

# Policy-Based Radios



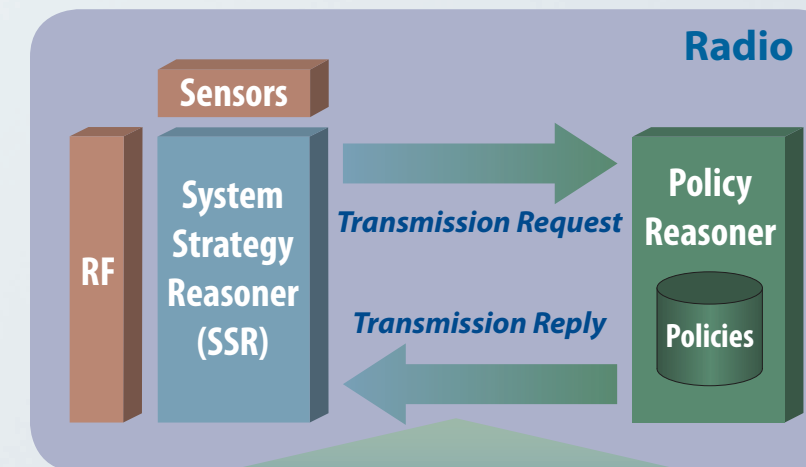
## Current SDR

- Policies programmed or hardwired into the radio
  - Mixing policy control and other radio control software
  - Written in a procedural language (usually C)
- Consequences:
  - Accessible only to radio engineers
  - Difficult and time-intensive to change or extend
  - Accreditation of radios is costly
  - Non-standardized

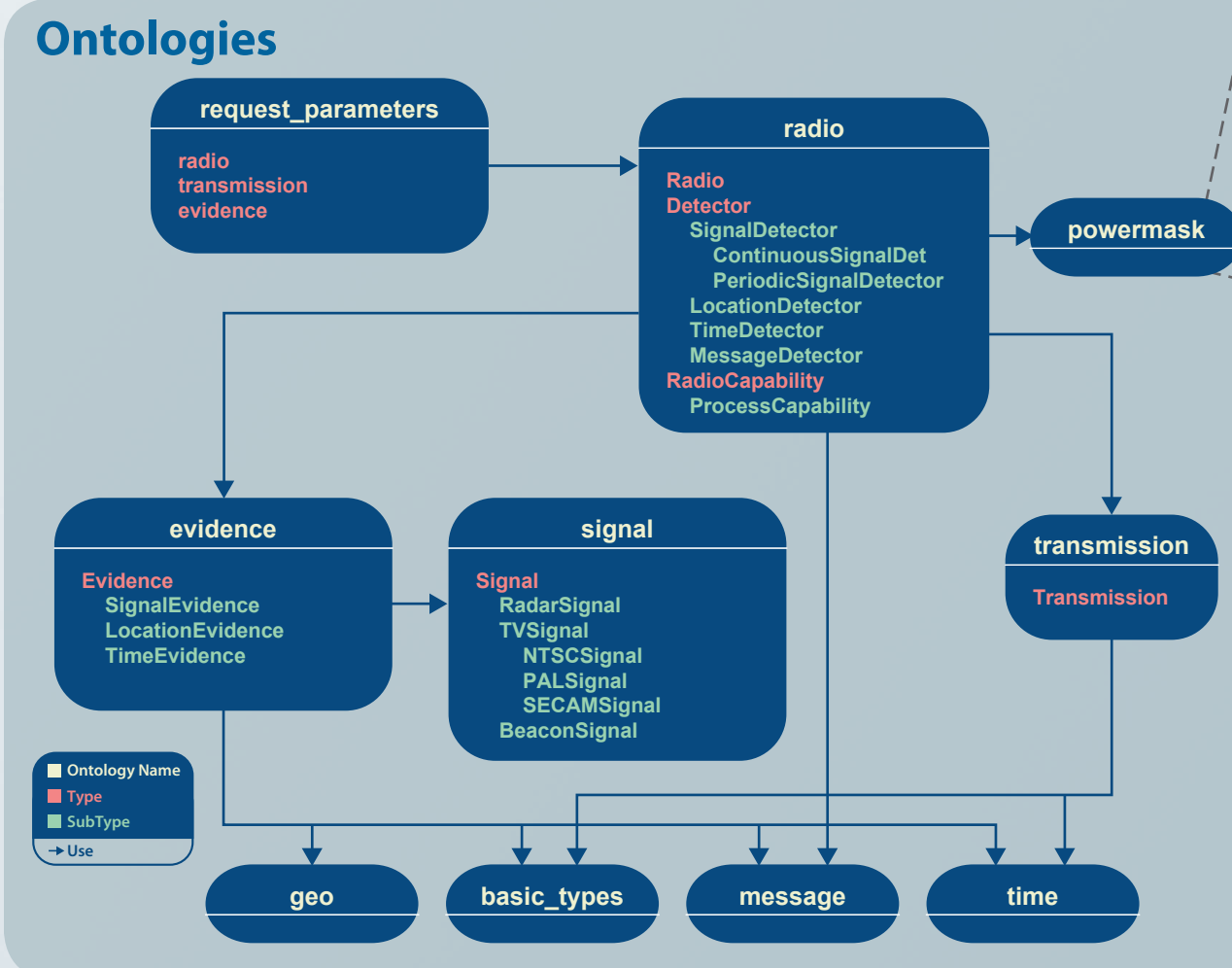
## Policy-Based Radio

- Separation between policies and firmware
  - Policies describe “what” not “how”
  - Policies are platform-independent
- Consequences:
  - Policies written independent of radio
  - Policies created by different authors are integrated in real time by device
  - Policies change radio behavior rapidly in tactical situations

## (Nominal) XG Architecture



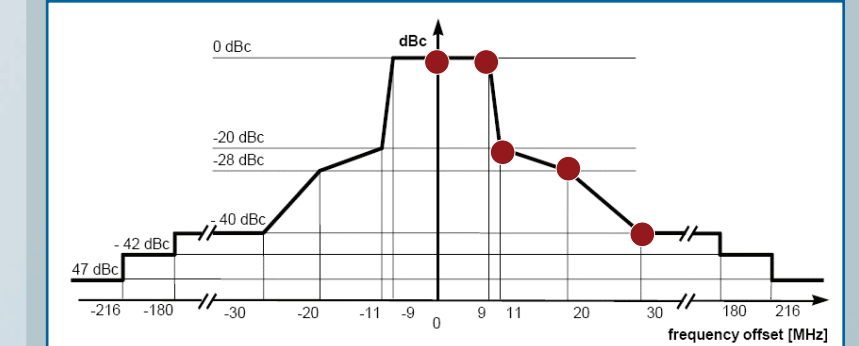
Shared ontology of domain concepts and request parameters



## Powermask

```
ontology powermask is
  deftype PowermaskValues = [(Frequency, Power)];
  const powermaskLessThan :
    Powermask, Powermask -> Bool;
```

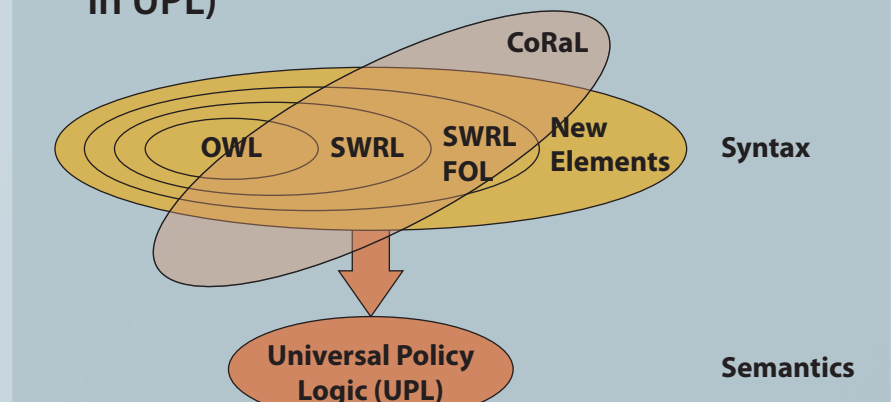
## Powermask instance: DFS



```
defconst maxInBandLeakage : Powermask =
  symmetric linear
  [ (0, 0), (9, 0), (11, -20), (20, -28),
    (30, -40), (180, -40), (180, -42), (216, -42),
    (216, -47), (inf, -47)]
```

## Universal Policy Logic

- UPL is NOT a policy language
- Logical Basis for Semantics
- OWL, SWRL, SWRL FOL, CoRaL can be translated into UPL (and given semantics in UPL)



## Cognitive (Policy) Radio Language (CoRaL)

Shared Domain Concepts	Frequency, power, location, powermask, signal, ...
Permissive & Restrictive Policies	Restrictive takes precedence over permissive ensuring “No Harm”
Mechanisms to Dynamically Adjust Policies	Load policy to allow military radios to use GSM band when conflict starts
Reasoning on Numerical Constraints	Frequency between 5000 and 5500 MHz, power ≤ 2dB

## Encoded Policy Types

- DFS & complex LBT
- TV
- Spatial & Temporal
- Beacon Signal
- Device-based

## Temporal Policy

“Allow XG radios to transmit *between 06:00 and 13:00 local time.*”

```
policy Morning-Transmissions is
  use request_params;
  allow if
    (exists ?te:TimeEvidence, ?t:TimeInstant)
    req_evidence(?te) and timeStamp(?te) = ?t and
    hour(?t) in {6 .. 12};
  end
```

## Beacon Policy

“Allow XG radios to transmit if it *can hear a permit-use beacon operating at 300 MHz broadcasting a beacon signal continuously for duration of 100 milliseconds every one second*”

```
policy Beacon1 is use ssc_params;
  allow if
    (exists ?se:SignalEvidence, ?t:TimeInstant)
    req_evidence(?se) and
    detectedSignal(?se, permitUse) and
    300.0 in scannedFrequencies(?se) and
    lastCompletedEmptyScanDuration(?se) = td(0,0,0,0,0,100)
    and
    timeStamp(?se) = ?t and
    timeDurationLongerThan(timeBetween(?t, lastDetected(?se),
    td(0,0,0,0,0,1,0)) = true;
  end
```

## Summary

- SRI has developed CoRaL
  - Key is balancing expressiveness and efficiency
  - Can express complex policies (such as DFS) with powermasks, numerical constraints, and so forth
  - Supports wide variety of policies: networking, routing, spectrum, resource management, ...
- SRI has developed an efficient Policy Reasoner
  - Processes ~180 request per second with Demo policies
  - 6 ms reasoning time consistent with 500 ms abandonment time