GERDCS™

The Geographic Electromagnetic Radiation Domain Control System

A system used 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.
Audience

- **Regulators**
- **Transmitter operators**
  - Licensed incumbents
  - License-exempt
- **Network planners**
- **Emergency response personnel**
Scalable Distributed or Centralized Model

• The proposed system is a set of interconnected services
  – In a single device or in an intranet or internet of networked of devices

• Consisting of at least one instance of each of the following
  – Spectrum User (SU) - transmitting/receiving device
  – Coexistence Enabler (CE)
  – Coexistence Database Server (CDS), SQL Server, DNS Server

• With optional operation enhancement servers
  – AAA & Radius Server
  – TV White Space (TVWS) regulatory Server
  – Geographic/Topographic Resolver (GR)
  – Topographic Database Server
Environment

• 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
  – 19-10-0055-03-0001-system-design-document.pdf
  – With alterations avoiding what WISPs perceive as unacceptable pitfalls
Throughout this document, a **network** is defined as
- a set of devices with zero or more links allowing the devices to communicate with each other

- **A device** is either
  - a physical object exhibiting a specific behavior
  - an instantiation of a service within one or more physical objects

- **A link** is a point-to-point means of communication between two devices
  - Multiple links may conglomerate to form link sets
    - in a point to multi-point fashion
    - In a multi-point to multi-point fashion
Example Topology Semantics I

Network A

Device 1

Device 2

Device 3

Device 4

Device 5

Network B

Internet

Optional NAT

Link 5I

Link NI

link4N

link12

link24

link23

link14
Semantics II

• A **coexistence enabler** (CE) is a service that
  – Interfaces devices to a CDS
  – Normally situated in or communicating with
    • Stations or CPEs, Access Points or Base Stations

• A **coexistence database server** (CDS) is a service that
  – May performs AAA (authentication, authorization, accounting)
  – Encapsulates and protects the SQL database integrity
  – Securely communicates with
    • CE
    • SQL databases, RADUIS databases, TVWS database, etc...
  – Recognizes and traverses NAT firewalls when required
  – Acts as firewall between CE
    • Provides required communications
    • Protects CE privacy (if needed)
Example Topology Semantics IIa

Network A

- Device 1 SU
- Device 2 SU
- Device 4 SU

Network B

- Device 3 SU
- Device 5 SU

Internet

- Optional NAT
- CDS Server
- CDS Server
- TVWS Server
- GERDCS DNS Server
- Internet

Link type legend:
- network
- private SU-CE
- private CE-CDS
- private CDS-ext
Example Topology Semantics IIb

Network A

Network B

Link type legend:
- network
- private SU-CE
- private CE-CDS
- private CDS-ext
Propagation Conditions

- GERDCS provides for terrain and vegetation
  - With the addition of a GR and topography servers
    - may take into account
      - Terrain topography
      - Radio propagation conditions
CE functions

- Monitors devices
- Interacts with the CDS
  - Announces to the CDS
    - Device ID & presence
    - Condition changes
  - Receives, processes and responds to CDS queries
  - Effects changes to devices in their specific terms
- May provide limited support of
  - Foreign devices
  - Legacy devices
Coexistence Database
Server Functions

– Act as a proxy
– Allow controlled communication
  • Between otherwise anonymous devices
  • Via an information storage and an exchange of queries and responses
– Provide the essential links
  • Between CE
  • Other CDS
  • To databases such as topographical and TVWS databases
– Analyze the information to improve coexistence situations
– Provide CE with information and recommended actions
– Become aware of the device's compliance to the recommended actions and further disseminate recommended actions to optimize coexistence
Global Access

- The coexistence database server(s)
  - Each server having a globally accessible URL and service port
  - Supporting defined dialogs under the SSH and/or TLS protocols
  - All required information for coexistence shall be openly accessible
    - As per policies to be defined within 802.19
    - To 802.19.1 CE
Global Access

- The CDS
  - Shall publish their public URL with all known peer devices in a limited geographical area
    - Such as to enable discovery and exchange of information on an ongoing basis
  - Shall publish all known peer database enabled service public URLs
    - Such as to propagate and disseminate known public database enabled service URLs to all peer devices.
  - Database enabled public URLs shall be in a text format specifying latitude, longitude and coverage to allow for traffic-free filtering
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
Awareness

• Helps to avoid and resolve coexistence issues
  – Between license-exempt operators

• Help to protect licensed operators
  – From license-exempt operators
CDS 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

- **CE 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
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
• It's 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