A Cognitive Radio TV Prototype for Effective TV Spectrum Sharing

Why TV Set-Assisted Spectrum Sharing?

CNS #1247941

1. US Metropolitan Areas:
Overcrowded Wireless Devices, Limited TV White Space

28-9 8 7 6 5 4 3 2 1 0   White Space Channels

San Jose, San Francisco
Los Angeles
Chicago
Philadelphia
Baltimore
New York City
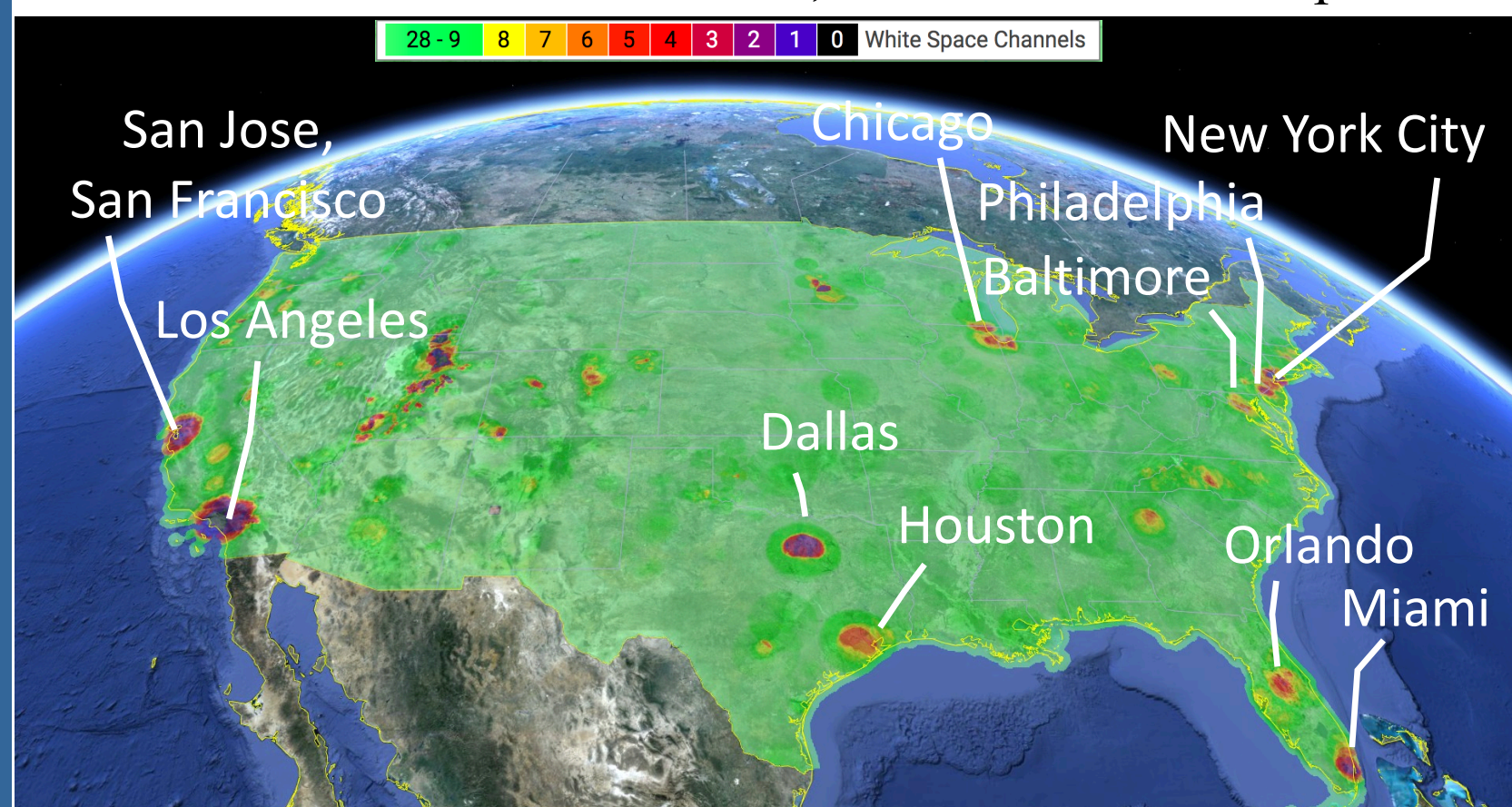Dallas
Houston
Orlando
Miami

Fig. 1. TV White Space Availability in U.S. (Google Spectrum Database)

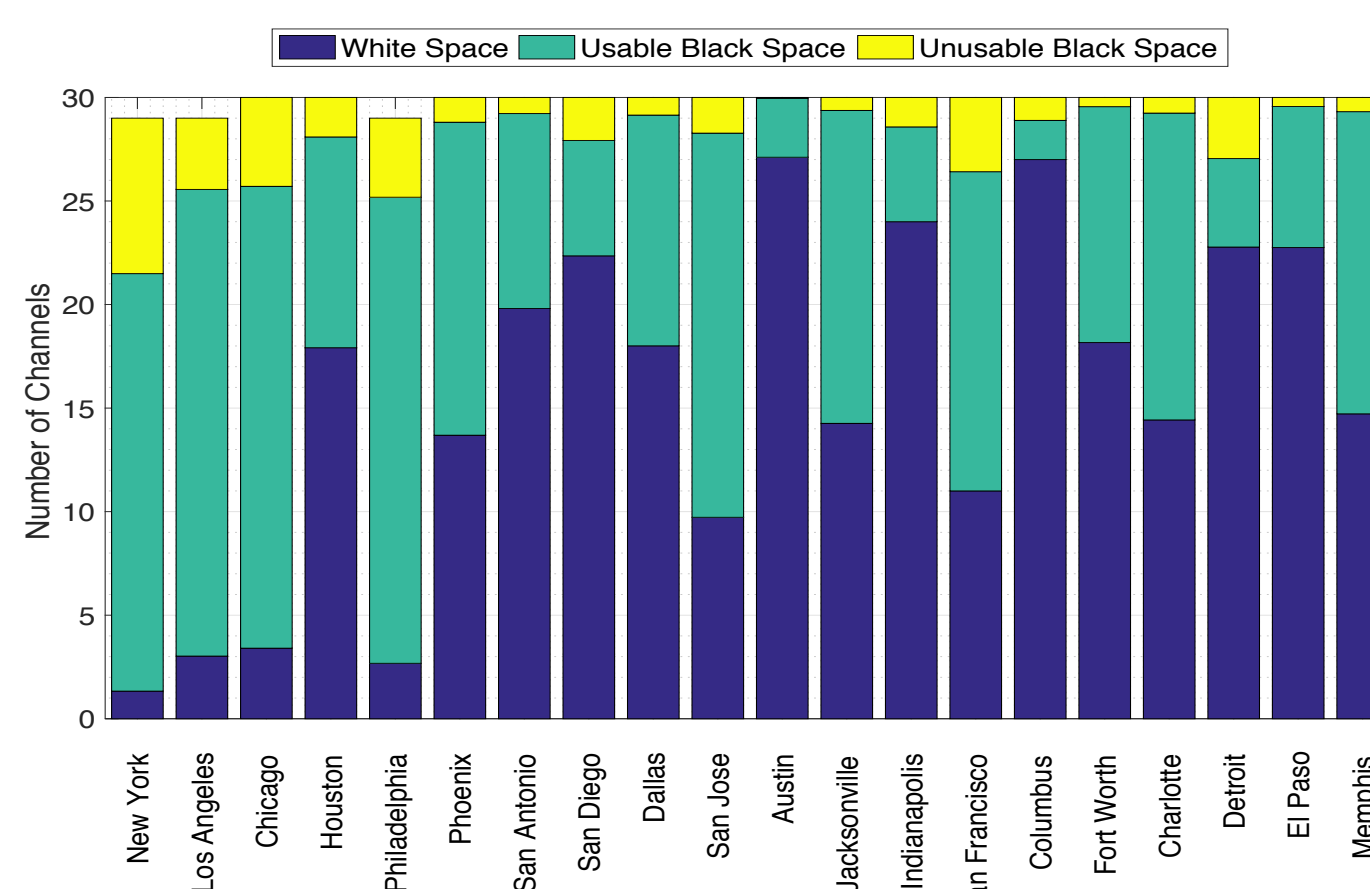2. 10x Available Channels: Secondary User access active TV channels w/o interference TV user

■ White Space ■ Usable Black Space ■ Unusable Black Space

Number of Channels

New York, Los Angeles, Chicago, Houston, Philadelphia, Phoenix, San Antonio, San Diego, Dallas, San Jose, Austin, Jacksonville, Indianapolis, San Francisco, Columbus, Fort Worth, Charlotte, Detroit, El Paso, Memphis

Fig. 2. Available TV Channels in Top-20 U.S. cities (by population)

3. TV Set Feedback standardized in Next Generation Terrestrial TV!! ATSC 3.0 ADVANCED TELEVISION SYSTEMS COMMITTEE
+Broadband is everywhere,
+Connected TV set is trending up

TV User → TV signal
Cog-TV User ····· WiFi Link
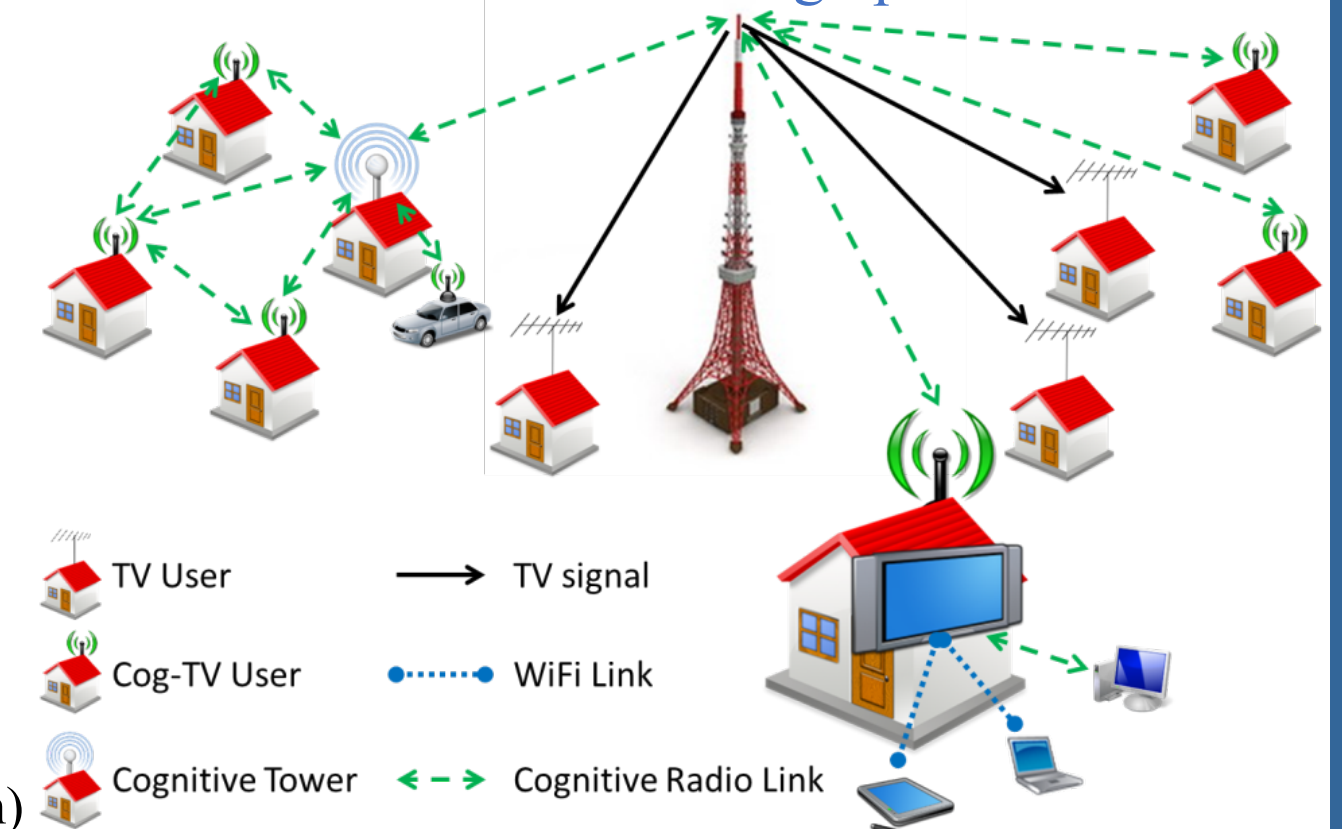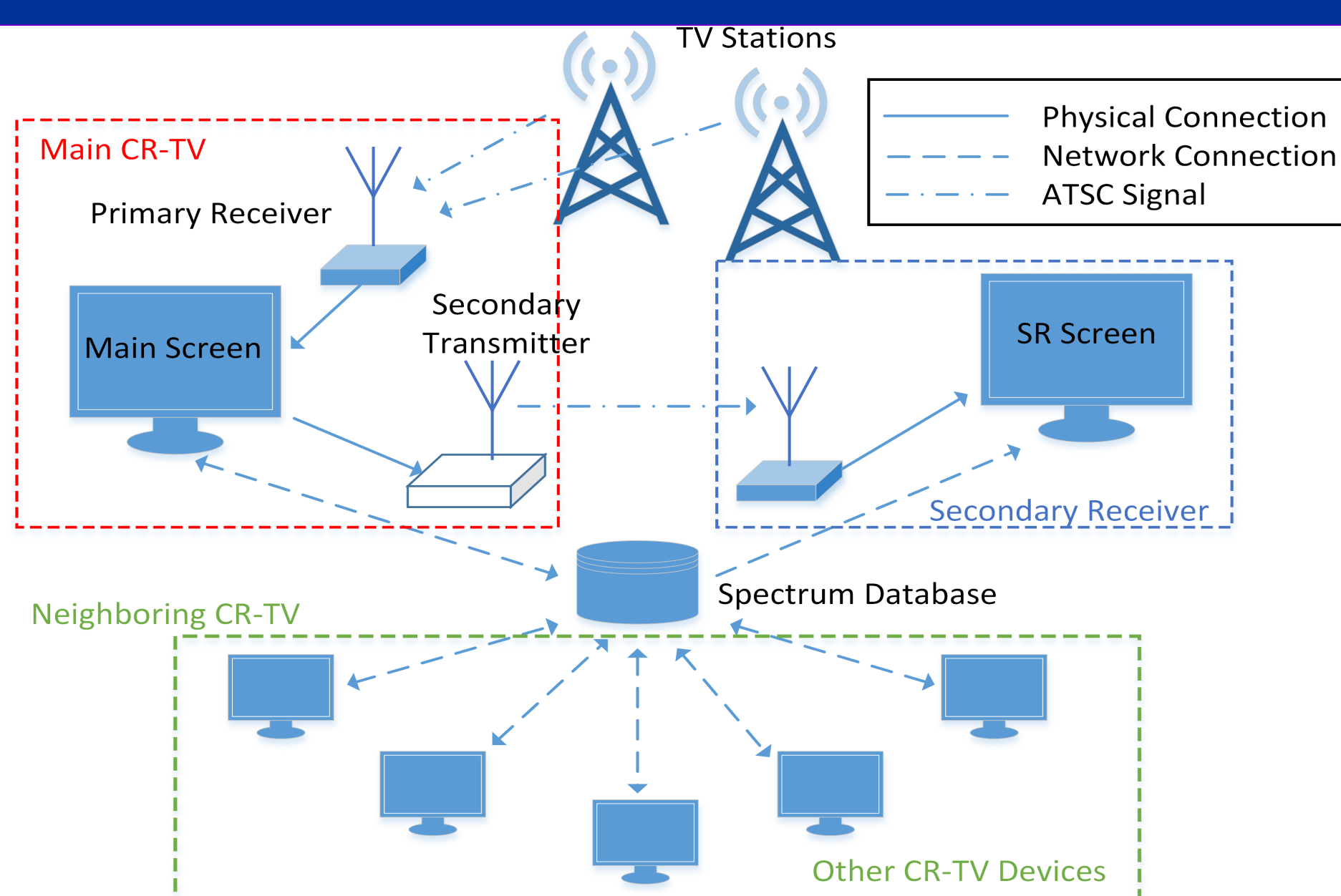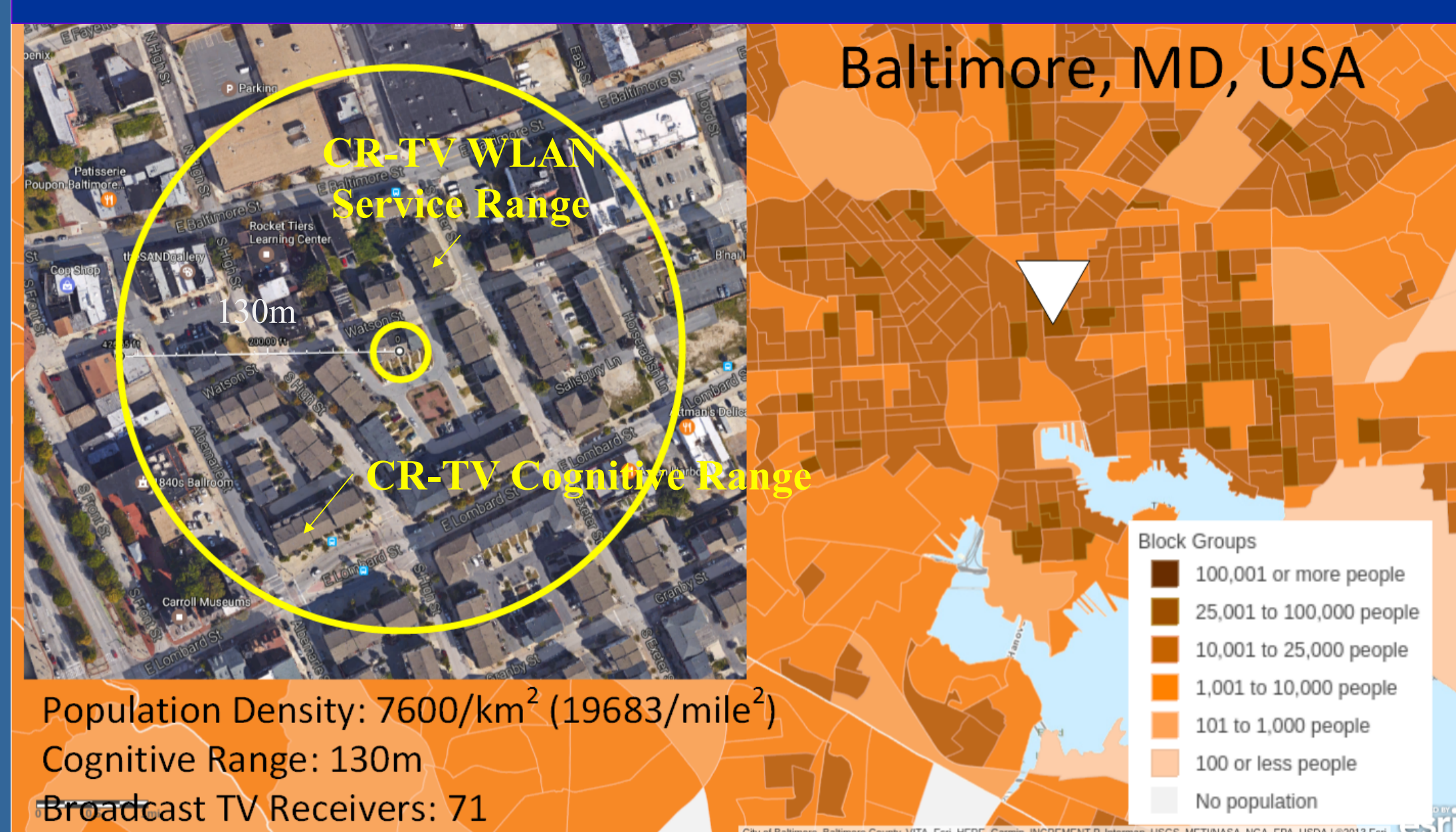Cognitive Tower ← → Cognitive Radio Link

Fig. 3. Envisioned Cognitive TV (Cog-TV) System

*This demo shows **How TV users are affected** when CR user on active TV channels!*

CR-TV Demo System
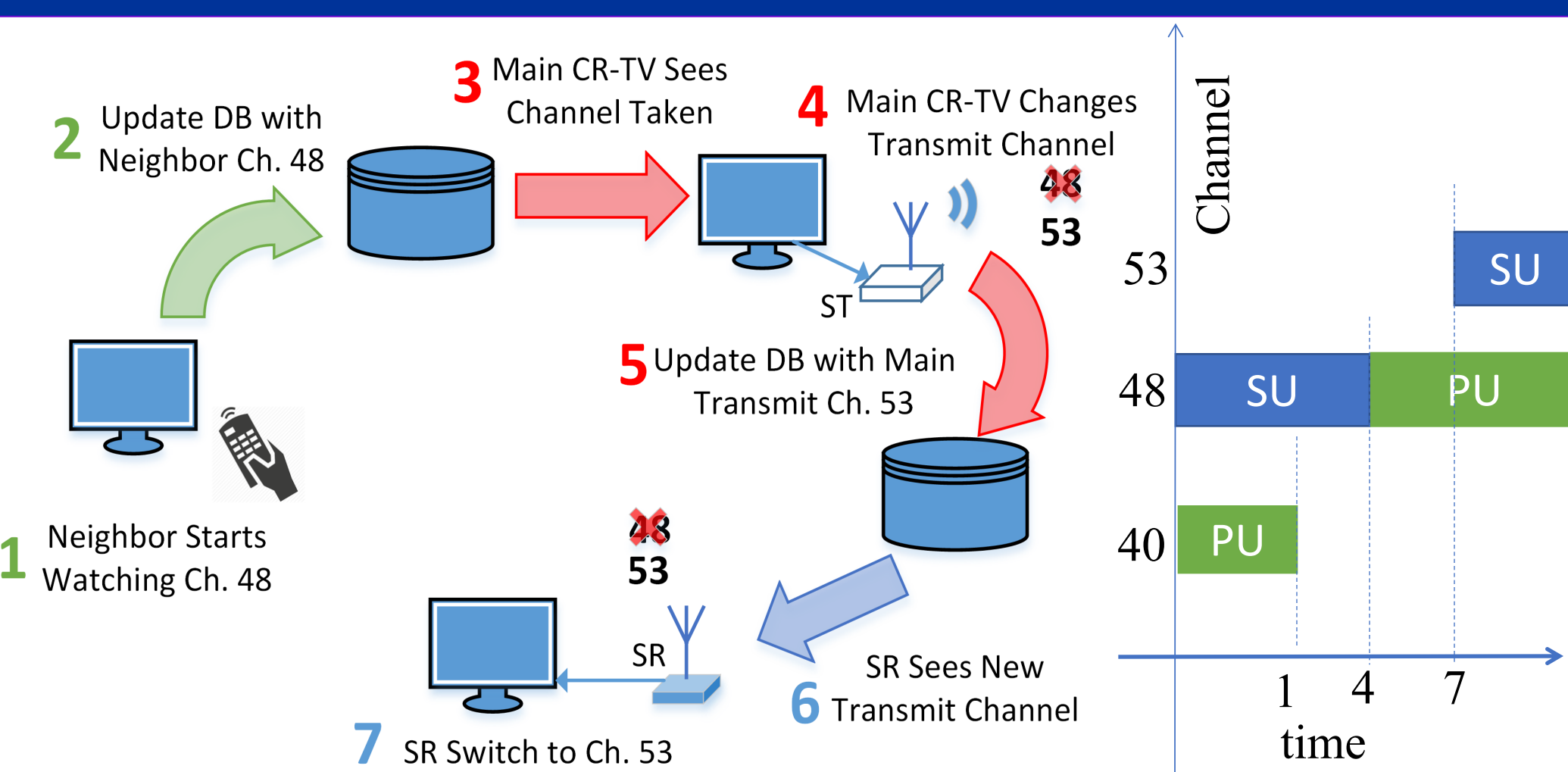

TV Stations

Main CR-TV
Primary Receiver
Main Screen
Secondary Transmitter
SR Screen
Secondary Receiver

Physical Connection
Network Connection
ATSC Signal

Neighboring CR-TV
Spectrum Database
Other CR-TV Devices

CR-TV Cell

Baltimore, MD, USA

CR-TV WLAN Service Range
130m
CR-TV Cognitive Range

Block Groups
■ 100,001 or more people
■ 25,001 to 100,000 people
■ 10,001 to 25,000 people
■ 1,001 to 10,000 people
■ 101 to 1,000 people
■ 100 or less people
No population

Population Density: 7600/km² (19683/mile²)
Cognitive Range: 130m
Broadcast TV Receivers: 71

TV User-Triggered Spectrum Handover

2 Update DB with Neighbor Ch. 48
3 Main CR-TV Sees Channel Taken
4 Main CR-TV Changes Transmit Channel 48 53
ST
5 Update DB with Main Transmit Ch. 53
1 Neighbor Starts Watching Ch. 48
48 53
SR
7 SR Switch to Ch. 53
6 SR Sees New Transmit Channel

Channel
53 — SU
48 — SU | PU
40 — PU
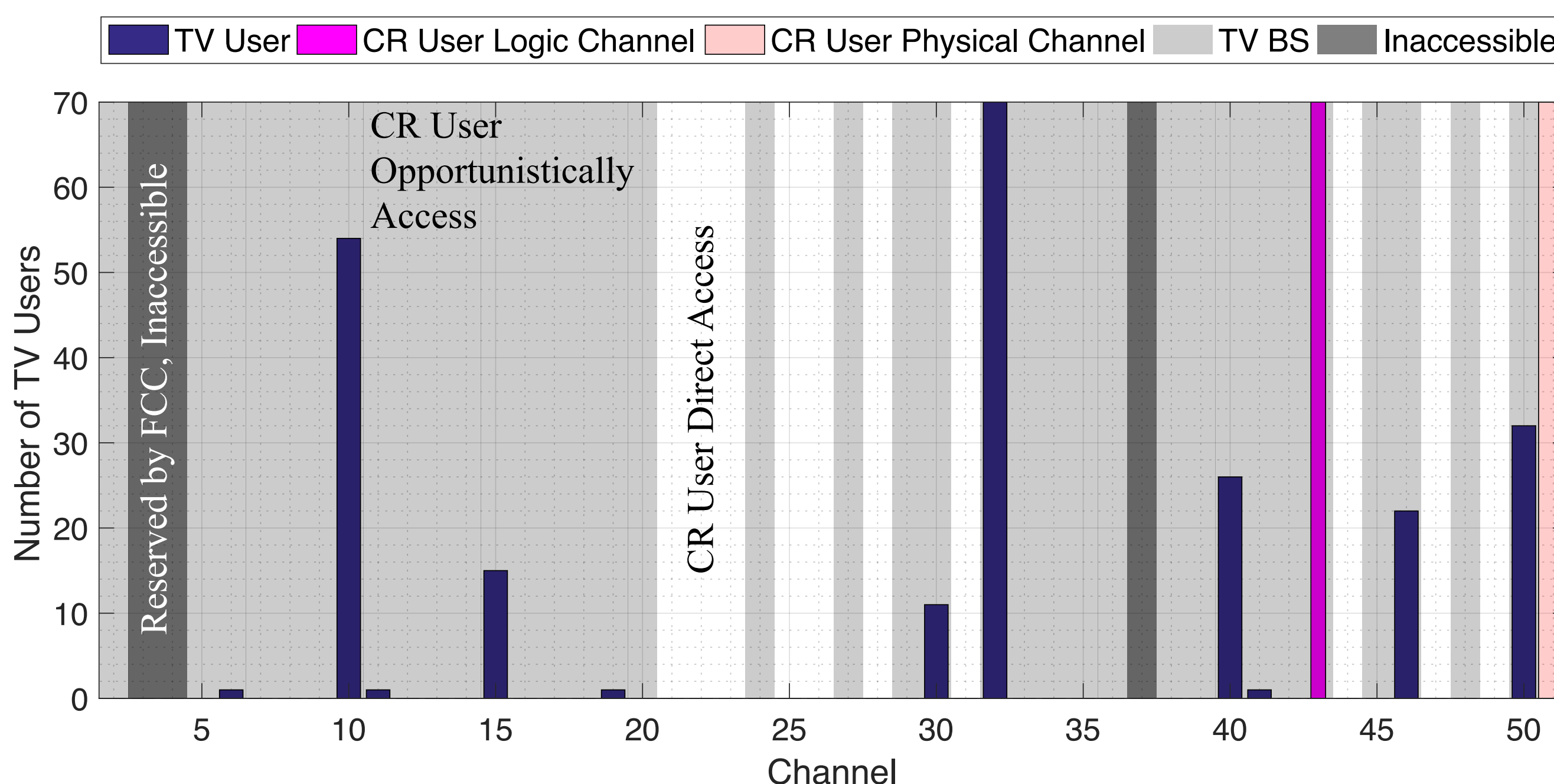1 4 7
time

Key Features & Key Components

SCAN ME

➤ Play Broadcast TV Programs
➤ Stream Video over Cognitive Link
➤ Spectrum Collision Exhibition on TVWS Channel (mini TV Station)
➤ TV Spectrum Monitor
➤ Neighboring TV User Traffic Simulator
➤ Online Spectrum Handover Analysis

Find out More or Go to
http://cpn.unl.edu/projects/cogtv

MATLAB python MySQL
mythTV GNURadio ubuntu
HD HomeRun CONNECT Ettus Research A National Instruments Company
USRP B200

Exemplary TV Spectrum Usage

■ TV User ■ CR User Logic Channel ■ CR User Physical Channel ■ TV BS ■ Inaccessible

Number of TV Users

Reserved by FCC, Inaccessible
CR User Opportunistically Access
CR User Direct Access

Channel

Spectrum Handover Impact

■ TV User Interference ■ Secondary User Overhead

Frequency

Delay from Step 1 to Step 4

Impact on TV Viewer
Zapping Time + 5~10%
(80ms/1~2s)

Delay from Step 4 to Step 7

Cognitive User
130 ms overhead (interrupt) per spectrum handover

Milliseconds