

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

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Abstract

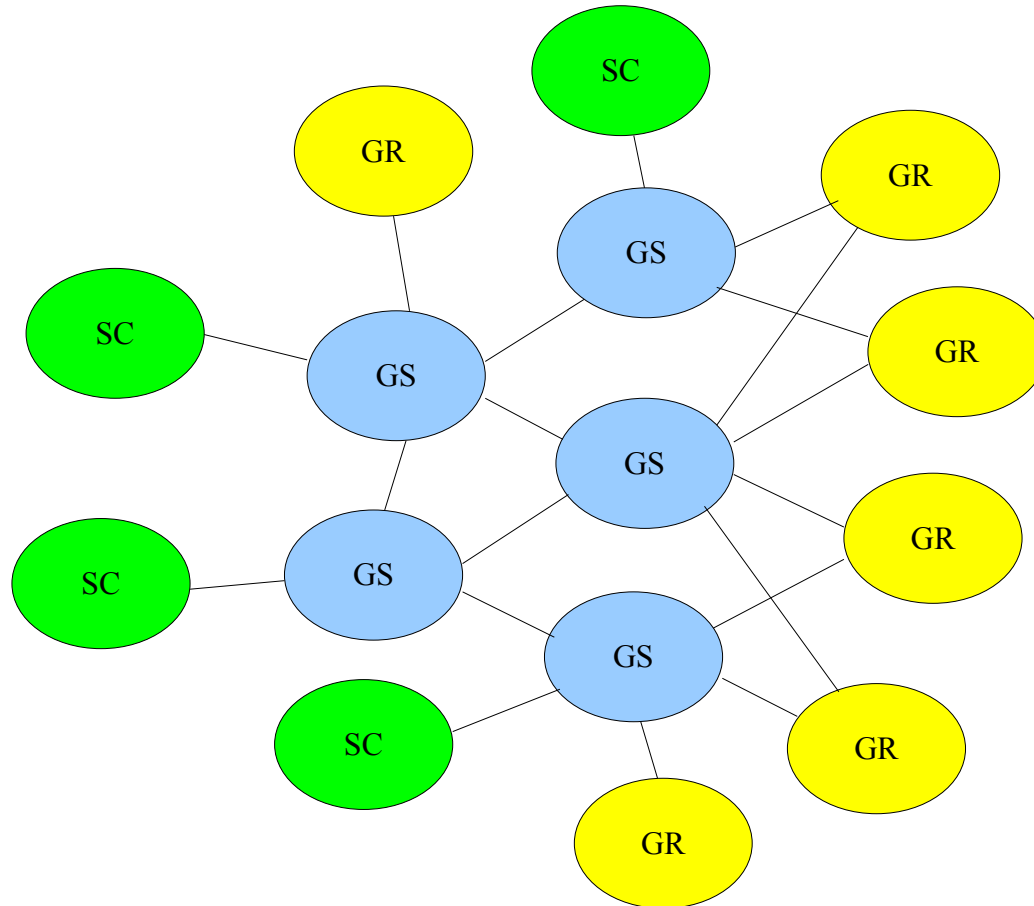
The Geographic Electromagnetic Radiation Domain Control System (GERDCS_{TM})

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

Geographic Resolver

- **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

Geographic Resolver

- **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



Geographic Resolver

- **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



Geographic Resolver

- **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**



Geographic Resolver

- **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**

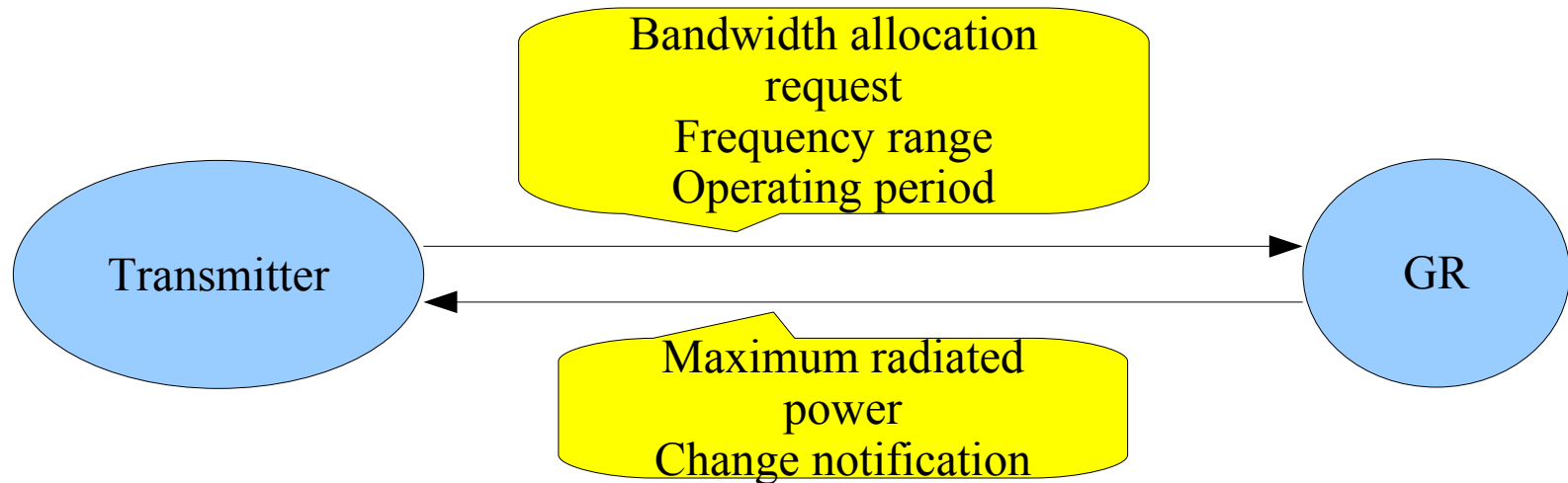


Geographic Resolver

- **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**



Transmitter – Resolver relationship



Geographic Server



- **The Geographic Server (GS)**
 - Receives secure connection requests
 - From registered GERDCS clients
- **Grants secure client-server**
 - connection sessions
- **Stores and forwards**
 - 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



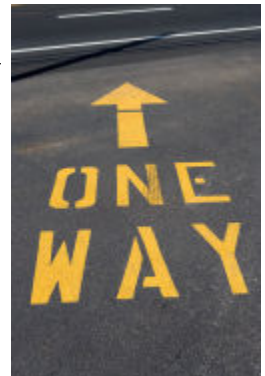
Domain Definition

- **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-recommended-practice.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 provides a common framework**
- **It disseminates information**
- **Allowing law-abiding citizens to make informed decisions to comply with complex requirements**
- **Negates ignorance as a plea or excuse for non-compliance**
- **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
 - Regulators may be given additional tools to query resolvers to obtain
 - “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 an 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.

