and regulators
 - under better control
- GERDCS would in essence be a dynamic on-line lite-licensing system.

Regulatory Compliance Insurance

If a regulator also enforces GERDCS compliance

- GERDCS can be extended to enforce compliance via
 - Live, on-line communication



- "Unlicensed" (illegal) GERDCS connected BS location
- Owner and contact information
- GR-GS registration information from authoritative GS
- Order on-line shutdown or apply restrictions to offending BS'
- GERDCS can become a electromagnetic environment code
 - Similar to road traffic codes that regulate road vehicles
- Coexistence can be enhanced as the GERDCS provides a uniform out of band means to coordinate various devices that may not be able to communicate over the air.