

# How I learned to stop worrying and love interference

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# Harmful Interference is like Love\*

Each is:

- A many-splendored thing: “How do I love thee? Let me count the ways”
- In the eye of the beholder
- A fact of life
- Best left to consenting adults to figure out the details

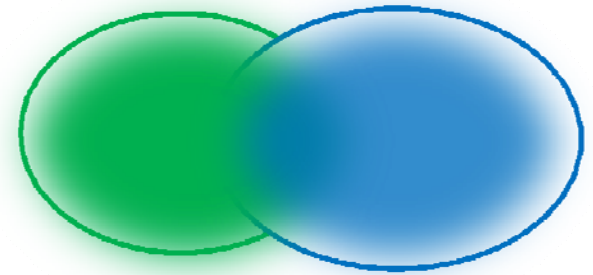
So: Defining “harmful interference” should not be an output of regulation

- Though it can be an input: it’s politically unavoidable when defining new rights in the presence of incumbents

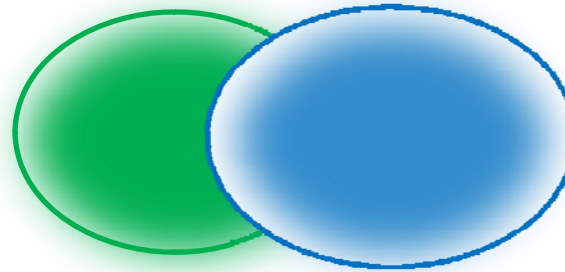
\* or Hate...

# Resolving conflict (interference) is a problem only when the responsible party cannot be identified

4. Clear rights – can sell right to coexist



3. Clear rights, no conflict



2. Overlap -> less waste, but conflict



1. No overlap -> no conflict, but waste



# Postulates

Radio conflict is unavoidable and necessary (→ no waste!)

- Altruism is not sufficient

Conflict resolution is primarily a bilateral activity between those involved

3<sup>rd</sup> parties (e.g. the government) should get involved only when negotiation fails

Government has two distinct roles

- The regulator's role is to define rights clearly enough that negotiation can be delegated to operators
- Adjudicating unresolved disputes is a distinct role that should be kept separate from rule making

# The Approach

Policy Question: Not how to *avoid conflict* but how to *resolve conflict*

Strategy: Define rights with the goal of *maximizing concurrent operation* – not *minimizing harmful interference*

# More “Not This but That”

Not *spectrum*

but *operation*

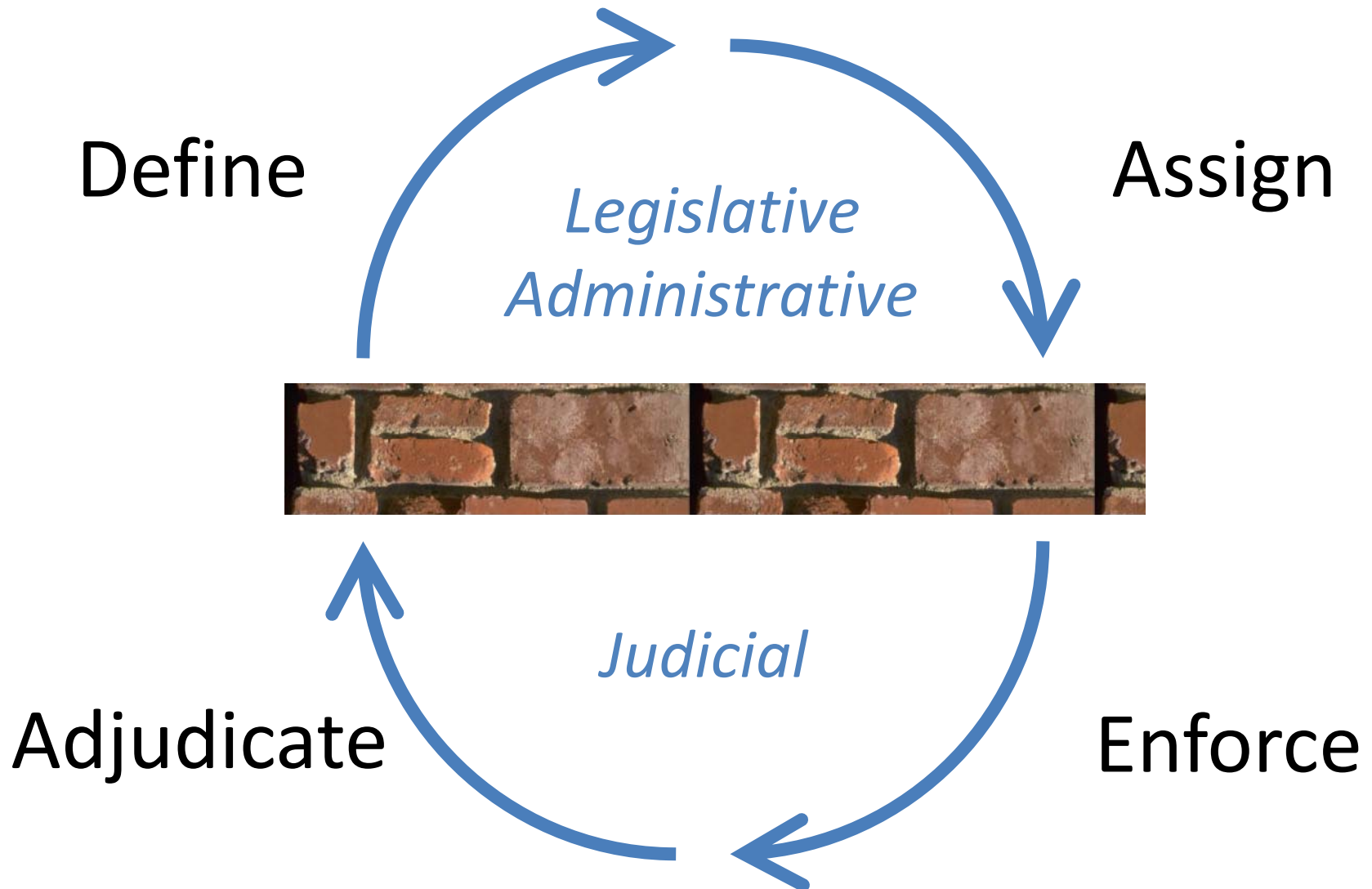
Not *neighbors*

but *concurrent operations*

Not *harmful interference*

but *failure of concurrent operation*

# The Regulatory Loop



# Today's Agenda

1. Rights Definition: Main focus
2. Rights Assignment: Some pointers
- ~~3. Enforcement: Skip~~
4. Conflict resolution: Secondary focus



# 1. Rights Definition: Overview

## Technical

- Probabilistic Parameters
- Reception Protection
- Transmission Permission

## Procedural

## Legal/economic

# Probabilistic Parameters

A statistical envelope of energy levels

Rights not assigned are in the public domain and can be appropriated by any licensee until the next license renewal point

Models vs. measurement?

- Neither is perfect; e.g. both are necessarily statistical
- Models: better guidance for planning and adjudication

# Sample Parameter Set

Parameter	Notes
EM energy	Power density or field strength e.g. $W/m^2$ , $V/m$ Spectral density e.g. $W/(m^2.Hz)$ , $V/(m.Hz)$ Transmission permission: absolute value of resulting energy Reception protection: absolute value or ratio e.g. $I/N$ or $C/I$
Reference bandwidth	For measuring/calculating energy
Location profile	Geographic range (x, y, z) Discrete (boundary) or continuous
Frequency profile	Frequency range e.g. MHz Discrete (boundary) or continuous
Percentage of Time	
Percentage of Locations	

# Reception Protection

A license explicitly states the deemed protections as a statistical ceiling on energy from other operations

Used by regulator when determining transmission permissions for other license allocations

- Basis for licensee to contest transmission parameters of new allocations

BUT they are not a basis for complaint of one licensee against another

- Use exceeding transmission parameters for that

Explicitly excluded:

- Intermod protection
- Receiver standards

# Alternative Reception Protection Regimes - Considered but Rejected

Not necessary to define any reception protections

- Ofcom SURs position
- operator can derive the signal levels their receiver has to tolerate by examining the terms of all neighboring licenses
- BUT: no assurances that neighboring licenses may not change in adverse ways in future (cf. AWS-3 conflict)

Provide licensee guaranteed, explicit reception protection ceilings

- Certainty for planning receivers
- BUT
  - Hard to assign responsibility for excess among multiple transmissions
  - How to resolve conflict between transmission and protection rights? (cf. public safety/Nextel)

# Transmission Permissions

Parameters defined so that concurrent operators\* can determine the environment in which their receivers will have to operate

Defined in terms of resulting energy, not transmitter parameters

\* AKA “neighbors” in geography, frequency and time

# 1. Rights Definition (ctd.)

## b. Procedural

– Use license renewal to add new parameters

- Change values? No, let operators do that by negotiation

– Registry of current parameters for all licenses

- Register any changes e.g. ex negotiation or regulatory waiver

## c. Legal/economic: What kinds of entitlements?

– Strong vs. weak protection rights?

- e.g. exclusive use vs. open access

– Property vs. liability rights?

- i.e. injunction vs. damages

# 2. Rights Assignment

## Choosing who gets entitlements

- Economic efficiency
  - E.g. Calabresi's algorithm: most informed chooser, then least cost avoider, then lowest transaction costs
- Wealth distribution effects
  - The economic optimum can be achieved in many ways, each with different winners and losers

## ... and how

- By fiat, beauty contest, auction, rule...

## Coping with transaction costs

- Minimize fragmentation since it prevents reaching optimum
- Beware of monopoly: can get locked in into configuration



# 3. Conflict resolution

Separate adjudication from rights definition & assignment

Rule maker shouldn't decide conflicts by changing rules

- Clear rights should make most conflicts soluble bilaterally
- Use courts, either administrative (e.g. FCC ALJs) or conventional (e.g. Federal District)

Update rights

- through common law in the interim
- By new rules at license renewal

# Observations & Summary

# Invoking “sharing” doesn’t obviate the need for rights definitions

It probably makes it even harder, because there’s even more opportunity for conflict

In a dynamic system conflicts have to be pre-empted through rights definitions since they can’t be solved after the fact by regulatory or legal process

When sharing, what rights do the various parties have? How are they defined in a way that regulatory interpretation isn’t necessary when conflict arises?

Technology is necessary but not sufficient; it encodes rights. What are the rights? What rights definitions and assignments will make conflict resolution easiest?

# Institutional Context

Can be implemented incrementally

- One license + neighbors at a time: doesn't require a big bang

Regulator will have to give up power & privilege (oops)

- to design conflict resolutions
- to meddle between license renewals

# Not just for EAFULs\*

Works for unlicensed

- Transmission permissions as before
- Comparison of deployed outcome vs. reception protections of primaries allows transmission permissions to be adjusted

Applicable to intra-government coexistence, provided pricing is implemented

- In the same way that rights are assigned to commercial and state/local license holders, they could be assigned to the major cabinet agencies that fund/operate radio systems

However, G-NG coexistence is problematic because no conflict resolution venue exists

\* Exclusively Assigned Flexible Use Licenses

# Altruism vs. rational self-interest

Neither alone is sufficient

- Altruism only works in small groups
- Self-interest often isn't rational, and needs to be regulated

Engineer's vs. Economist's world views

Regulators traditionally assumed altruism

- Cf. language of “coordination”
- Doesn't work with many players with different interests

Use incentives and well-defined rights to bound groups within which altruism can operate, and prod self-interest in desired directions

# Takeaways

Maximize concurrent operation by defining unambiguous operating rights

Delegate interference management to operators

Separate rule-making from conflict resolution