Workshop on Cognitive Radio and Software Defined Radio: Policy and Regulations, organised jointly by ECC/ETSI/COST-TERRA, 02-03 May 2012, Mainz (Germany)

TVWS Challenges and Opportunities

Cognitive Techniques for Harvesting Underutilized Spectrum, such as TV White Space

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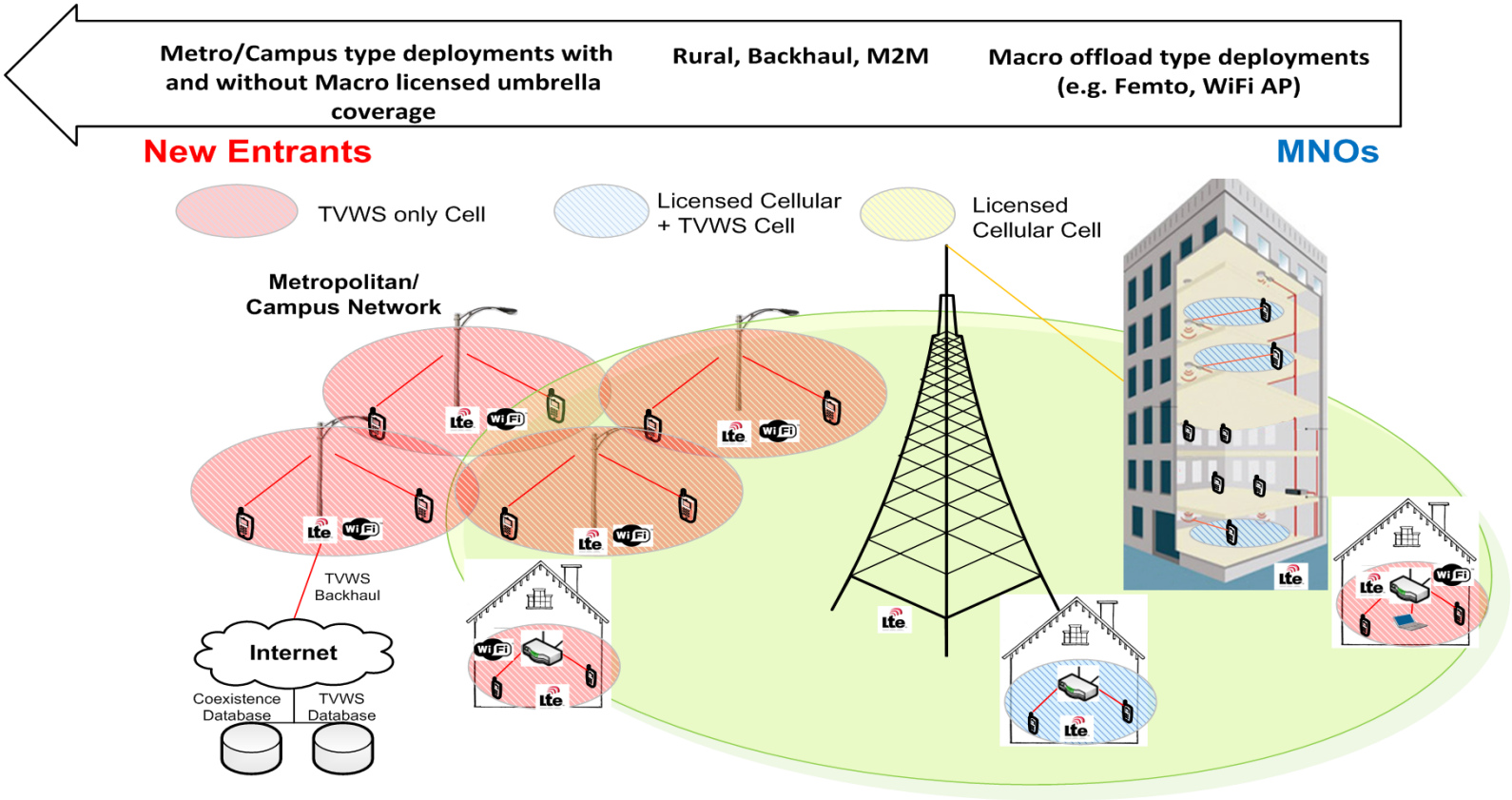
A Diverse Set of Use Cases and Technology for Operation in TVWS



	Small Cells			Wide Area
	Indoor Home	Indoor Enterprise	Outdoor	
WiFi Augmentation	✓	✓	✓	
Cellular Augmentation *Macro/Micro/Pico/Femto*	✓	✓	✓	✓
M2M / Special Purpose	✓	✓	✓	✓
Broadband for Rural/Underserved				✓

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Approach Is To Evolve Legacy Technology to Leverage TVWS Spectrum

Bandwidth & Spectrum Management at IP and Radio Access Level

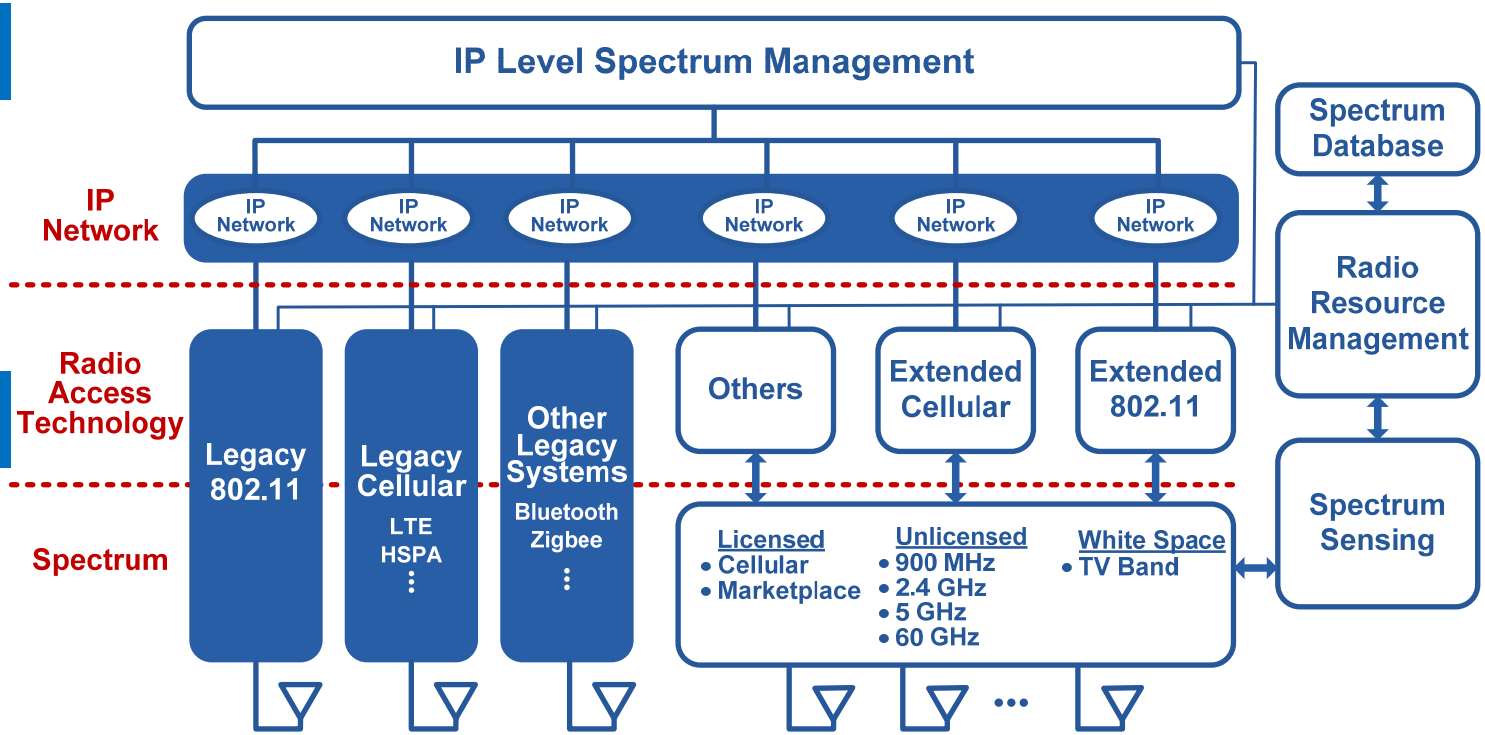
Low cost legacy technology plus the benefits of new spectrum

Bandwidth Management (BWM)

IP level bandwidth management aggregates or segregates IP flows across multiple radio access technologies, readily handling legacy technologies

Dynamic Spectrum Management (DSM)

Radio access level spectrum management promises improved spectral efficiency using MAC-layer aggregation/segregation and multiband radios



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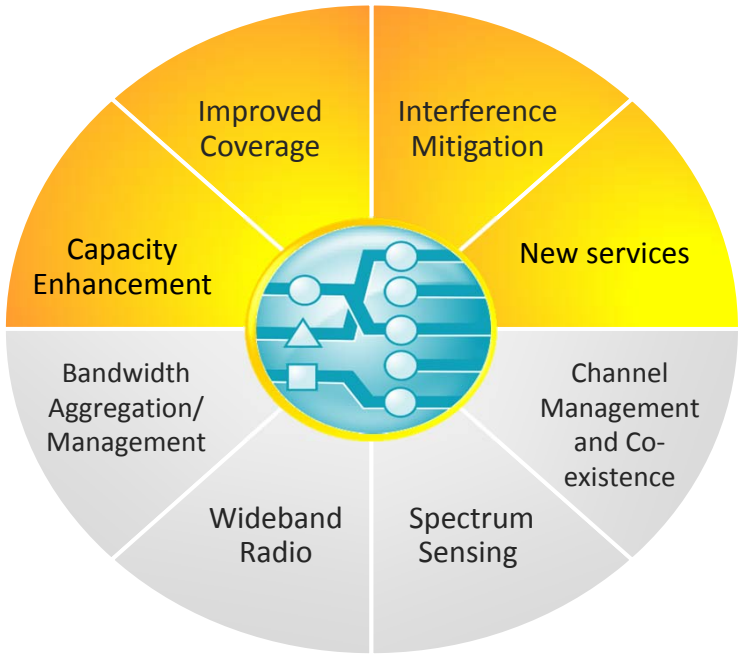
Technology that opportunistically allocates and aggregates bandwidth across heterogeneous spectrum bands



Key Benefits

- Eliminates concerns of small cell interference with macro cell
- Increases coverage/capacity at a minimal cost
- Enables the opportunistic use of TVWS while leveraging existing infrastructure; e.g. licensed band eNBs, Core Network
- Increased operational efficiencies via traffic offloading
- New high bandwidth services using newly exploitable spectrum
- New business models (e.g. tiered pricing, advertising)

Key technology blocks and Challenges

- Novel, and high performance, spectrum level (PHY/MAC) aggregation - requires standardization for mass market adoption
- Advanced cross-band RRM schemes to enable robust operation in TVWS
- Reliable spectrum sensing for both detection of primary and secondary users – requires certification
- Wideband, frequency and bandwidth agile transceivers
    - Digital transceivers and other wideband RF technologies are technically feasible
    - Industry commitment required to develop size/cost/power-efficient RFICs
- Co-existence and database mechanisms to enable co-existence between LTE and Wi-Fi systems
    - APIs and agents for network, edge, and clients

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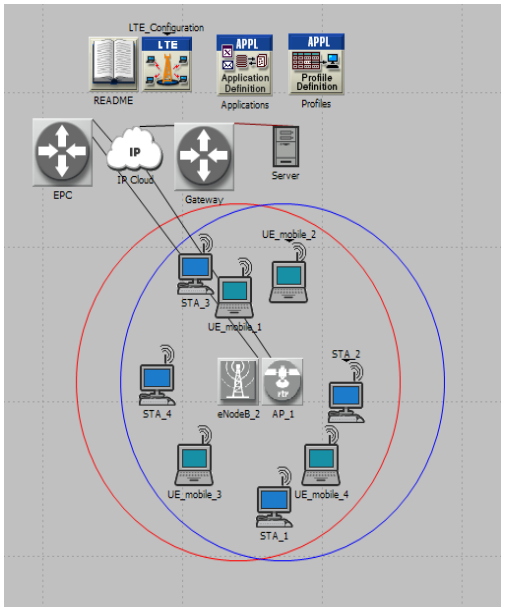
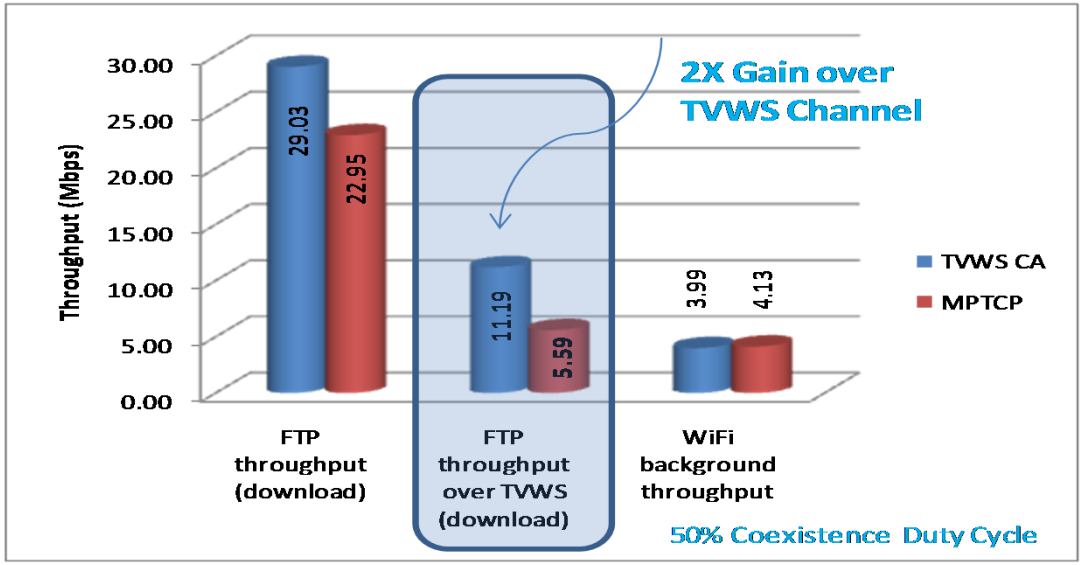
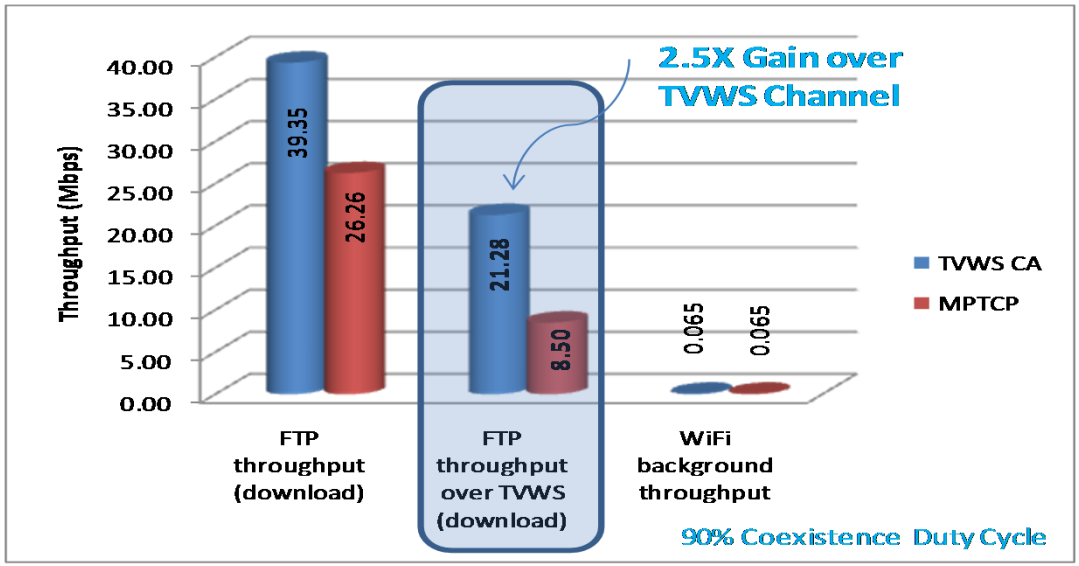
Clear Benefit to Enhancing a Single RAT (i.e. LTE) to use TVWS

- Simulations show that MAC/Spectrum level aggregation outperforms higher layer aggregation solutions (MPTCP shown as comparison)







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Approaches to Coexistence Policies and Spectrum Management

- Coordinated through the use of Co-existence databases
  - A more rigid structure can be put in place that tightly manages the use of the TVWS spectrum
  - Inter database and inter-operator co-ordination required
  - Tradeoff: Co-ordination Complexity vs Efficiency
- Combination of sensing and Co-existence databases
  - Interference, occupancy measurements are provided to the databases in order for them to make more intelligent decisions
  - Can reduce complexity as local decisions can be left to the devices
    - E.g. Database provides a ranked list of channels and devices select amongst the channels
- Rely on intrinsic support in the Radio Access Technology
  - Wi-Fi uses CSMA to co-exist
  - Transmission gaps can be introduced into LTE
    - Leverages the inherent nature of Wi-Fi CSMA to find the gaps to utilize the channel

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Regulatory Aspects and Remaining Technology Challenges

- Increasing availability of TVWS or Dynamic Shared Spectrum
  - Database technology is conservative by nature: protect incumbent users
  - Sensing and sensing only solutions complement database technology by making the database smarter, and can efficiently use the spectrum (i.e. FCC permits sensing-only)
- Management of spectrum (Two schools of thought)
  - A more rigid spectrum management structure is needed to encourage wider adoption
  - TVWS rules are designed to encourage cognitive techniques
    - Guaranteed spectrum will be difficult to realize
- Non-contiguous nature of TVWS channels limits use cases, and data rates
  - Commercialization of digital wideband radio technology needed to enable efficient aggregation techniques to increase flexibility and data rates
- RF emission, Power and Height restrictions
  - Height, power, and RF emission restrictions need to be carefully chosen to balance the needs of the various use cases: i.e. too severe a limit can restrict rural applications while one too lax may make it more difficult to operate lower power devices
  - Location specific power limits may make it difficult to deploy networks that span more than one pixel
- TVWS is only one use case for Cognitive Radio Techniques: many more use cases will follow if this is successful

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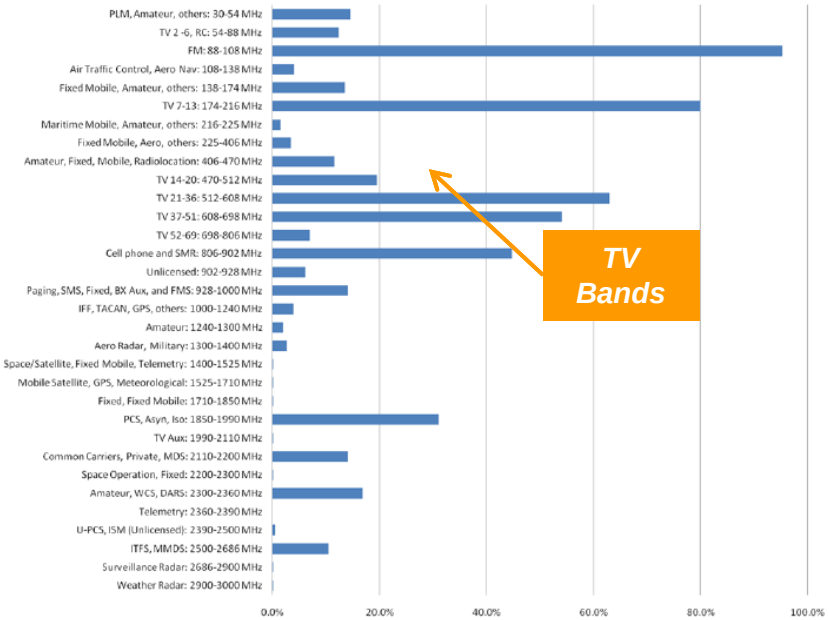
There is Plenty of Bandwidth – If We Know How to Use it

Spectrum is a Scarce Resource and Spectrum Sharing is a Key Weapon in our Arsenal that Needs to be Exploited

Measured Spectrum Occupancy Vienna , Va. September 2009



From: General Survey of Radio Frequency Bands – 30 MHz to 3 GHz, Version 2.0, Shared Spectrum Company, 23 September 2010.

TV White Space Channels Available for TV Band Devices

Channel	Frequency Band	Frequency (MHz)	Fixed	Portable
2	Low VHF	54 - 60	X	
5 - 6	Low VHF	76 - 88	X	
7 - 13	High VHF	174 - 216	X	
14 - 20	UHF	470 - 512	X	
21 - 35*	UHF	512 - 602	X	X
39 - 51*	UHF	620 - 698	X	X

*TVBDs are not permitted to operate on the first channel on each side of TV channel 37, which will at a minimum prevent use of channels 36 and 38.

UK UHF Bands After the Digital Switchover

From: Digital dividend: cognitive access, Statement on licence-exempting cognitive devices using interleaved spectrum, OFCOM, 1 July 2009.

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Supporting Material

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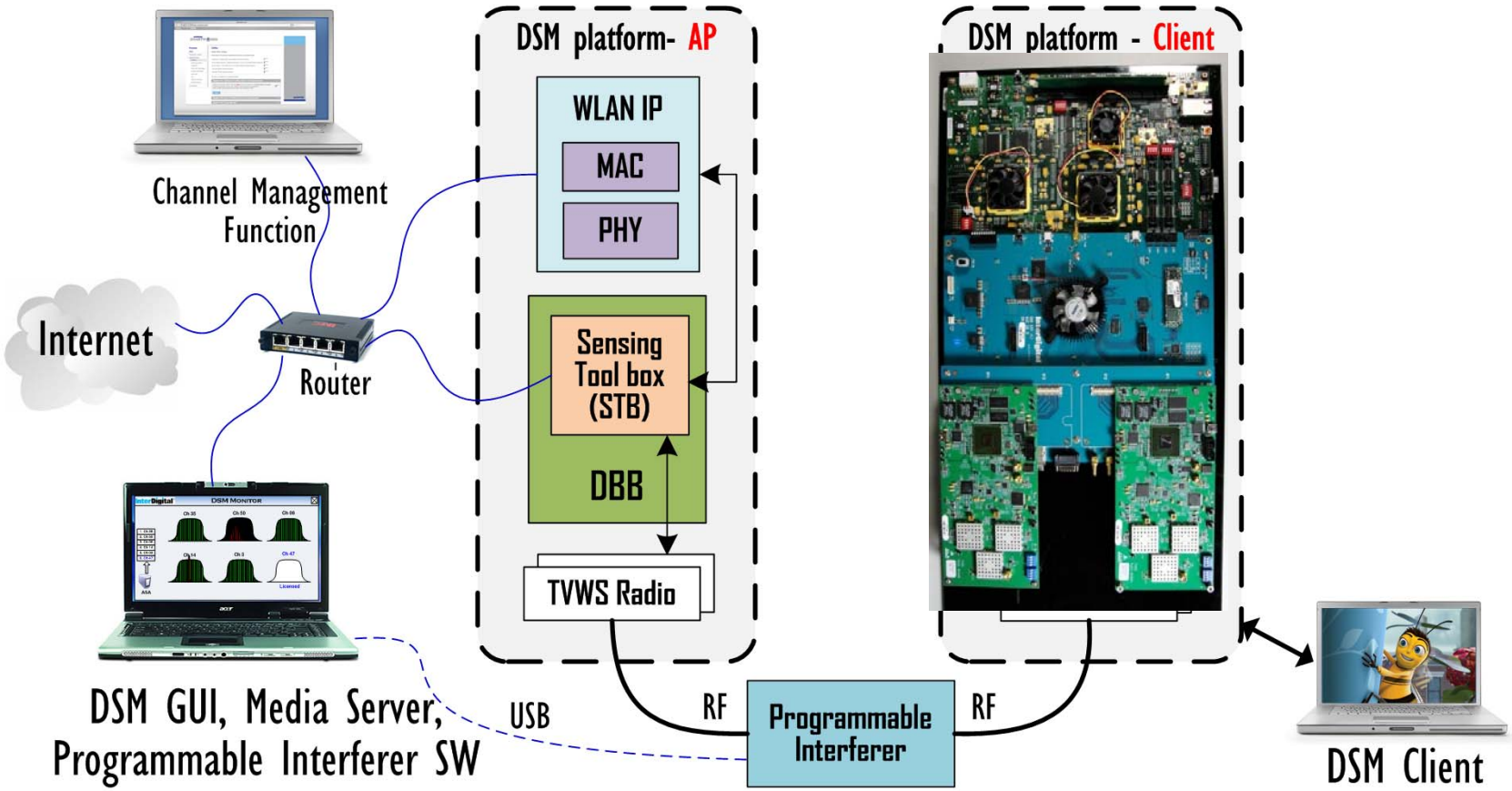
Wi-Fi Solution Platform Architecture



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