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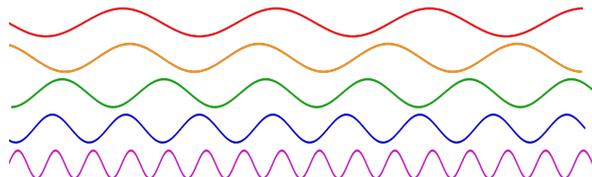
Henrique Santos, James P. McCusker, and Deborah L. McGuinness

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- Policies are commonly defined as **domain-specific assets for supporting decision-making**, specifying allowed or recommended actions under certain conditions (or rules)

- Largely **published in natural language**, but with increasing engagement in the development of computable policies

- They **can be location-specific**

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Request
- Requester (device, service, system …)
- Start and end time
- **Location (geo-coordinates)**
- Requested frequency (range)

Dynamic Spectrum Acces (DSA) Policy Framework

Spectrum manager

Permit / Deny / Obligations

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Geospatial relationships

US161 In the bands 81-86 GHz, 92-94 GHz, and 94.1-95 GHz and within the coordination distances indicated below, assignments to allocated services shall be coordinated with the following radio astronomy observatories. New observatories shall not receive protection from fixed stations that are licensed to operate in the one hundred most populous urbanized areas as defined by the U.S. Census Bureau for the year 2000.

(a) Within 25 km of the National Radio Astronomy Observatory's (NRAO's) Very Long Baseline Array (VLBA) Stations:

State	VLBA Station	Lat. (N)	Long. (W)
AZ	Kitt Peak	31° 57' 23"	111° 36' 45"
CA	Owens Valley	37° 13' 54"	118° 16' 37"
HI	Mauna Kea	19° 48' 05"	155° 27' 20"
IA	North Liberty	41° 46' 17"	091° 34' 27"
NH	Hancock	42° 56' 01"	071° 59' 12"
NM	Los Alamos	35° 46' 30"	106° 14' 44"
NM	Pie Town	34° 18' 04"	108° 07' 09"
TX	Fort Davis	30° 38' 06"	103° 56' 41"
VI	Saint Croix	17° 45' 24"	064° 35' 01"
WA	Brewster	48° 07' 52"	119° 41' 00"
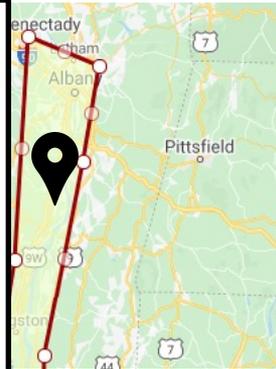
US91 In the band 1755-1780 MHz, the following provisions shall apply:
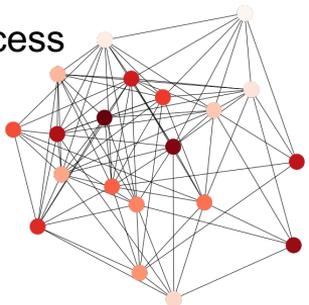
(b) In the band 1755-1780 MHz, the Federal systems listed below operate on a co-equal, primary basis with AWS stations. All other Federal stations in the fixed and mobile services identified in an approved Transition Plan will operate on a primary basis until reaccommodated in accordance with 47 CFR part 301.

(1) Joint Tactical Radio Systems (JTRS) may operate indefinitely at the following locations:

State	Training area	Latitude	Longitude
AZ	Yuma Proving Ground …........................	33° 12' 14"	114° 13' 47"
CA	Fort Irwin …………….………………….	35° 23' 19"	116° 37' 43"
LA	Fort Polk …………...…………………..	31° 08' 38"	093° 06' 52"
NC	Fort Bragg (including Camp MacKall)....	35° 09' 04"	078° 59' 13"
NM	White Sands Missile Range…………….	32° 52' 50"	106° 23' 10"
TX	Fort Hood ……………..........................	31° 13' 50"	097° 45' 23"

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Dynamic Spectrum Access Knowledge Graph

External system
Spectrum management tool

SETLr[2]

Whyis[1]
Knowledge Graph Framework

Census.gov shapefiles

Policy decisions

Policy evaluation engine
(GeoSPARQL + OWL reasoning)

1. http://tetherless-world.github.io/whyis/
2. https://github.com/tetherless-world/setlr

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Representing policy location rules

(3) In the sub-band 1761-1780 MHz, Federal earth stations in the space operation service (Earth-to-space) may transmit at the following 25 sites and non-Federal base stations must accept harmful interference caused by the operation of these earth stations:

State	Site	Latitude	Longitude
AK	Fairbanks ……………..	64° 58' 20"	147° 30' 59"
CA	Camp Parks …………….	37° 43' 51"	121° 52' 50"
CA	Huntington Beach ………..	33° 44' 50"	118° 02' 04"
CA	Laguna Peak …….....…..	34° 06' 31"	119° 03' 53"
CA	Monterey …………....…..	36° 35' 42"	121° 52' 28"
CA	Sacramento ………….......	38° 39' 59"	121° 23' 33"
CA	Vandenberg AFB ……..…..	34° 49' 23"	120° 30' 07"
CO	Buckley …………………	39° 42' 55"	104° 46' 29"
CO	Schriever AFB ……….....…	38° 48' 22"	104° 31' 41"
FL	Cape Canaveral AFS …......	28° 29' 09"	080° 34' 33"
FL	Cape GA, CCAFB ……….	28° 29' 03"	080° 34' 21"
FL	JIATF-S Key West …....…..	24° 32' 36"	081° 48' 17"
HI	Kaena Point, Oahu ………..	21° 33' 43"	158° 14' 31"
MD	Annapolis ……………..….	38° 59' 27"	076° 29' 25"
MD	Blossom Point ………….....	38° 25' 53"	077° 05' 06"
MD	Patuxent River NAS …...….	38° 16' 28"	076° 24' 45"
ME	Prospect Harbor ……..........	44° 24' 16"	068° 00' 46"
NC	Ft Bragg …………….....…	35° 09' 04"	078° 59' 13"
NH	New Boston AFS …….....…	42° 56' 46"	071° 37' 44"
NM	Kirtland AFB ……………...	34° 59' 06"	106° 30' 28"
TX	Ft Hood …………….....….	31° 08' 57"	097° 46' 12"
VA	Fort Belvoir …………….....	38° 44' 04"	077° 09' 12"
WA	Joint Base Lewis-McChord	47° 06' 11"	122° 33' 11"
GU	Andersen AFB ……...….....	13° 36' 54"	144° 51' 22"
GU	NAVSOC Det. Charlie …....	13° 34' 58"	144° 50' 32"

```
Class: USLocation
  EquivalentTo:
    prov:Location and
      (geo:sfWithin value STATE_01 or
        geo:sfWithin value STATE_02 or
      ...)
  SubClassOf:
    prov:Location

Class: US91-2-c_Location
  EquivalentTo:
    USLocation and (
    (geo:sfWithin value Fairbanks) or
    (geo:sfWithin value CampParks) or
    ...
  SubClassOf:
    USLocation
```

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Evaluating location-specific policies

RDF individuals
- Requester
- Time frame
- Location
  (**prov:Location**)
- Requested frequency

Description Logics
- Classification
- Realization
- DL query

Traverses the policy hierarchy
(**rdfs:subClassOf**) to identify
unsatisfied rules that would turn
the DENY effect into a PERMIT

```
FILTER(geof:sfWithin({{WKT_STR}}^^geo:wktLiteral, ?wkt))
BIND(geof:distance({{WKT_STR}}^^geo:wktLiteral, ?wkt, units:kilometer) AS ?distance)
```

Request evaluation engine

Requests ⟹

| GeoSPARQL | OWL reasoner (HermiT) | Precedence evaluation | Evaluation explanation |

- Request ID
- Policy ID
- Effect
- Obligations
- Explanations

⟹

:location geo:sfWithin <named_location>

Resolves conflicts
when multiple policies
are applicable

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Number of geographical features	915 polygons
Imported Census.gov datasets	STATE and MIL
Number of policies	96 policies
Number of involved physical radios	4 radios
DSA radios' rate of frequency change	Every minute
Number of transmission requests	450 requests
Number of calls to the evaluation engine	~23 calls
Number of transmission requests per call	~20 requests
Evaluation engine response time	< 10 seconds

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Concluding... advantages of semantic approach

- Support the direct referencing of external geographical data sources within policy constructs
  - OWL classes that represent policies directly refer to geographical features, facilitating the policy authoring process

- Integrated domain knowledge base
  - As a knowledge graph composed by policies, locations, domain knowledge
  - Exploration by users

- Results of geospatial reasoning are leveraged during OWL reasoning
  - **Policy evaluation engine fully implemented in a single platform**
  - Use of standardized vocabularies and off-the-shelf reasoners
  - **Explanation of results is possible** by identifying rules that were not satisfied

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Thank you!

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TetherlessWorld

IDEA
Rensselaer Institute for Data Exploration and Applications

Pre-print: https://tw.rpi.edu/web/doc/santos-geold-2021
DSA Policy Framework paper: https://tw.rpi.edu/web/doc/santos-iswc-2020

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