WiFi Services Using White Space

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Contents

- Data Explosion in Internet
- What is TV white space
- Research on White Space in IEEE, IETF
- Activities regarding TV white space in US, EU, etc
- Research topics on WS
- Conclusions

- Cloud and iCloud

What is iCloud?

iCloud stores your music, photos, apps, calendars, documents, and more. And <u>wirelessly</u> pushes them to all your devices — automatically. It's the easiest way to manage your content. Because now you don't have to.

- **Mobile Cloud Computing**

- **Usage of cloud computing in combination with mobile devices**
- **Tasks and data kept on the internet rather than on individual devices, providing on-demand access, over the Infrastructure where both the data storage and the data processing happen outside of the mobile device**
- **Not required to download or install applications onto the mobile devices**

Smart Devices (1)

- **Evolution of Smart devices**

PDA Phones: ~ '00 → **Smart Phones: ~ '10** → **Smart Appliance: ~ ??**

Modular PDA

BlackBerry, E-Mail Device
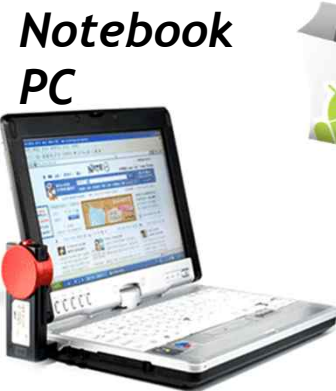
Notebook PC

Netbook

e-Book

Smart Devices (2)

- **The Smart Phone,** *Video-oriented* **Device?**

- 3D video recording
- 3D contents
  (UCC, Indep. Films, CF)
- 1.5G Dual Core
- 4.5" display
- Full HD quality

Demand for video applications will increase with the high-end smart phone and faster network

Unlimited Data Use

- **Data Explosion, Mixed Blessing for Mobile Telecoms**

  - Unexpected rush, 3G network was not designed for mobile broadband....
  - The smart phones make people to use the wireless network just as they would use their fixed broadband line at home....
  - 10% heavy-user traffic takes up 93% of total 3G traffic ....
  - How to solve .....
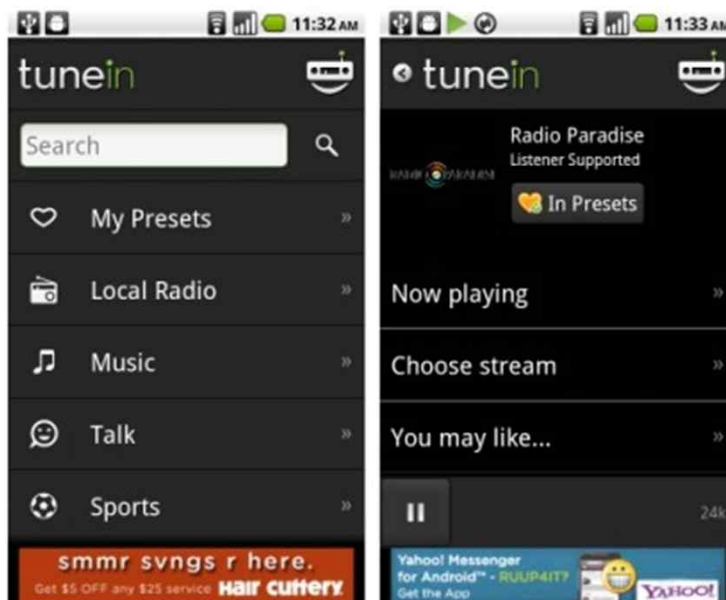
Data Explosion (1)

- **Data Big Bang in Mobile Universe**
  - **Forecasted mobile data traffic in North America**
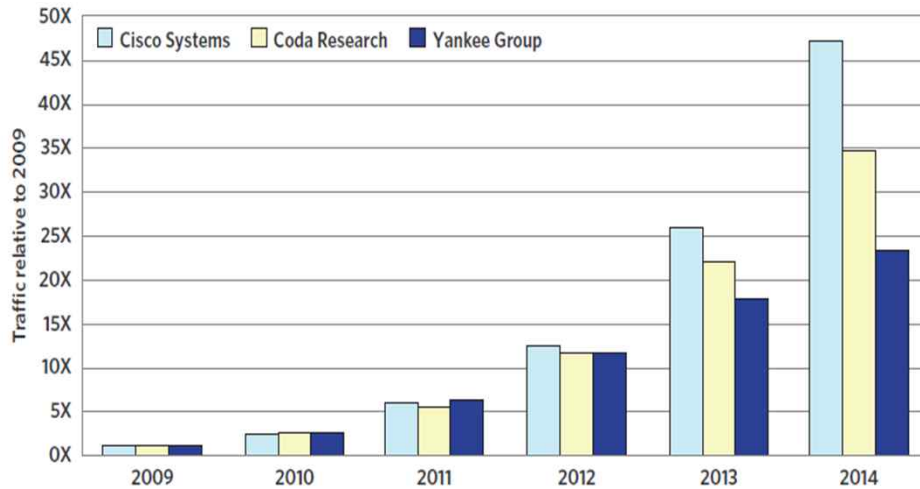
Approximately x 50 increase in mobile data traffic over 5 years since inception of smart phones to the market in US
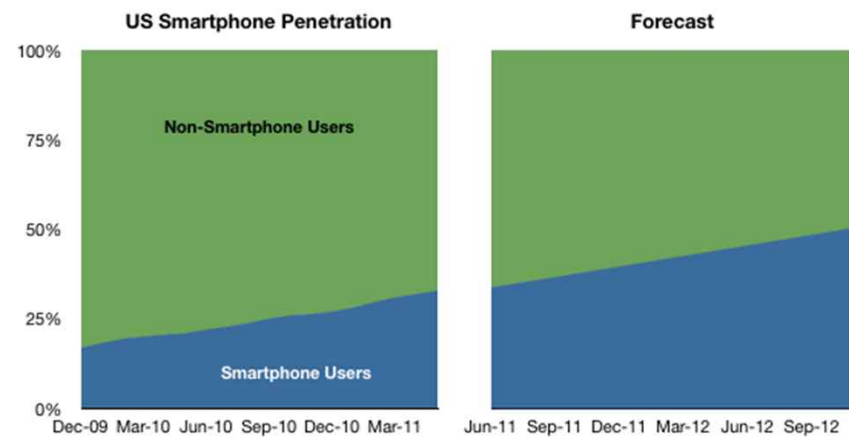
- **US smart phone penetration: forecast vs. reality**

US Smartphone Users and Penetration, 2009-2015

	2009	2010	2011	2012	2013	2014	2015
Smartphone users (millions)	40.4	60.2	73.3	84.4	93.4	101.5	109.5
—% change	46.6%	48.9%	21.9%	15.1%	10.7%	8.6%	7.9%
—% of mobile phone users	18.0%	26.0%	31.0%	35.0%	38.0%	40.5%	43.0%
—% of population	13.2%	19.4%	23.4%	26.7%	29.3%	31.5%	33.6%

Note: CAGR (2009-2015)=18.1%; individuals of any age who use a smartphone at least once per month
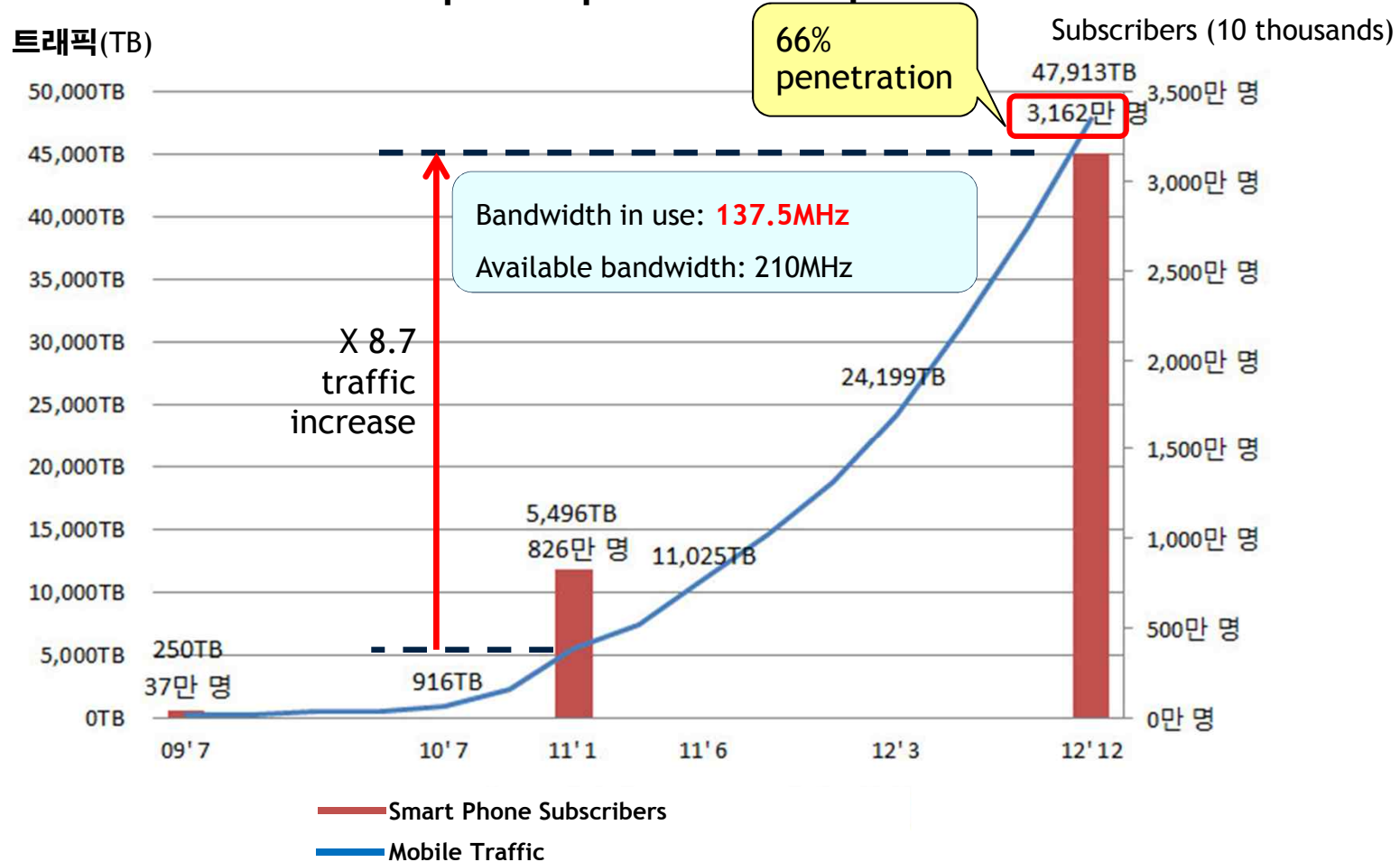Source: eMarketer, Dec 2010
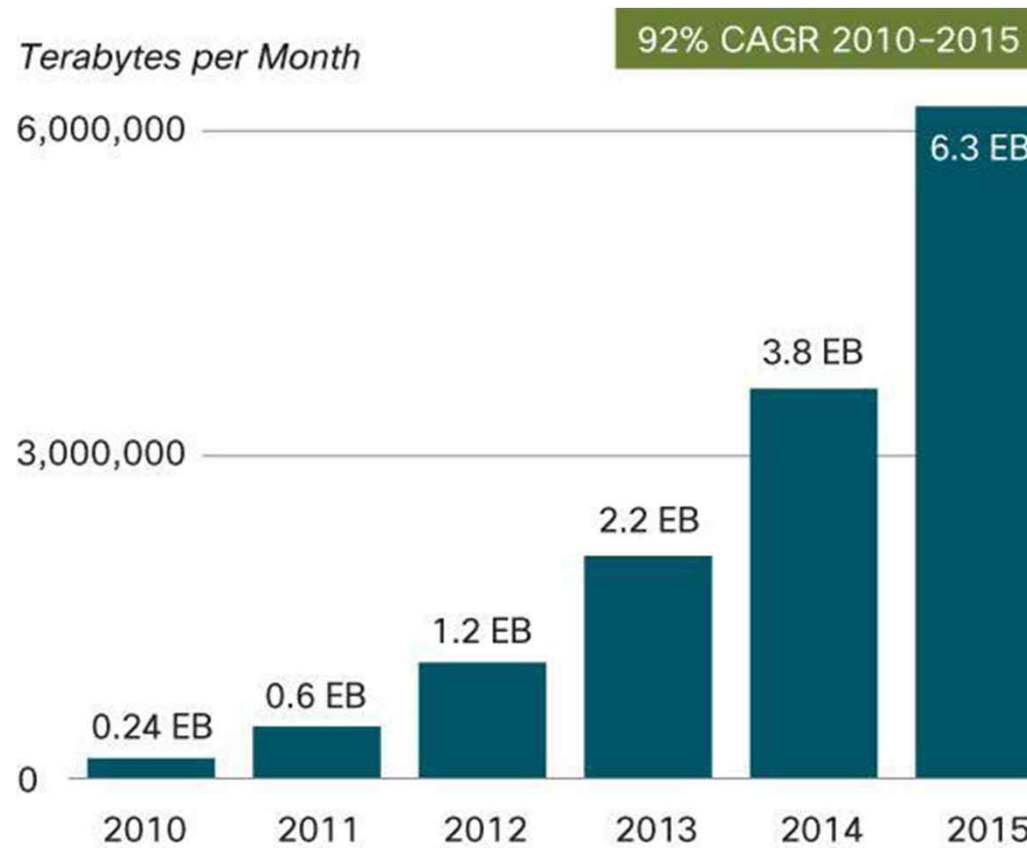122215

Data Explosion (2)

- **Data Traffic Demand in Korea**
  - **Traffic demand vs. smart phone penetration: past & future**

트래픽(TB)

Subscribers (10 thousands)

66% penetration

Bandwidth in use: **137.5MHz**

Available bandwidth: 210MHz

X 8.7 traffic increase

47,913TB
3,162만 명

24,199TB

5,496TB
826만 명
11,025TB

250TB
37만 명
916TB

50,000TB
45,000TB
40,000TB
35,000TB
30,000TB
25,000TB
20,000TB
15,000TB
10,000TB
5,000TB
0TB

3,500만 명
3,000만 명
2,500만 명
2,000만 명
1,500만 명
1,000만 명
500만 명
0만 명

09'7   10'7   11'1   11'6   12'3   12'12

Smart Phone Subscribers

Mobile Traffic

- Forecast on smart phone penetration implies that at least x 3 more bandwidth must be allocated over next 3 years
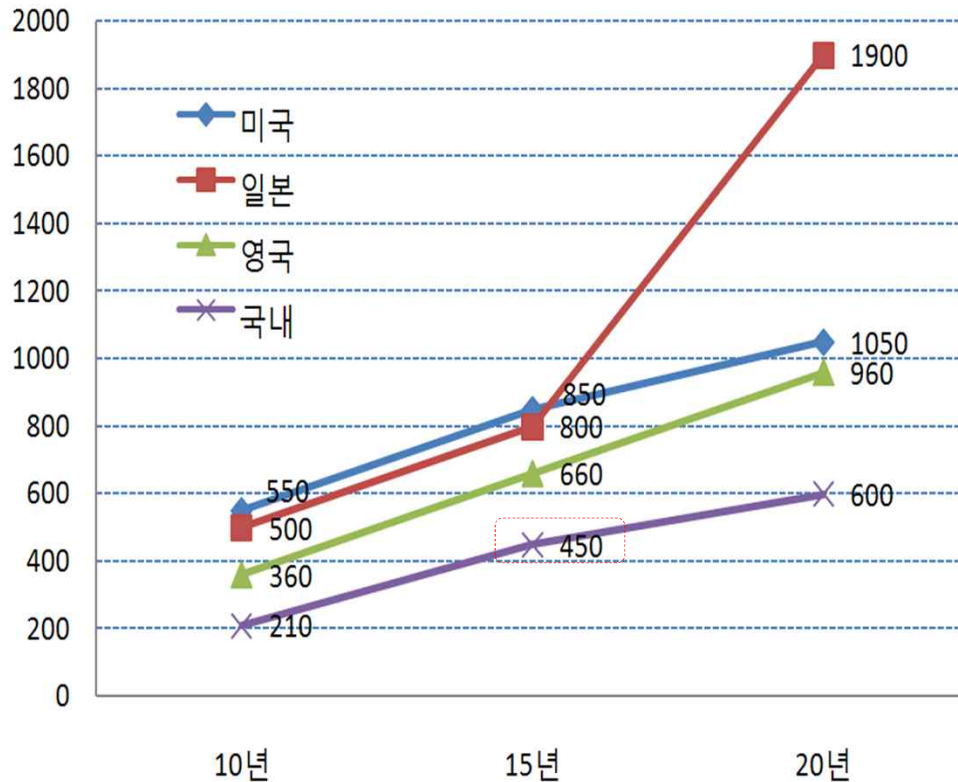
Data Explosion (3)

- **Cisco Forecast**

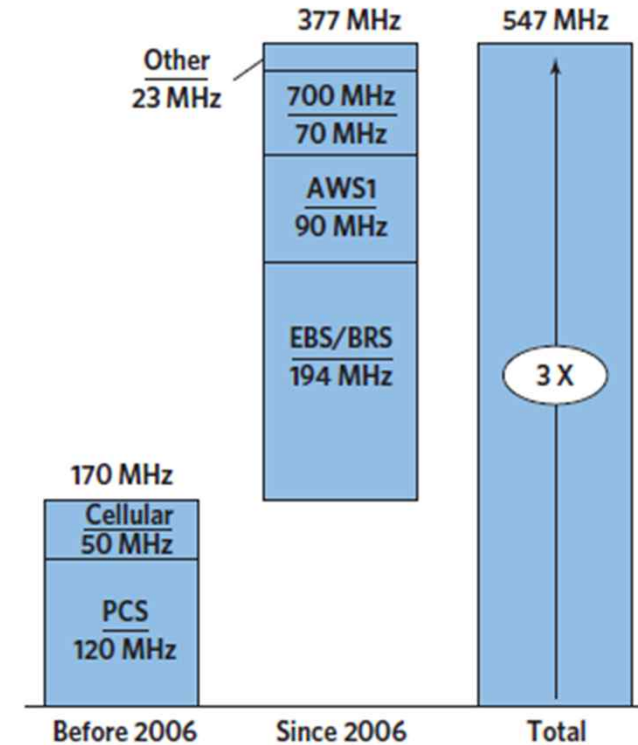   - **By 2015, a 26-fold increase of mobile data traffic over 2010**

Terabytes per Month

92% CAGR 2010-2015

Year	Value
2010	0.24 EB
2011	0.6 EB
2012	1.2 EB
2013	2.2 EB
2014	3.8 EB
2015	6.3 EB

Source: Cisco VNI Mobile, 2011

Requests on Frequency Spectrum Bands

- Demand by country

- Current band allocation in US

More than 200MHz additional bandwidth is required over next 5 years in Korea!

US already has taken a step to cope with smart phone traffic!

Requests on Frequency Spectrum Bands

NATIONAL BROADBAND PLAN
CONNECTING AMERICA

FCC ([Federal Communications Commission](#)) plan which deals with improving [broadband Internet access](#) throughout the United States, providing 100 million American households with access to 100 Mbit/s ([megabits](#) per second) connections by 2020

- Additional bandwidth made available for mobile data

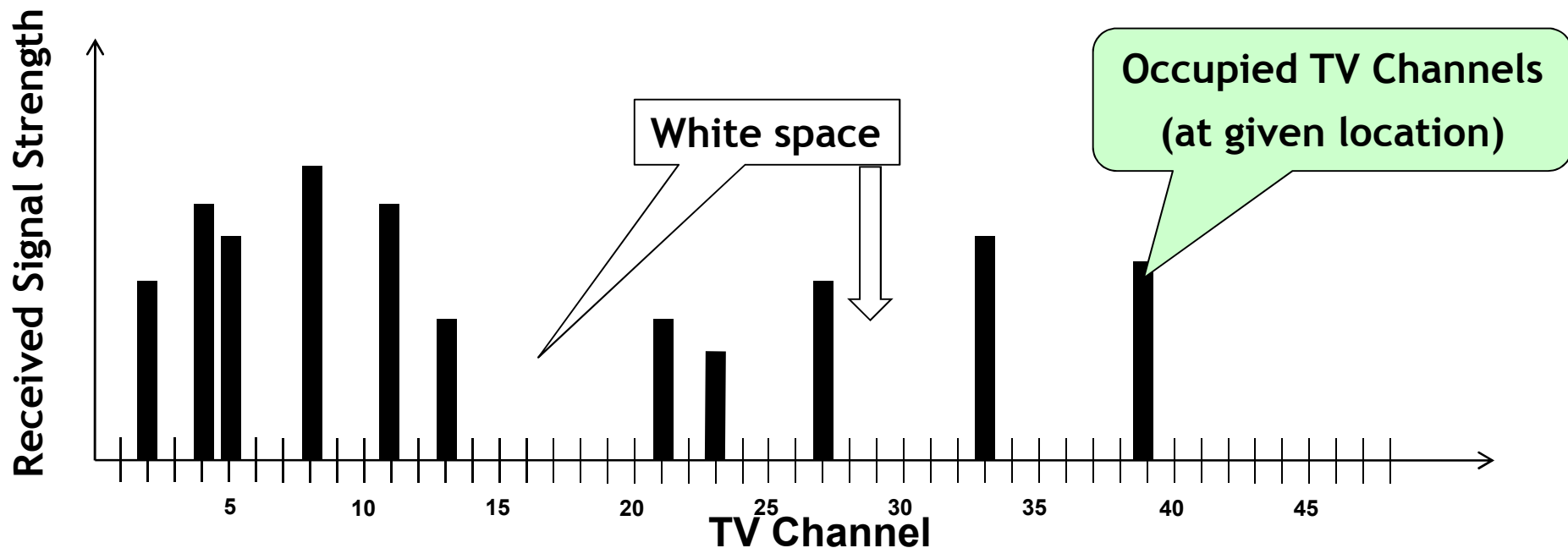| Band	Key Actions and Timing	Megahertz Made Available for Terrestrial Broadband
WCS	2010—Order	20
AWS 2/3[61]	2010—Order 2011—Auction	60
D Block	2010—Order 2011—Auction	10
Mobile Satellite Services (MSS)	2010—L-Band and Big LEO Orders 2011—S-Band Order	90
Broadcast TV[62]	2011—Order 2012/13—Auction 2015—Band transition/clearing	120
Total		300

- Philosophy in band plan

"Because there are ways to free up spectrum by delivering existing services more efficiently (rather than eliminating them altogether), the risk of overestimating spectrum needs is much lower than the risk of underestimating them."

What is TV White Space ?

- White spaces," which are empty fragments of the spectrum scattered between used frequencies"

- TV stations have traditionally broadcast over lower frequencies that carry information longer distances. However, with the ongoing transition from analog to digital broadcasts, more unused frequencies are opening up than ever.
  - 512 megahertz and 698 megahertz (channels 21 ~ 51)
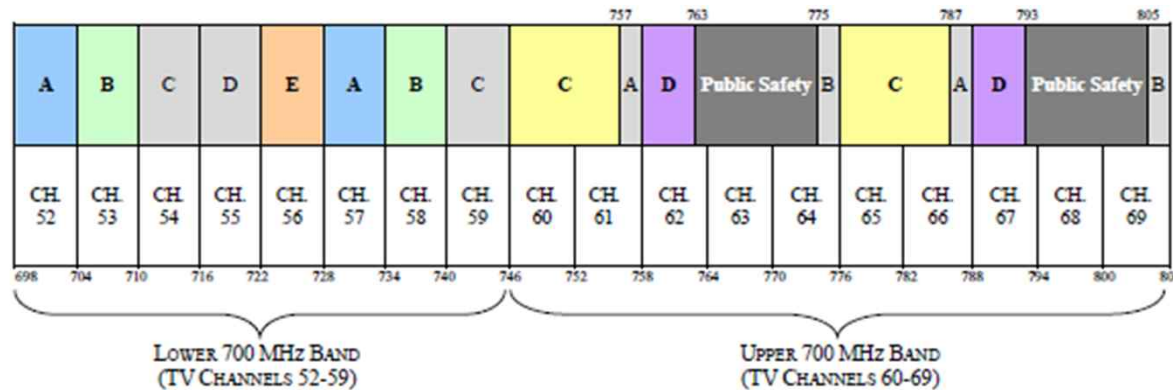 - 698 megahertz and 802 megahertz (channels 52 ~ 69)

What is TV White Space ?

- White space (WS): In a spectrum band that is licensed to primary users, the part of spectrum that is unused by the primary user at specific locations and sometimes at specific time.
  - Example: Television Channels – not every channel is used in every town
- White space allows secondary users to use the portions of spectrum not actually used by the primary user on an unlicensed basis.
- The unlicensed user must not cause interference.
- The unlicensed user cannot expect protection from interference

White space

Occupied TV Channels
(at given location)

Received Signal Strength

TV Channel

5   10   15   20   25   30   35   40   45

TV White Space

- **FCC Band Plan for 700MHz Digital Divident**

Block	Frequencies (MHz)	Bandwidth	Pairing	Area Type	Licenses
A	698-704, 728-734	12 MHz	2 x 6 MHz	EA	176
B	704-710, 734-740	12 MHz	2 x 6 MHz	CMA	734
C	710-716, 740-746	12 MHz	2 x 6 MHz	CMA	734
D	716-722	6 MHz	unpaired	EAG	6
E	722-728	6 MHz	unpaired	EA	176
C	746-757, 776-787	22 MHz	2 x 11 MHz	REAG	12
A	757-758, 787-788	2 MHz	2 x 1 MHz	MEA	52
D	758-763, 788-793	10 MHz	2 x 5 MHz	Nationwide	1 *
B	775-776, 805-806	2 MHz	2 x 1 MHz	MEA	52

* Subject to conditions respecting a public/private partnership.

The blocks shaded above in gray (Lower 700 MHz Band C and D Blocks and Upper 700 MHz Band A and B Blocks) were auctioned prior to Auction 73.

- Auction 73 (2008):

   Net bids $18,957,582,150

- 70MHz bandwidth allocated for terrestrial mobile services (e.g., LTE)

TV White Space

- **Recommendations for National Broadband Plan in US**

    - **120MHz** from broadcast TV band

> **RECOMMENDATION 5.8.5:** The FCC should initiate a rule-making proceeding to reallocate 120 megahertz from the broadcast television (TV) bands, including:[82]
>
> ➤ Update rules on TV service areas and distance separations and revise the Table of Allotments to ensure the most efficient allotment of six-megahertz channel assignments as a starting point.
>
> ➤ Establish a licensing framework to permit two or more stations to share a six-megahertz channel.
>
> ➤ Determine rules for auctions of broadcast spectrum reclaimed through repacking and voluntary channel sharing.
>
> ➤ Explore alternatives—including changes in broadcast technical architecture, an overlay license auction, or more extensive channel sharing—in the event the preceding recommendations do not yield a significant amount of spectrum.
>
> ➤ Take additional measures to increase efficiency of spectrum use in the broadcast TV bands.

Capacity Boosting : Off-Loading

- **Off-Loading Data with WiFi: Dark Sides of Reality**

  - IEEE 802.11n: 600Mbps peak rate with 40MHz channel

  - A plenty of channels?

  72MHz @ 2.4GHz
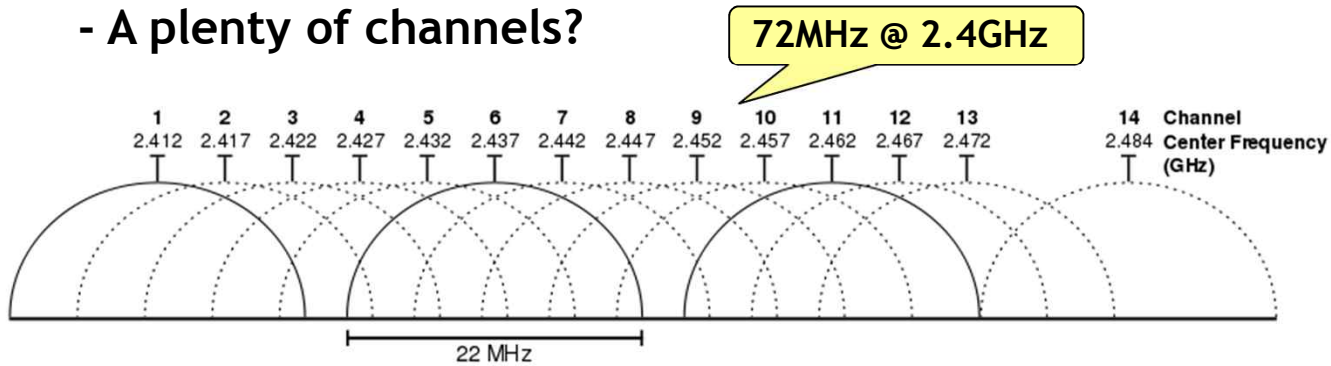
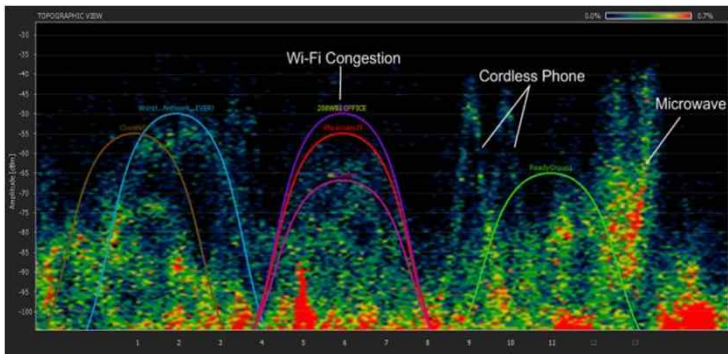
  150MHz @ 5GHz ➔ To play with 4 channels only ...

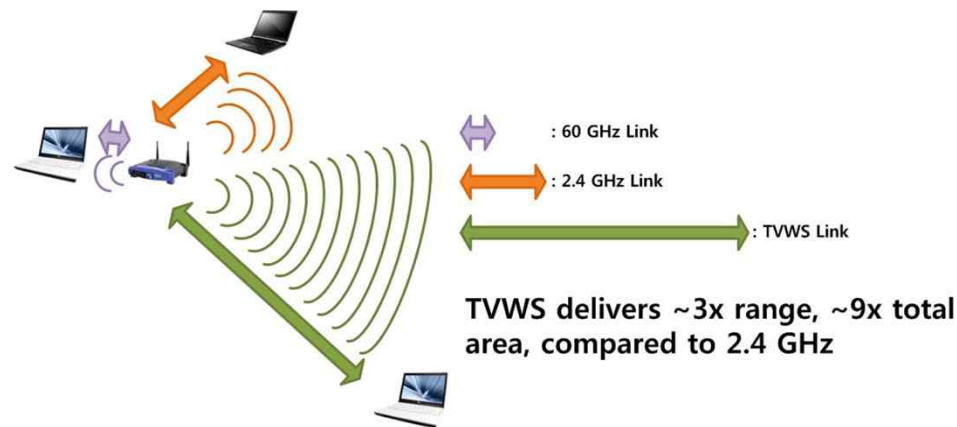 - Congestion in 2.4GHz ISM band   - Limited coverage

  Olleh WiFi Zone Finder

Why WiFi Service Using White Space?

- Mostly meaning TV White Space
- Offering a longer range than conventional Wi-Fi, which operates at 2.4 gigahertz

: 60 GHz Link

: 2.4 GHz Link

: TVWS Link

TVWS delivers ~3x range, ~9x total area, compared to 2.4 GHz

- Be easier to provide broadband Internet access in rural areas and fill in gaps in city Wi-Fi networks
- White Space Coalitions
  - Microsoft, Google, Dell, HP, Intel, Philips, Earthlink, and Samsung Electro-Mechanics, etc.
- To solve mobile devide

How to Use White Space

- The FCC ruled that companies could build devices that transmit over white spaces but also gave strict requirements that this should not interfere with existing broadcasts, both from TV stations and from other wireless devices that operate within the same spectrum

- Until now, in wireless networks, we were given a spectrum, and we would share it with everyone else. Everyone was an equal stakeholder

- Now, we have this spectrum where there are certain people who are primary users

Works in IEEE and IETF

- ## IEEE 802.22 :
  - Enabling Rural Broadband Wireless Access Using Cognitive Radio Technology in TV Whitespaces
- ## IEEE 802.11af : Wireless LAN in the TV White Space
- ## IEEE 802.19 : Wireless Co-existence Working Group
  - standard, which enable effective use of TV white space by IEEE 802 algorithms via coexistence methods

- ## IETF : PAWS WG
  - Protocol to Access to White Space Database

Master   Internet   WS DB
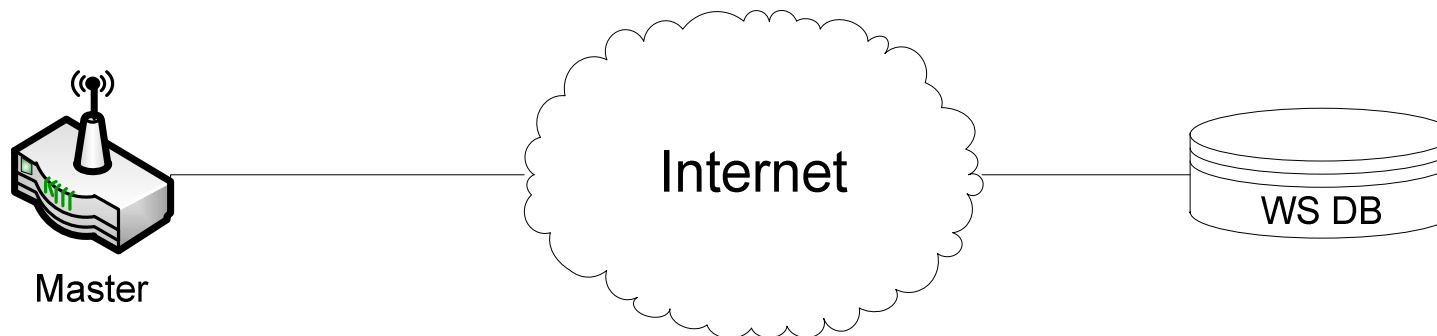
Strategies of TV white space in US, EU, etc

- US
  - November 4, 2008, the FCC voted 5-0 to approve the unlicensed use of white space
    - ✓ FCC announced TV white space a publically accessible database
  - September 23, 2010 the FCC released a Memorandum Opinion and Order that determined the final rules for the use of white space for unlicensed wireless devices
- EU
  - **ETSI : Cognitive System for White Space**
  - **TC RRS: Technical Committee Reconfigurable Radio Systems**
  - **ECMA : 2009.12 : PHY/MAC for White Space (ECMA-392)**
  - **Ofcom : 2011.09 : announced** plans to run an 'enhanced Wi-Fi' service using the white space within the existing TV spectrum
    - ✓ Enhanced Wi-Fi would typically operate at between 470 and 790MHz
- Japan : Examination Team For New Radio usage Vision,"Communication News, Vol.20, no.20, January 2010
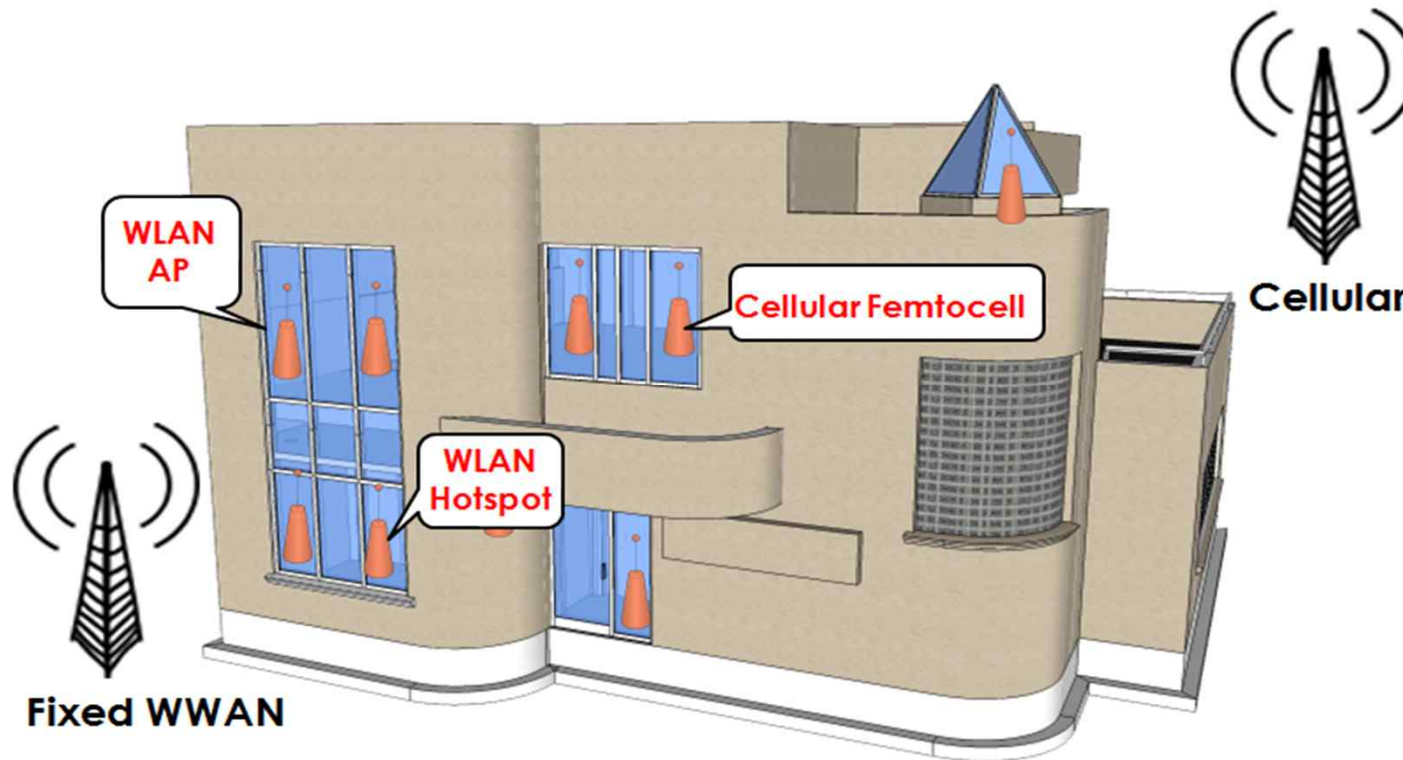- Korea : Testing the spectrum distribution

Use Case of WiFi Services using TVWS

- Potential Uses (for Home)
  - Device-to-Device (Machine-to-Machine)
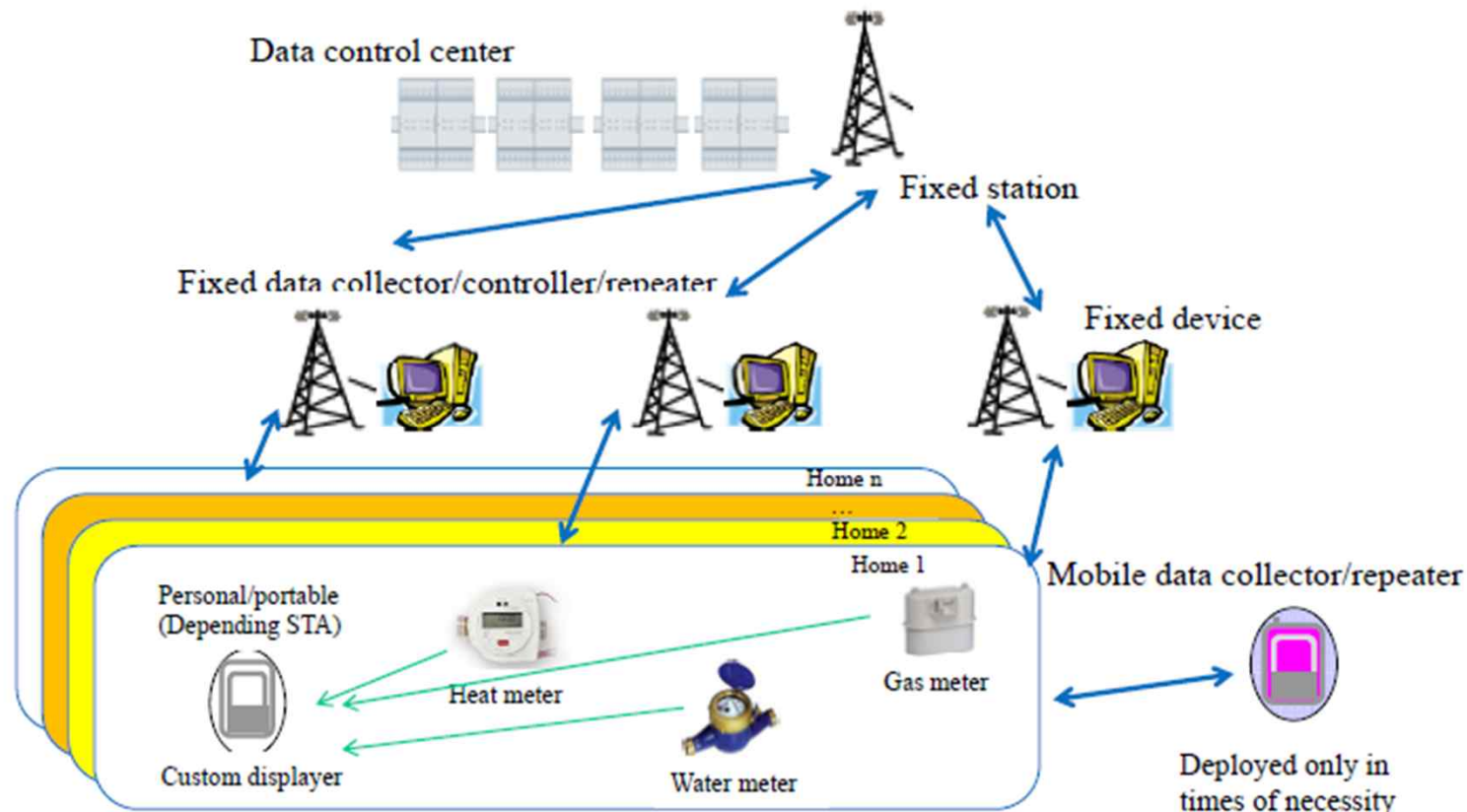 - WLAN Access
  - Backhaul
  - Cellular offload

Use Case of WiFi Services using TVWS

- Similar usage to the home use case, but very different environment (for business)

Use Case of WiFi Services using TVWS

- Potential uses (for Utility Grid)
  - Collection of metered data
  - Reporting of aggregated data over the backhaul
  - SCADA support

Use Case of WiFi Services using TVWS

- Potential Usage (for public safety)
  - Rapid deployment of emergency personnel networks
  - Inter-personnel communication
  - Network backhaul
  - Communication to the main office

Research topics on White Space

- Efficient Coexistence mechanism between 802.22 and 802.11af

- WiFi mobility in white space

- Efficient channel bonding and aggregation Technologies

Coexistence in TVWS: What is it?

- 802.19: deals with coexistence between unlicensed wireless networks. Many of the [IEEE 802](#) wireless standards use unlicensed spectrum and hence need to address the issue of coexistence

- TVWS presents a complex regulatory environment
  - Licensed devices: allowed to use the spectrum whenever, following appropriate rules
  - Unlicensed devices: permitted to use the spectrum when it is not occupied by licensed devices

- Licensed and unlicensed devices do not coexist
  - Licensed devices make no special allowances for unlicensed devices
  - Unlicensed device must "protect" licensed operation by regulation

- Protection of licensed devices is a medium access problem
  - Thou shall not access access spectrum when these guys are around

Coexistence in TVWS: So what is it then?

- Coexistence happens between peers
  - In TVWS, these are unlicensed devices and networks
  - Not mandated by regulations
  - Impetus must come from mutual benefit consideration: higher spectrum efficiency for all involved

- Why do they need to coexist
  - Once available channels are known, the various networks and users need to decide – who goes where
  - This cannot be static – channel availability will change

- Who specifies how this can be done
  - Some (not all) standards specify how different networks using same technology coexist
    - ✓ 802.11, 802.15 do this
    - ✓ Do they do it well??
  - Some standards don't even do that
    - ✓ cellular standards do not specify how different operators use the same spectrum
  - No MAC/PHY standard specifies how other MAC/PHY standards should behave
    - ✓ Nor should one MAC/PHY do it – it would rule over all the others
    - ✓ This void is filled by standards such as 802.19.1 in TVWS

The Coexistence Problem : a case
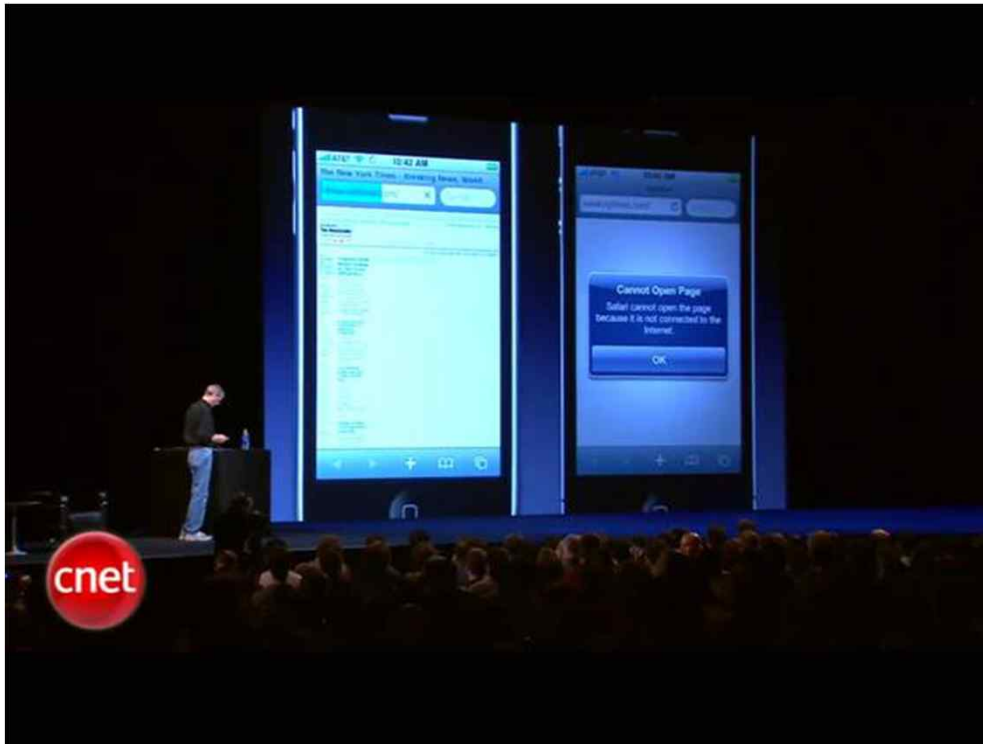
"… you know you could help me out here.   If you are on WiFi, if you could just get off…"

"… we figured out why my demo crashed.   Because there are 570 WiFi base stations operating in this room…"

Steve Jobs

see e.g.

http://www.youtube.com/watch?v=yoqh27E6OuU

So many talkers …

… and no common language to discuss sharing

Thank you !