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Problem. Solved.

Key Differences between Radar and Communications Systems

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Goals of Communications & Radar Systems

- **Communications**
  - Transfer information from a source to a sink.
  - Transmit signals through a channel connecting source and sink.
- **Radar**
  - Detect the presence of targets and/or estimate their parameters.
  - Radiate electromagnetic energy and gather information about the environment by observing echoes.

Communications and Radar Systems

Communications

- **Input:** Communications Signal
- **System:** Direct path and multipath
- **Output:** Noisy, distorted version of signal

Radar

- **Input:** Radar waveform
- **System:** Targets in environment
- **Output:** Noisy echoes due to targets

Radar vs. Communications

- **Radar**

"Given the radar waveform and the observed echoes, characterize the system."

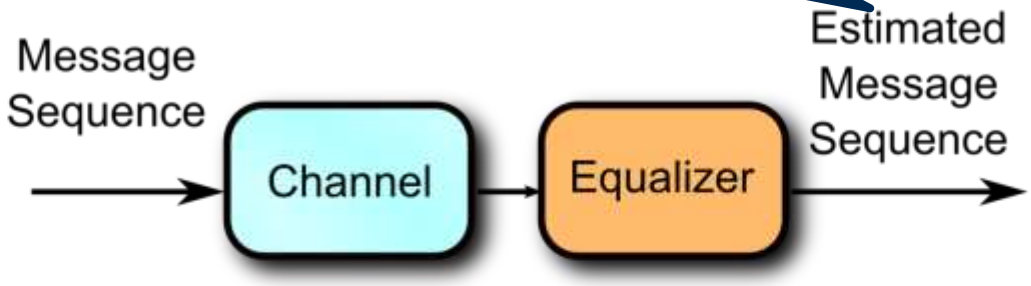
- **Communications**

"Given knowledge of the system (channel) and an observation of the signal, estimate the transmitted signal."

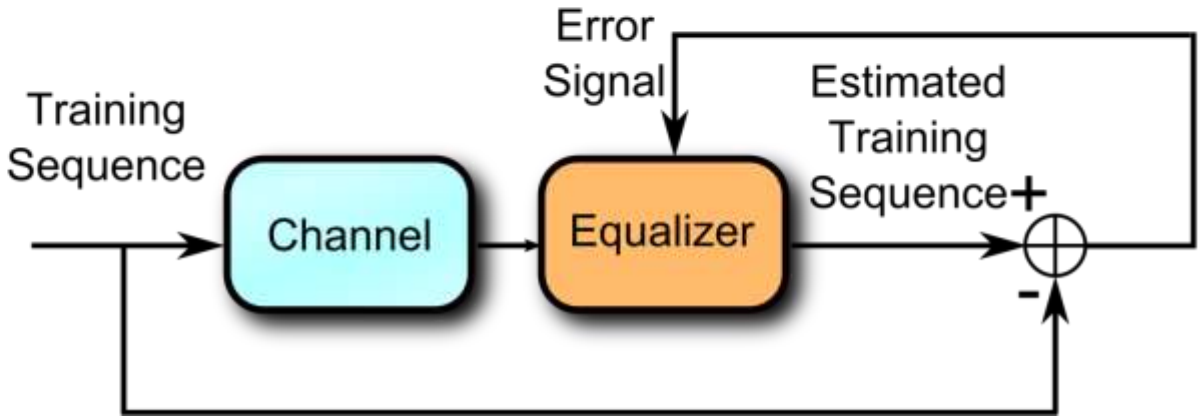
Communications: Data Transmission

Receiver estimates message sequence given knowledge of how the channel responds to certain inputs.

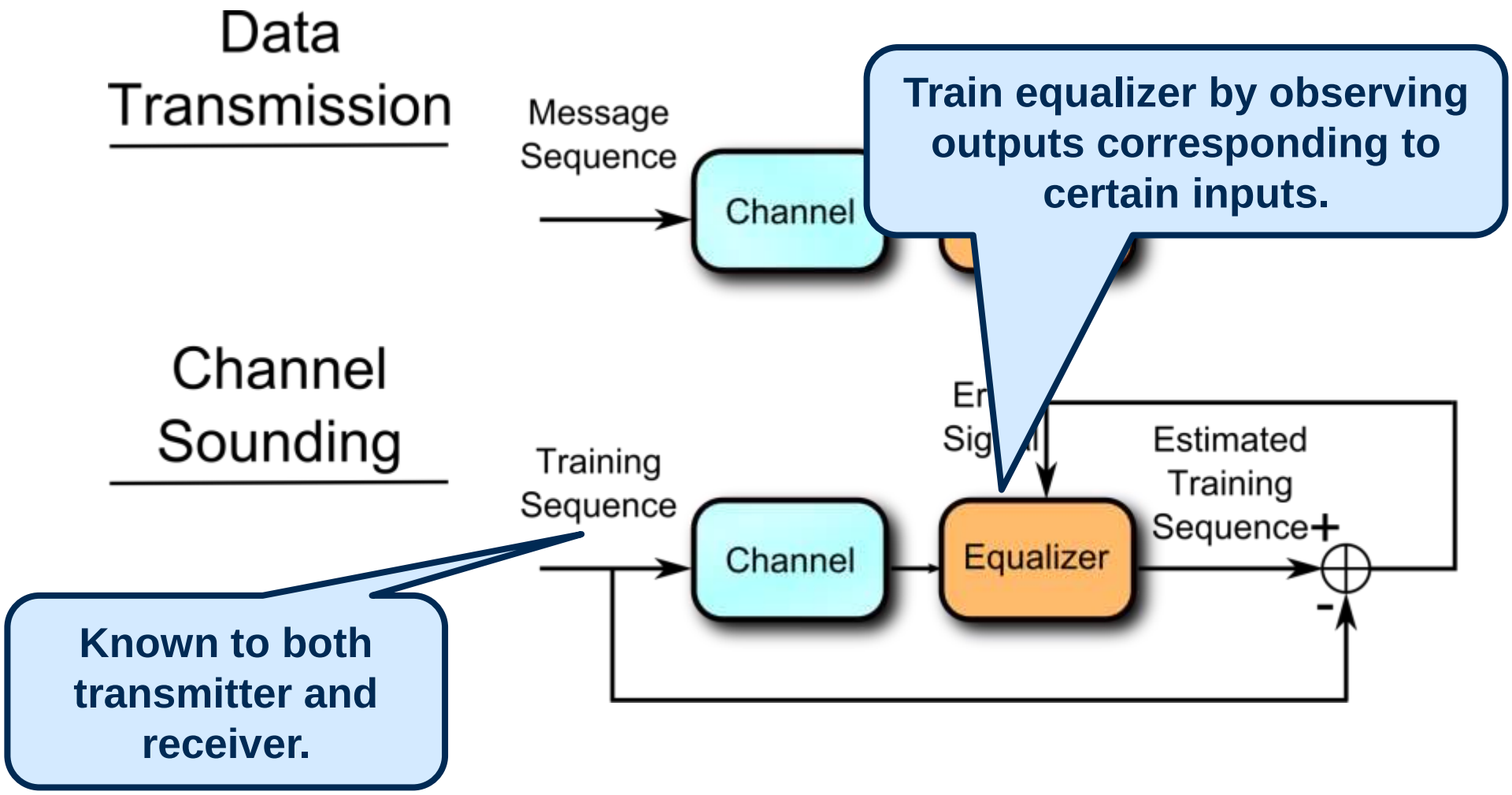
Data Transmission



Channel Sounding



Communications: Channel Sounding



Radar vs. Channel Sounding

- In communications, the characteristics of the channel are nuisance parameters that must be accounted for but are of no inherent importance.
- In radar, the “channel” and its characteristics are of primary interest.
- Example: The Channel Impulse Response
  - Each time tap is due to the direct path or scattering from reflectors at a particular range.
  - Comms Apply an equalizer to compensate.
  - Radar Use multiple pulses to resolve in cross-range.

Radar Missions

- Detect presence of targets at particular locations/Dopplers.
  - Ground moving target indication (GMTI)
  - Air moving target indication (AMTI)
- Estimate parameters of targets at a particular location
  - Synthetic aperture radar (SAR) imaging

Detection vs. Estimation

- **Radar systems typically search a volume/surface for targets by scanning a directional beam. Within each beam position, the decides if a target is present at a particular range/Doppler by calculating the likelihood ratio.**
- **After synchronization, communications systems estimate the chip value for a particular modulation chip by calculating the maximum a posteriori (MAP) estimate.**

Radar vs. Communications “Links”

- **Propagation Losses**
  - **One-way comms propagation models usually assume something on order of R^2 / R^3**
  - **Radar is a two-way channel, so ERP must account for R^4 propagation loss.**
- **Direct path vs. Multipath**
  - **Comms may include direct path or reflections off of surface.**
  - **Radar returns are always due to scattering, which may require increased power for “small” targets.**

Radar vs. Communications "Capacity"

- Communications channels may be bandwidth limited, so increasing transmit power may be of limited utility.
- Some radars can increase search volumes by increasing transmit power and decreasing dwell times.

Radar Waveforms: Coherence Requirements

- Coherent radar systems require signal to have some spectral support for a specified coherent processing interval (CPI)
- Airborne pulse-Doppler radars transmits a series of identical pulses to suppress clutter. (CPI on order of milliseconds)
- Synthetic aperture radar (SAR) forms high resolution imagery of the ground by transmitting a sequence of pulses. (CPI may be on order of seconds, during which the waveform cannot change significantly)

Radar vs. Communications Antennas

- Mobile units of communications systems typically employ nearly omnidirectional antennas.
- Radar systems typically scan a high-gain antenna over a specified surveillance volume/search area/scene to be imaged.
- Incident power density of radar system may fluctuate rapidly due to antenna scan.

Radar Development Cycle: SPY 1

- First installed on USS Norton Sound, 1973.
- Entered active service in 1983 as SPY-1A.
- Subsequently upgraded to B/D and D(V) versions.
- Currently deployed on about 100 surface ships.

1983 AMPS Mobile Phone

"SPY-1 is the most widely fielded naval phased array radar in the world. It is the heart of the Lockheed Martin-developed Aegis Weapon System. It automatically detects and tracks hundreds of targets from the wave tops to the exoatmosphere."

-LM Brochure

Source: Wikipedia!?

Summary

- Radar and communications exploit similar electromagnetic phenomena and are well described by similar mathematical theories.
- Significant differences in operational requirements exist between the two.