

# A Hardware Platform for Utilizing TV bands with a Wi-Fi Radio

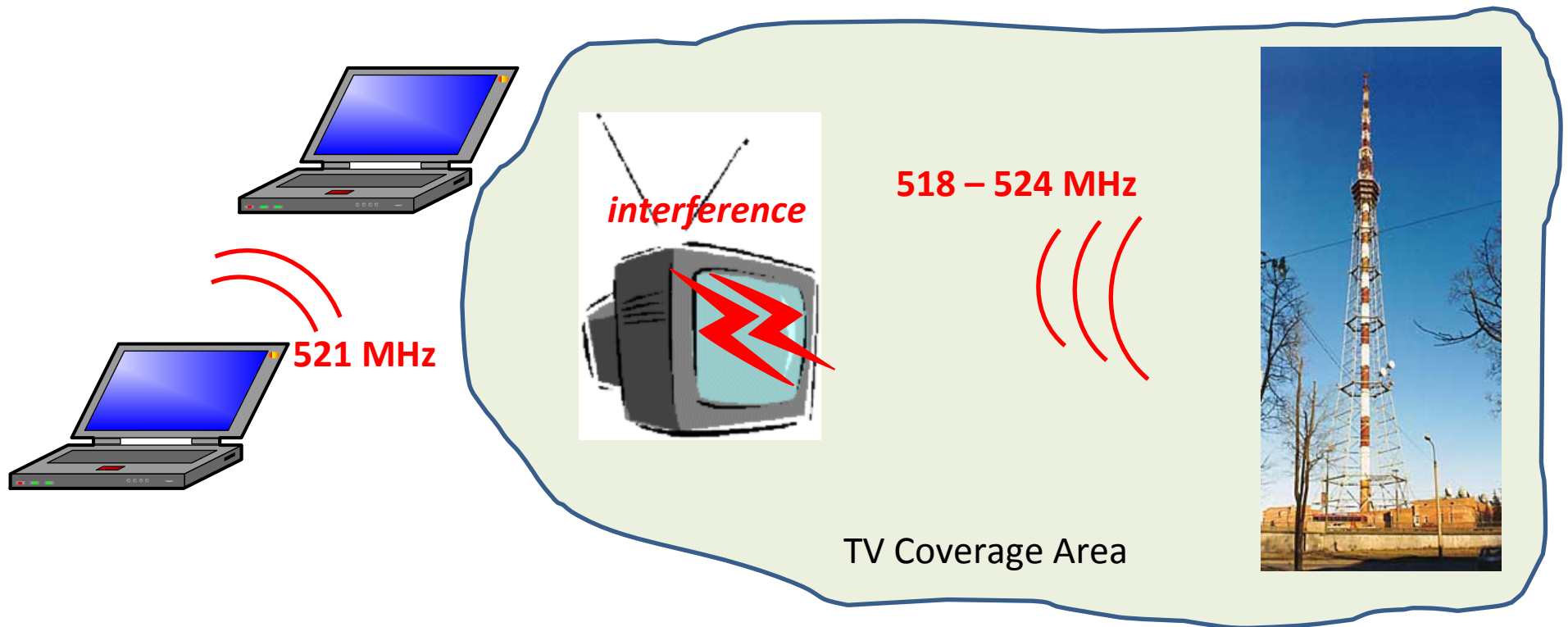
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# Recent Developments

- FCC exploring to open up vacant 512-698MHz TV spectrum for unlicensed usage
- Why is this exciting?
  - 200MHz BW and 3x Propagation Range
  - Less cluttered spectrum than ISM bands.
  - Huge bandwidth for new wireless applications
- What is missing?
  - Technology for data communication in TV bands without interference

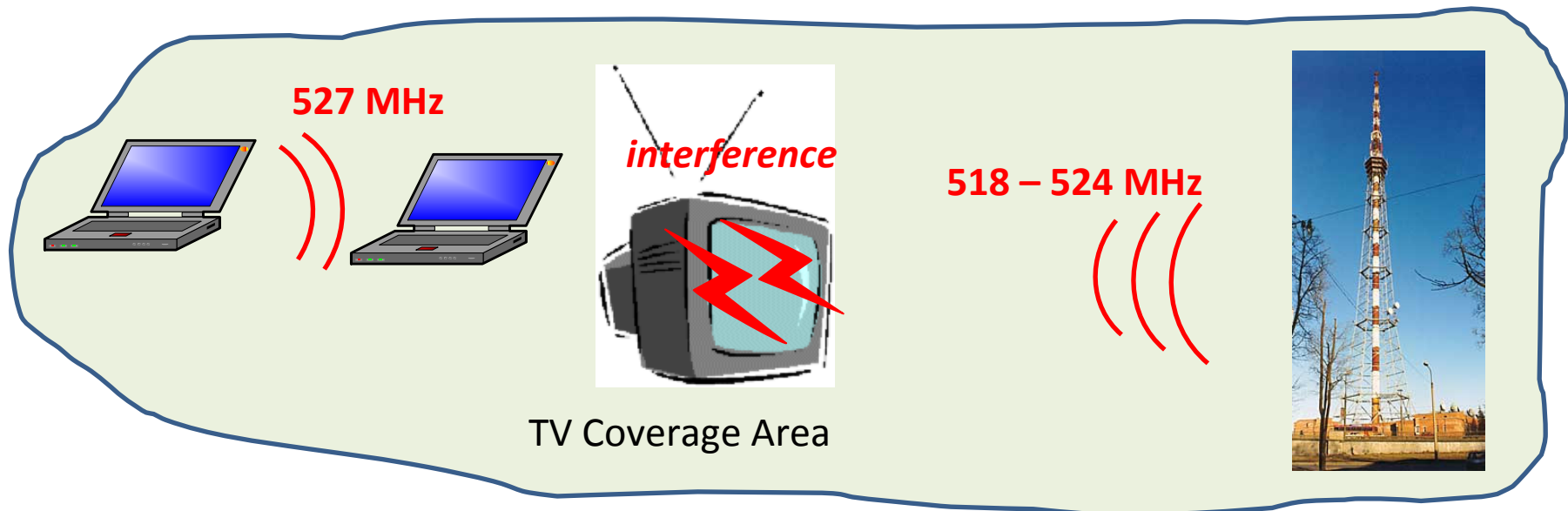
# What are the Issues?

- Broadcasters pay *huge* amount for spectrum
  - Unlicensed devices should not interfere
    - Hidden node interference in same TV band



# What are the Issues?

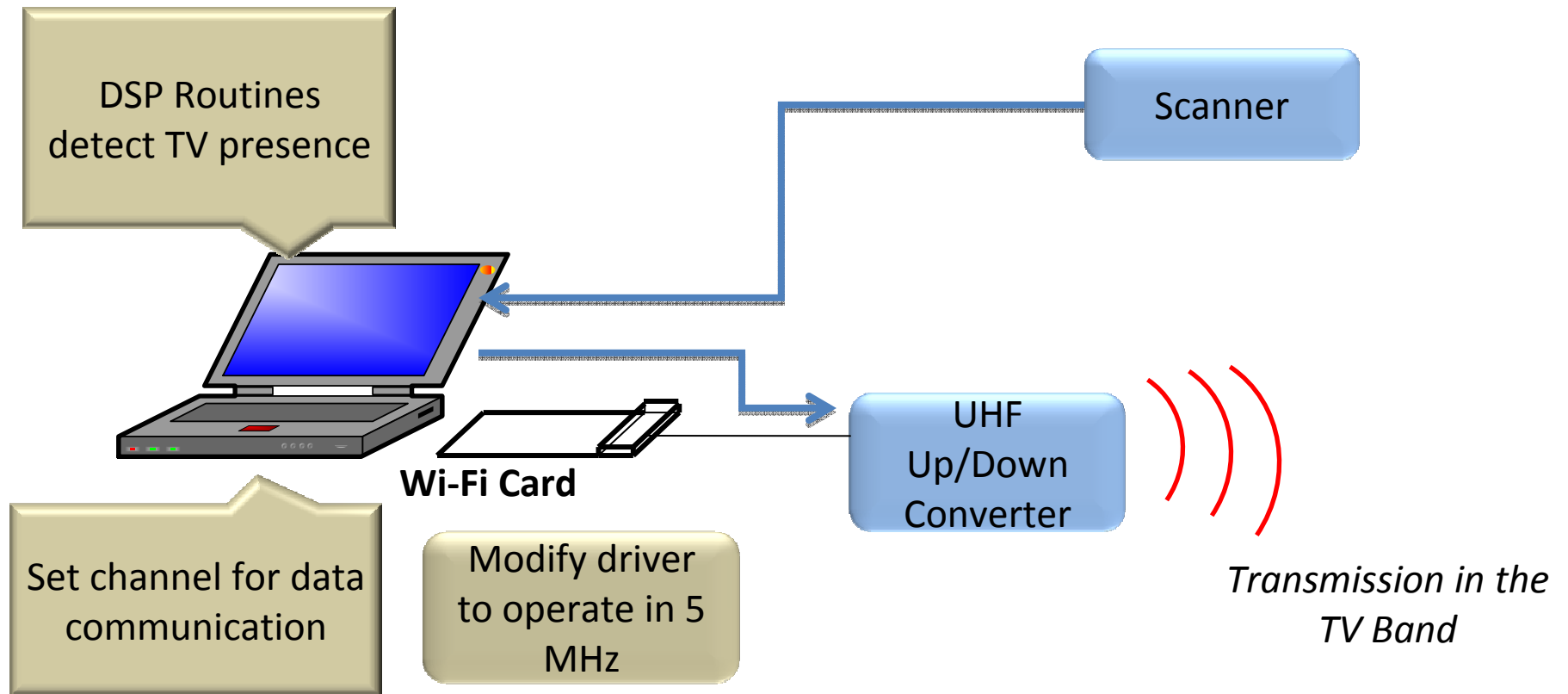
- Broadcasters pay *huge* amount for spectrum
  - Unlicensed devices should not interfere
    - Hidden node interference in same band
    - Adjacent channel interference in neighboring bands
      - Existing technologies don't fit in TV band



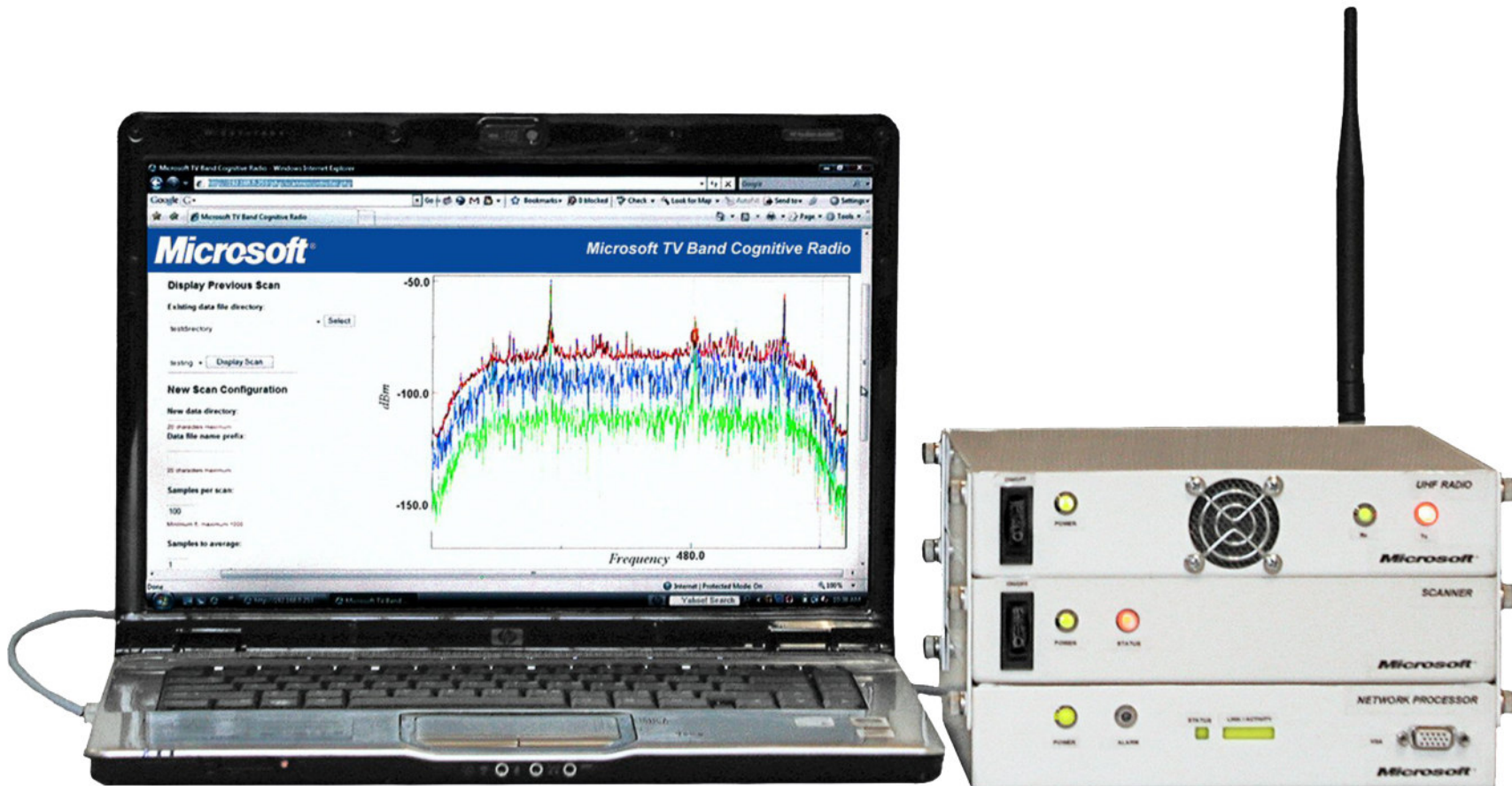
# Our Approach

- Detect TV transmission *much* below TV receiver threshold
- Operate in vacant TV bands.
  - Avoids hidden terminal problem
- Use Wi-Fi radio for data transmission
  - Can achieve high data rate communication.
  - Proven , well understood technology.
  - Commercially available off the shelf, low cost Radios.
- Shape Wi-Fi waveform to fit in TV band
  - Avoids adjacent terminal interference

# System Architecture



# Cognitive Radio in TV Band



# Hardware Implementation

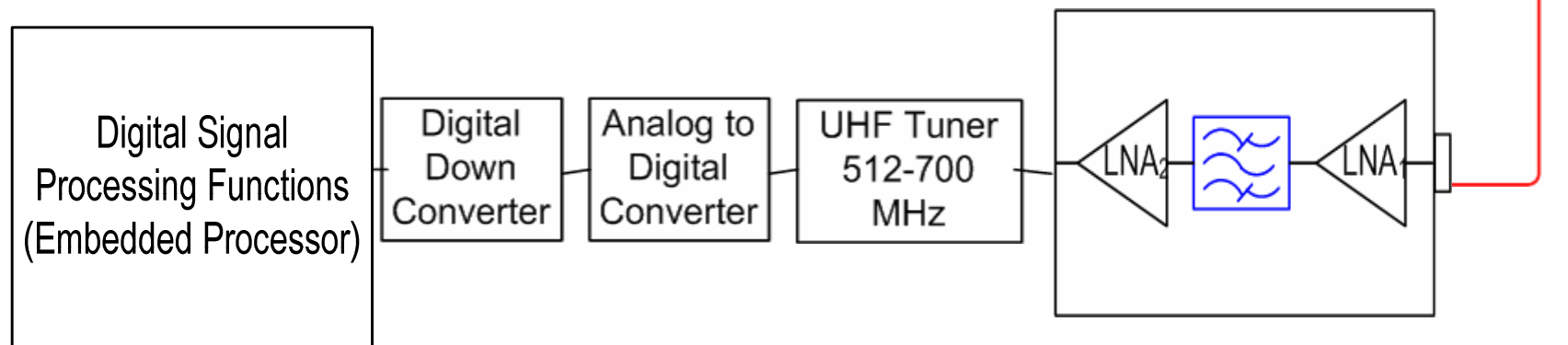
HW Platform consists of three main components:

- Wideband spectrum scanner:
  - Discover vacant TV channels in 512-698 MHz
- Tunable UHF half-duplex transceiver
  - Frequency Translator for down/up conversion of 2.4GHz signal to TV band signal
- Network processor
  - X386 based processor that controls scanner, UHF radio
  - Process scanner samples, apply DSP routines for feature detection
  - It also controls the Tx power

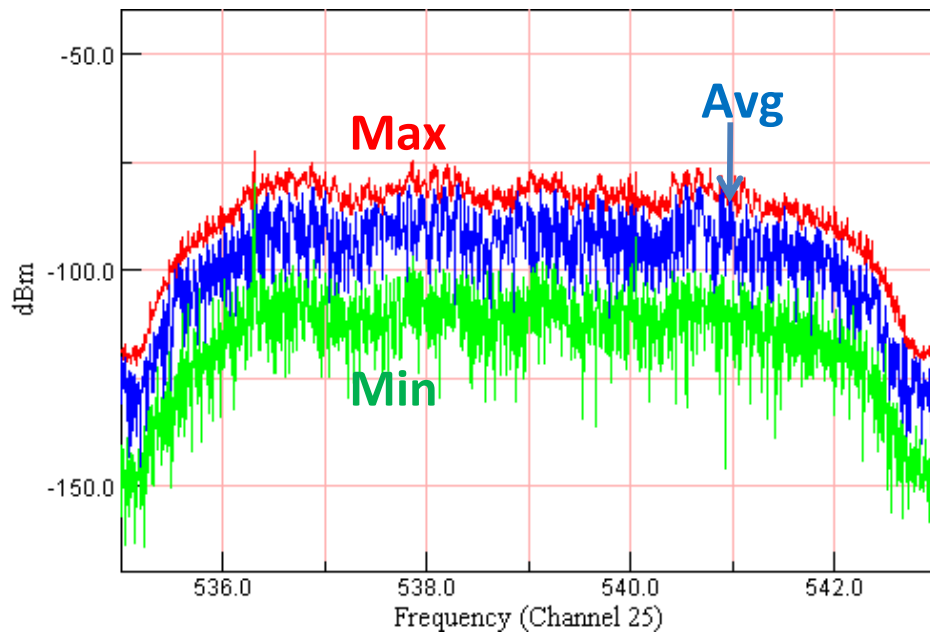


# Wideband Spectrum Scanner

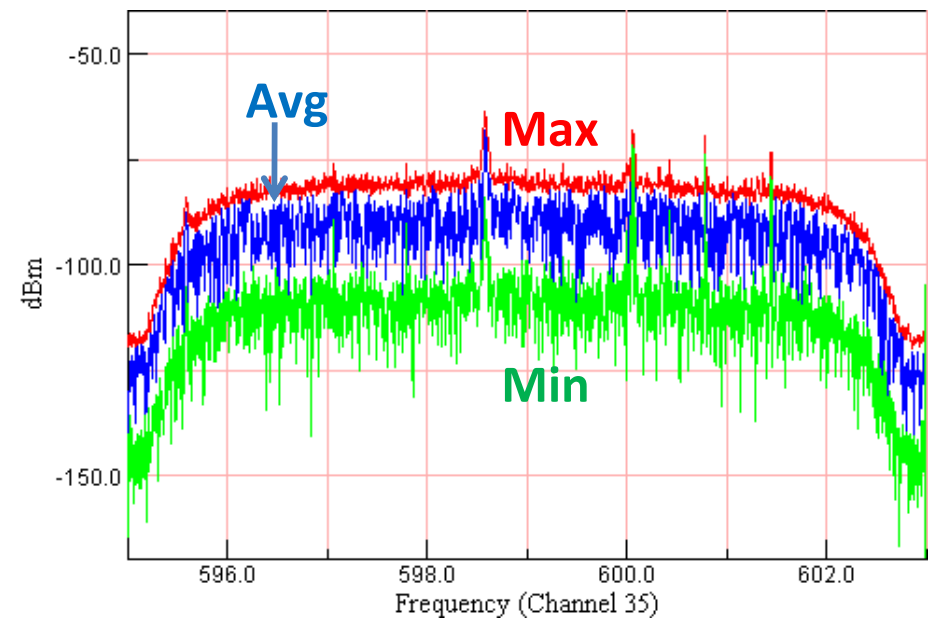
- Frequency Range: 512-698MHz
- Scan Frame Bandwidth: 8MHz
- Scan Frame FFT size: 2048MHz
- Minimum DTV pilot tone sensitivity: **-114dBm** << **-85dBm**



# TV Signal detection



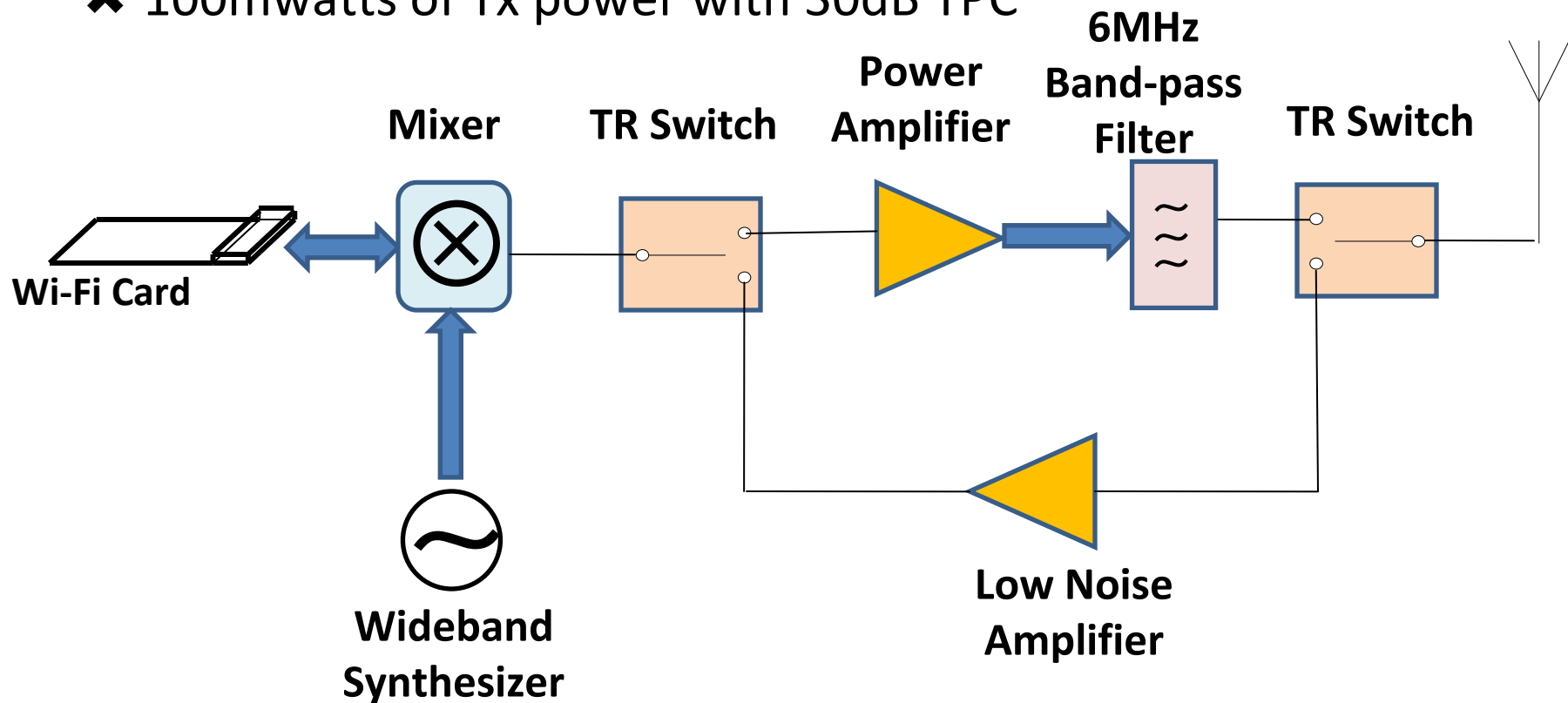
DTV



NTSC

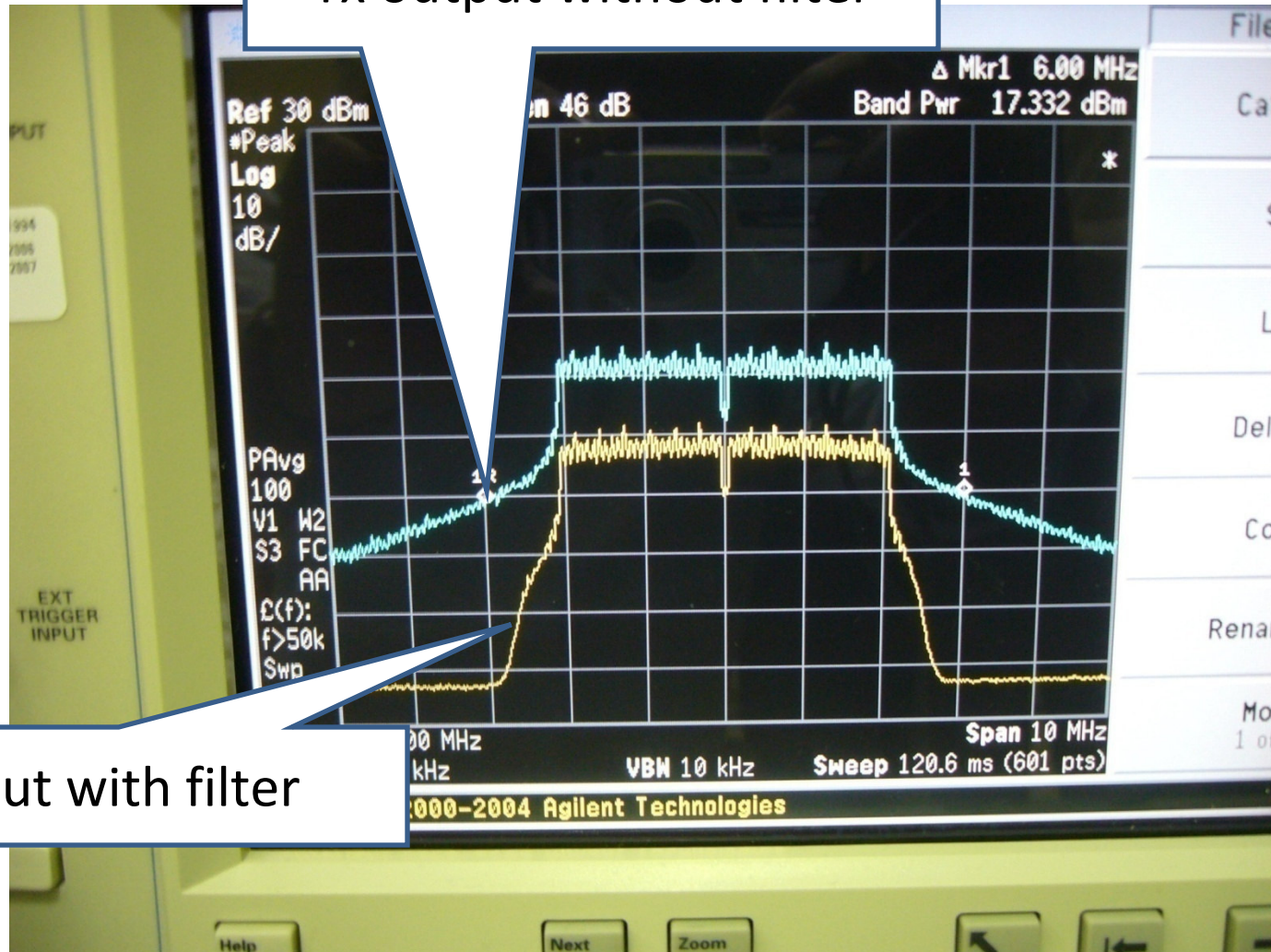
# UHF Translator Design

- ✘ Uses 2.4GHz 802.11g modem for primary signal generation
- ✘ Shapes OFDM signal to fit in 6 MHz TV band
- ✘ 100mwatts of Tx power with 30dB TPC



# UHF Translator Output

Tx output without filter



Tx output with filter

# Network Processor

- Integrates scanner with UHF translator
  - Determines white spaces by processing scanner output
  - Sets appropriate parameters at the UHF translator
  - Implemented as 2 processes that talk using shared memory
- Processes samples from scanner
  - Applies 2048 FFT on scanner samples
  - Matches feature templates for digital TV, analog NTSC signals, etc.
- Controls parameters of the UHF translator
  - Channel frequency, Tx power

# Summary

- People have talking about using TV bands for a long time. This is the first system to the best of our knowledge... currently being evaluated by FCC.
- Contribution: Real system for high data rate in TV bands
  - Without modifying the Wi-Fi radio
  - Without interfering with nearby TV receivers on same channel
  - Without interfering with nearby TV receivers in adjacent channels
- Future work:
  - Standardize Tx wave shape to avoid adjacent channel interference
  - Explore cooperative sensing to further reduce interference
  - Study propagation characteristics in the TV bands

# Questions?

<http://research.microsoft.com/netres/projects/KNOW>

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