Peaceful Coexistence:
Cellular Systems and Rotating Radar Using the Same Spectrum

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ISART 2011

Speaker represents no one but himself.

Thanks to R. Saruthirathanaworakun, CMU Ph.D. student

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Beyond "Unused" Spectrum

- Much of the discussion on making more spectrum available has focused on "unused" spectrum
  - Easier to do
  - But limited, possibly insufficient in the long term
  - For many kinds of systems, more sharing is possible
- In case of radar, radar systems may not operate over entire U.S. in given band
    - Should the rest be "exclusion zones"?
- Can we share "used" spectrum: frequency bands and geographic areas where radar systems also operate?

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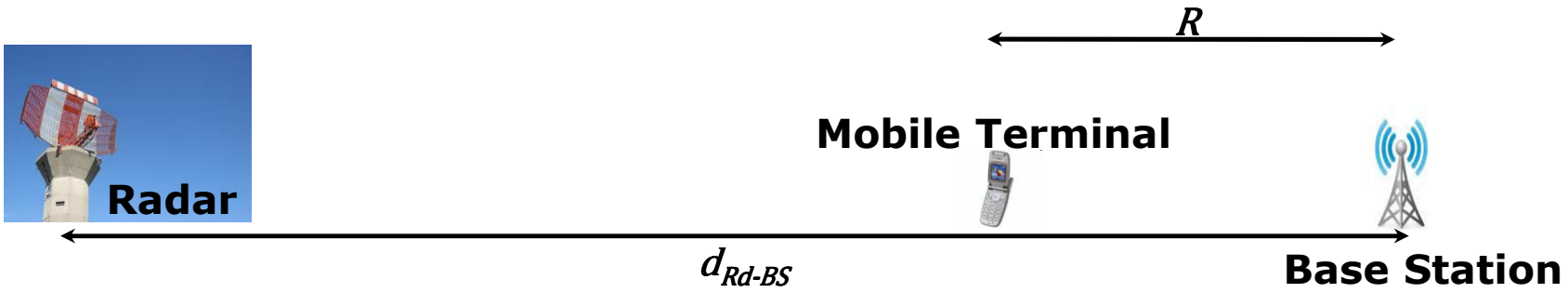
Radar and LTE



- Radar in fixed location, rotates at constant rate
  - Antenna gain to a given LTE device changes over time
  - LTE max power adjusted to keep radar INR below threshold
- LTE system
  - Capacity in shared spectrum varies with LTE max power, and interference from radar
  - Scenario: When cell capacity from dedicated spectrum is exceeded, traffic overflows into shared spectrum.

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Some Assumptions

- Cellular system knows about radar, e.g. transmit power, rotation time, tolerable interference.
- Shared spectrum at 2.8 GHz. Bandwidth = 3 MHz
- ITU-R P.1546 and COST 231 Walfisch-Ikegami path loss models, urban area, flat terrain
- Tolerable radar INR = -10dB
- Radar transmit power = 0.45 MW
- Antenna is a uniformly-distributed aperture type with elevation, azimuthal 3-dB beamwidth, and front-to-back ratio = 4.7^{o}, 1.4^{o}, and 38 dB, respectively
- Gain of the radar's main beam = 33.5 dBi,
- LTE cell radius = 0.8 km.
- LTE uses 2 by 2 MIMO in both directions

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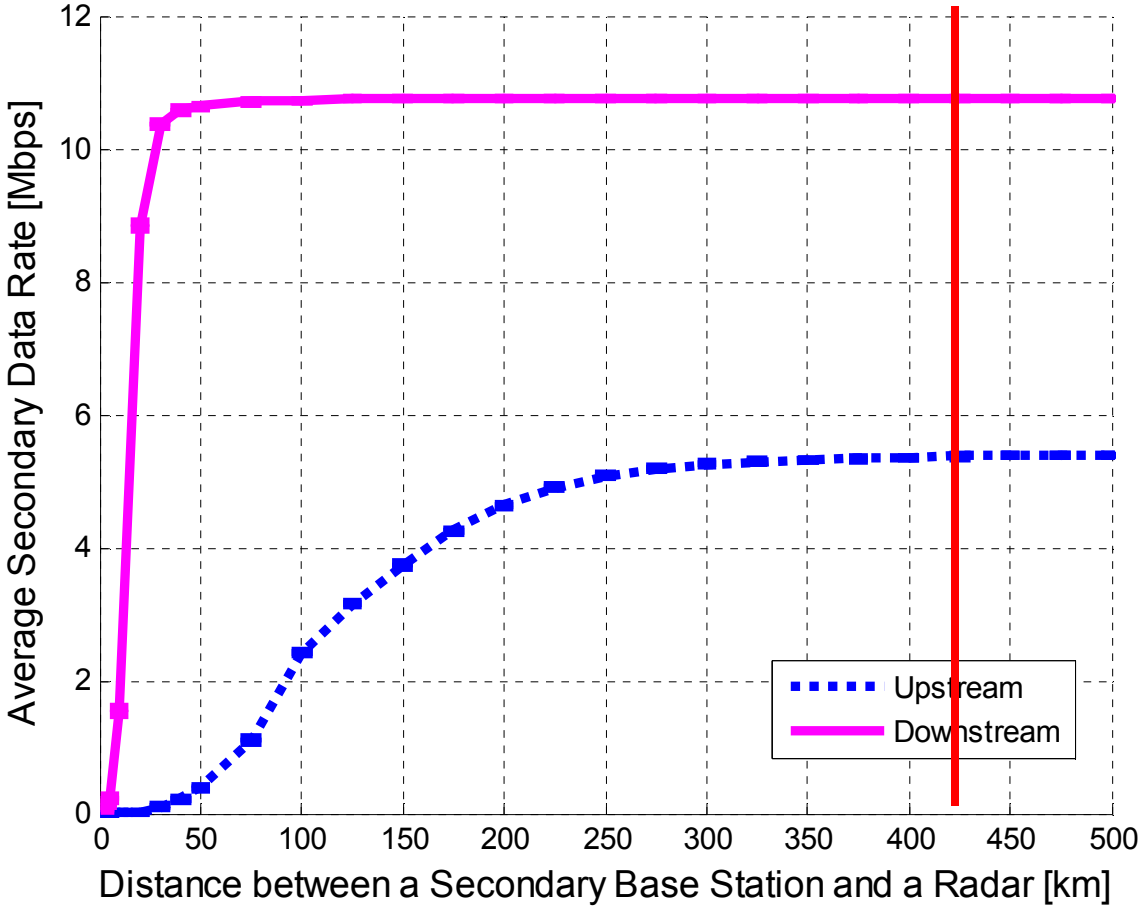
LTE data rate vs. Distance to Radar



High mean data rate close to radar, although with interruptions.
More efficient in downstream than upstream.

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What About Data Rate Fluctuations?

- Perceived data rate fluctuates over time as antenna rotates.
- Approaches mean rate for large files, but not for small.
  - For file size in the MBs, worst-case QOS is close to average.
  - For file size in the kBs, worst-case QOS much worse than average
- Our analysis shows that sharing is
  - Great for video streaming
  - Great for P2P file sharing
  - Very good for web browsing
  - Very bad for VOIP
- So sharing supports the *dominant applications*.

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Implications and Issues

- Spectrum shared with radar can be very useful for LTE
  - For video, P2P, large file xfer, web browsing. NOT VOIP.
- *But systems become interdependent*
- Secondary system requires knowledge of primary.
  - Requires more coordination than is typical.
  - Upgrading primary requires secondary to change or move.
- Greater risk of harmful interference.
  - Greater challenges for precertification
  - Must be possible to terminate secondary operation quickly
- Requires appropriate policy and governance
  - Either primary user or trusted third party must have ability and authority to address interference risks.
    - DoD/FAA? Band manager? FCC? NTIA?

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References

J. M. Peha, "Cellular Systems and Rotating Radar Using the Same Spectrum," *ISART*, 2011.

R. Saruthirathanaworakun, J. M. Peha, and L. M. Correia, “Opportunistic Primary-Secondary Spectrum Sharing with a Rotating Radar,” 2011.

J. M. Peha, "Sharing Spectrum through Spectrum Policy Reform and Cognitive Radio," *Proceedings of the IEEE*, April 2009.

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