

Interference Avoidance, Infostations and Economics

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WHAT IS WINLAB?

- Academic Research Unit within E&CE
 - Strong ties to CS
 - 15 Faculty, 40+ Grad students in a trailer
 - 5 to 10 year wireless horizon
 - Supported by corporate sponsors and Gov't grants
 - Recently added Economists to the mix!!
- ⇒ now looking to influence national spectrum policy

AN INTERESTING OBSERVATION

- Cellular Voice: 10kb/s, \$V/minute
 - Cost of 1MB Data: $\approx 13V$
 - 30 minutes of MPEG3 music: 30MB — 390V
 - Syncing a disc: 100MB — 1300V
 - A typical powerpoint presentation: 3MB — 39V
 - At 1 or 0.1 cents/minute: carefree use unlikely
 - 0.1 cents/minute: voice revenue disappears
 - NO difference for 3G wireless because 13V is 13V is 13V.
- BOLD CLAIM: Cellular can't carry low (enough) cost data**

WIRELESS HARDWARE OF YORE

- Clumsy, Fixed Transceivers
- Expensive Equipment
- Little Wireline Infrastructure

SPECTRUM MANAGEMENT OF YORK

- Central Licensing Authority
- Spectrum Police
- Litigation to protect infrastructure investment

What is spectrum management of tomorrow?

- Sophisticated signal processing
- Cheap Transceivers
- Agile Transceivers
- Extensive Wireline Infrastructure

WIRELESS HARDWARE TODAY

Standards committees meet at sanitariums

- Multiple uses and users
- Unpredictable uses
- Multiple manufacturers and service providers
- Irregular network structures

LAY OF THE LAND

- Develop Hardware – spend money
- Roll Out Infrastructure – spend big money
- Roll Out Service – make (LOTS)² of money (eventually)
- **OR NIGHTMARE**
- Someone else deploys a noise-bomb application
 - Service dies
 - Investment lost

A TYPICAL WIRELESS DREAM

- Must buy license to preclude noise-bomb
- No idea what license fee is sustainable *a priori*
- Business fails
 - from lack of license
 - from (ignorantly) high bid for license

CATCH 22

Social Cost: service diversity suffers

- Massive entry costs require deep pockets
- Entry costs preclude many competitors
- Deep pockets require large stable return
- Carefully assess market
- Find least common denominator cash cow

THE USUAL SCENARIO

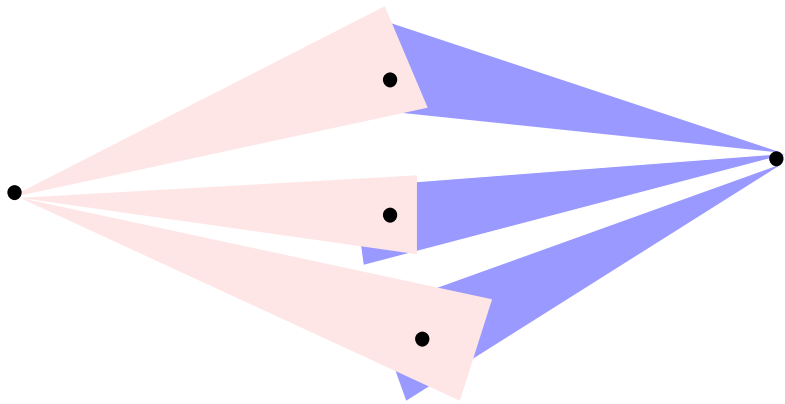
Make the Commons Bigger!

- Spectrum as the “Commons”
- Greediness
- Overuse
- Service Degradation

TOWARDS A SOLUTION: first, an abstraction

Each cow brings grass!

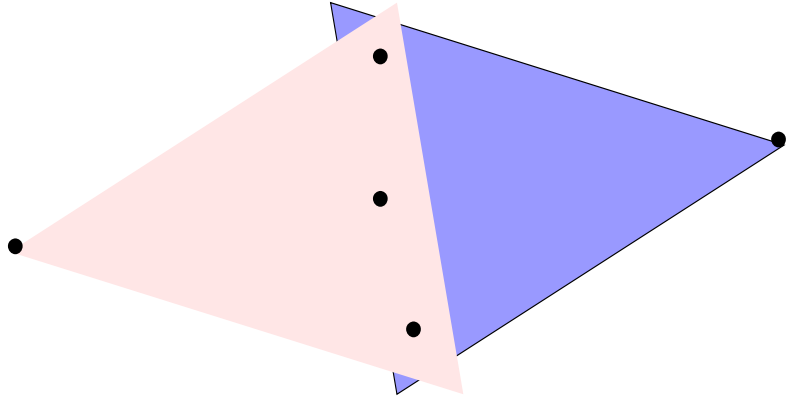
$$\text{Per User Rate} = (M-1)W \log \left(\frac{(M-1)WN_0}{P} + 1 \right)$$



SOLUTION I: A Bigger Commons

Tragedy of the Commons

$$\text{Per User Rate} \leq \frac{1}{M} W \log \left(\frac{MP}{N_0 W} + 1 \right)$$



- Overcrowding Probably Inevitable
 - scattering limitations
 - aperture and directivity limitations

NOTHING IS FOREVER

SOLUTION II: Discrete Unlicensed Wireless Zones

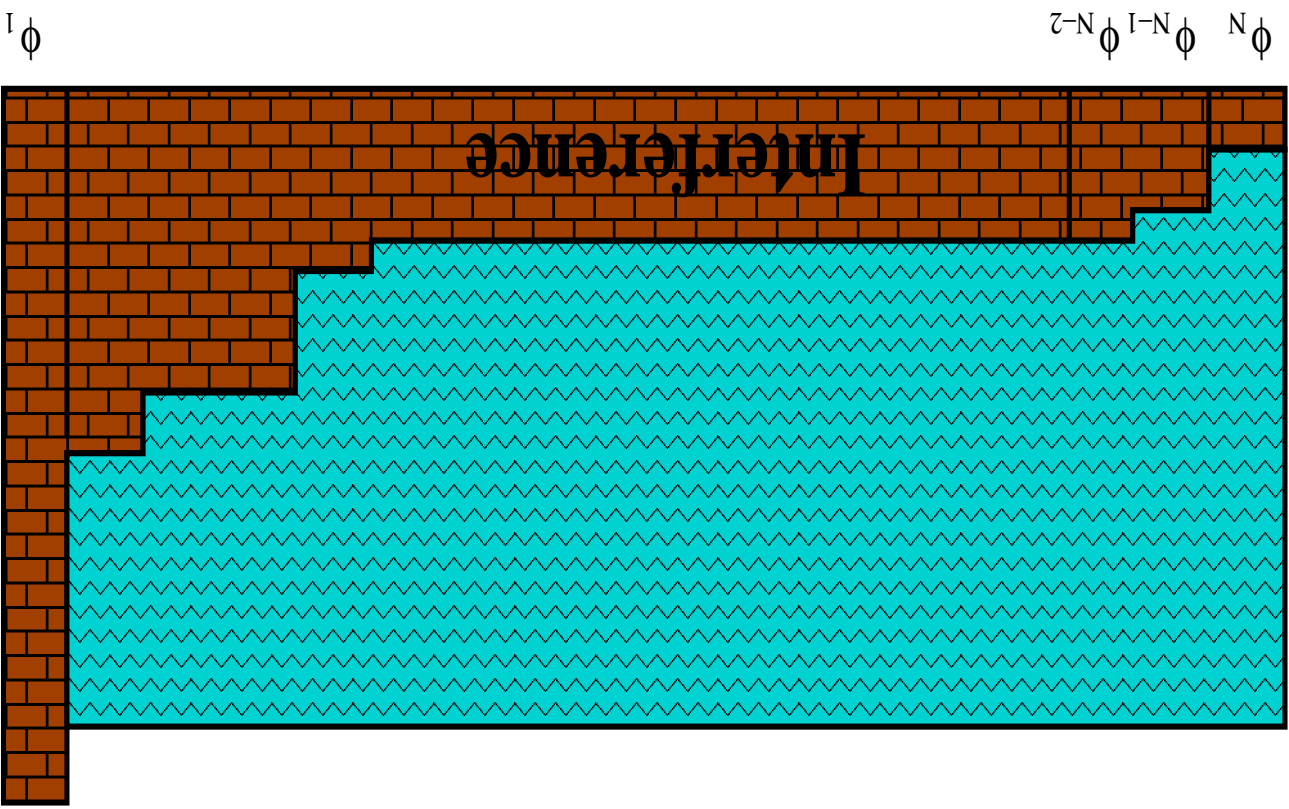
- Some Observations
 - people tend to congregate
 - long range transmissions kill you (interference)
 - long range carriage kills you (multihop)
- Local zones of coverage are natural
 - contiguous cells, (or more likely at first) isolated hotspots
- Congregation points often have landlines

WHAT NOW?

ZONAL POLICY: Adam Smith and Darwin

- Define zones via real estate ownership
- Tie spectrum rights to zone
- Cobble into network with landlines (*a la* Internet)
- Let market evolve transceiver protocols
 - Agile, Self-policing, Interoperable
 - The fittest survive
- Selective **economic** pressures
 - Landowner policing
 - Landowner system choice

AGILITY: Interference Avoidance

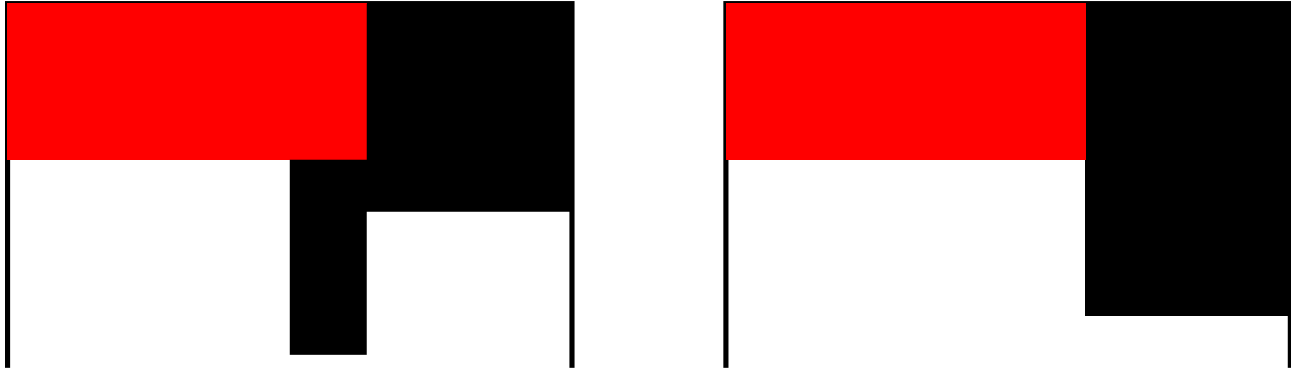


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SELF-POLICING: Spectrum Warfare

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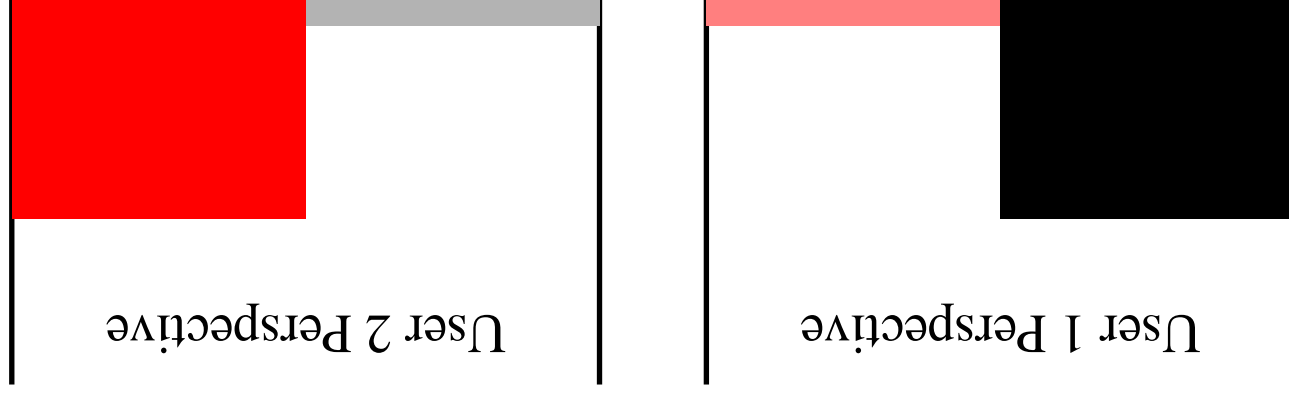


Self-Interest and Aggression Can Work!



THE FITTEST SURVIVE: Fear of the Zone God

Games of Cooperation and Defection



Average Play Judged by Zone

- Growth toward zonal contiguity
 - might need adjudication between “landowners”
 - interference sniffers for provable right/wrongdoing
 - but evolved protocols might be respectful enough
- Cannot let wireline gouge wireless!
 - wireline carriage as commodity
 - multiple competing carriers

OTHER DISCRETE ZONE ISSUES

CONCLUSIONS

ASSUMING: Agile (software) radios + wireline infrastructure

- Unlicensed Spectrum With Zone “Mineral Rights”
 - Adaptive Transceivers (interference avoidance)
 - Self-Policing (spectrum warfare)
 - Informed Market Choice By Zone (expel bad systems).
- Lowers Entry Barrier
- Encourages Competition

SOCIAL BENEFIT: Market-sustainable service innovation