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Founding Principle(s) to build the Next Gen Ubiquitous sub-1GHz Underlay Broadband Access Network

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September 15, 2017

Why focus on sub-1GHz ?

- Sub 1GHz "beach-front" spectrum
  - Premium coverage quality
  - Simple antennas, proven electronics, and SISO/SIMO links
    - Read → Massive MIMO or costly RF/Analog not required

- Can the TV-UHF band be released for Cellular Broadband use?
  - Only perhaps 40MHz to 100MHz can freed-up from re-farming the TV-UHF band (450-690MHz)
  - This is too little to carve out for 4-6 broadband operators
  - 5G wants to use it (primarily) for IoT and M2M

- Innovative ways to increase spectral utilisation is vital
  - Can this spectrum be **shared** so that
    - It is better utilised than when given to a single cellular operator
    - It can support QoS better than unlicensed (Wi-Fi) networks

What is shared in Cellular networks today?

- Sharing available today commercially for
  - Tower-sharing
  - Inter-circle roaming
  - Intra-circle roaming – "spectrum sharing" within same region in India; it is to help smaller operators pool their infra if they have licensed spectrum in same band

- Sharing studies have also been done for
  - Indoor base-station sharing (CEWiT) by multiple operators
  - Licensed Shared Access (LSA) – by Ericsson, Qualcomm, & Red
    - Orthogonal sharing of spectrum (time or freq slices)
  - Many research papers available on
    - Spectrum pooling, Cognitive radio based Secondary usage, etc
    - Non-orthogonal multiple access – for uplink users of same operator

- We propose Licensed Shared Simultaneous Access (LSSA)

“Simultaneous” Spectrum Sharing – Lit. Survey

- In open literature
  - Spectrum sharing for small cells -- Alsohaily, A.; Sousa, E.S., "Spectrum sharing LTE-advanced small cell systems," *WPMC – June 2013*
  - Spectrum sharing using SDMA – few papers in 2012 by E.Jorsweick at TUD
  - Spectrum sharing in 27GHz/60GHz bands – T.Rappaport, J.Andrews, etc (2015, 2016)

- In 3GPP
  - 14.2: New WIs/SIs: Spectrum related WIs/Sis : RP-151549 -- Study Item Proposal: Study on US 3.5GHz band for LTE → proposed by Verizon

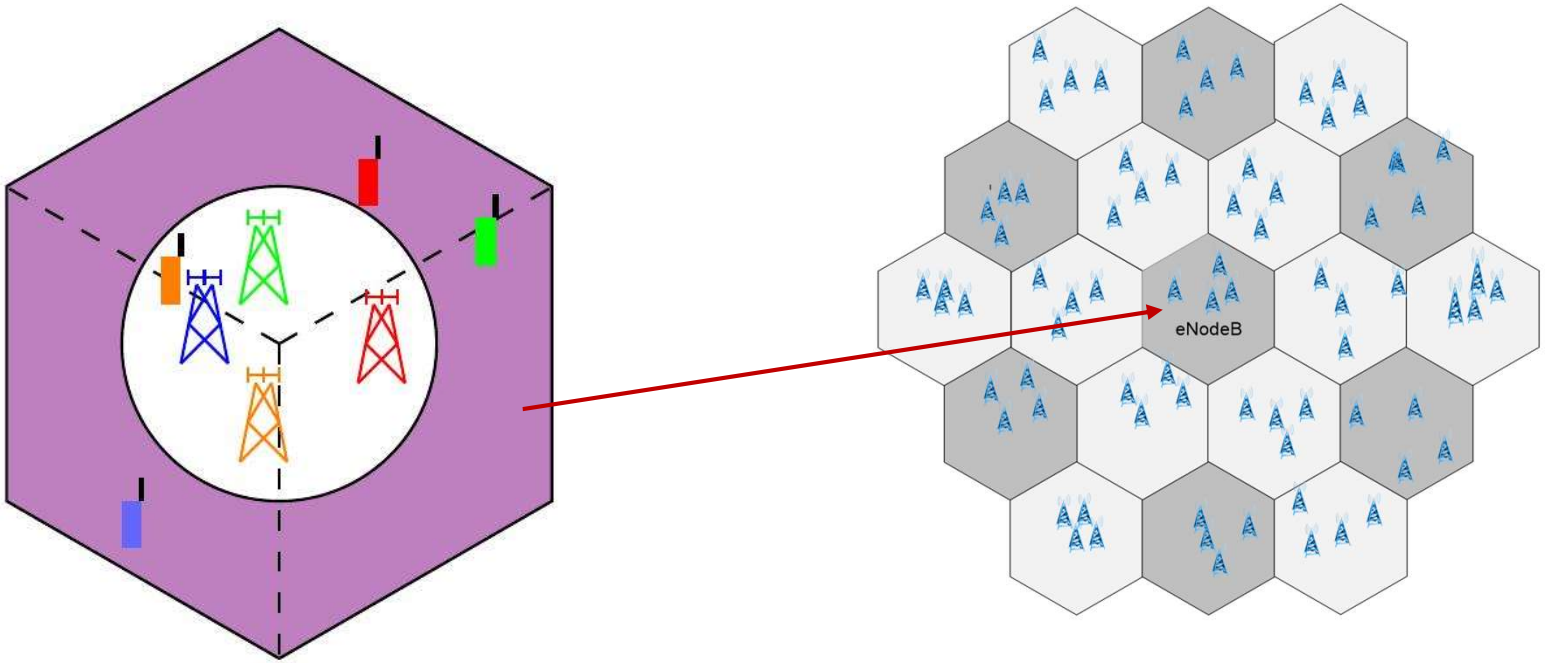
LSSA *aka* MOSSSAIC

- **MOSSSAIC**
  - **M**ulti **O**perator **S**imultaneously **S**hared **S**ynchronized **A**ir **I**nterface for **C**ommunications
  - 4 operator MOSSSAIC has been developed by IITM (6 also possible)

- **SSSB**
  - **S**imultaneously **S**hared **S**ynchronised **B**and: 40MHz TDD in TV-UHF Band
  - Allocation of contiguous, fixed, pan-India band for MOSSSAIC
  - More such TDD bands could be released once MOSSSAIC is successful

MOSSSAIC Benefits

- Simultaneous spectrum sharing by 4 to 6 operators can be great!
  - ◊ Low spectrum cost per operator
  - ◊ Low equipment cost per operator – Macro-Net!!
  - ◊ Much higher throughputs/sq.km compared to single-operator network
  - ◊ Superior support for ultra-reliable and emergency communications
  - ◊ Enhanced QoS support



MOSSSAIC Throughput Simulation -- Example

No of drops = 10
Channel averages = 10 per drop
UEs per Sector = 30
No of Operators = 4
Bandwidth = 40 MHz

	MOSSSAIC with 4 Operators		Single Operator		Gain Factor
	Measured (Mbps)	Max (Mbps)	Measured (Mbps)	Max (Mbps)	
Max	447.10	662.65	76.3	168.30	**5.86**
Median	371.05	657.32	102.48	174.67	**3.63**
Min	378.82	663.09	141.48	180.24	2.68
Mean	389.79	643.96	106.81	175.45	3.64

Results are with "dumb" Round-Robin Scheduler

Why MOSSSAIC for/from India?

- Can spur innovation in India at various levels
  - Core IPR on algos and designs will be Indian
  - Less costly electronics; USP is in the baseband algorithms
  - Fabless semi-C startups, UHF antenna/RF companies can participate
  - Can leverage learnings from 4G-LTE available in Indian telecom industry
- Can build highly reliable & efficient (6G?) underlay network !!
  - Peak of 200Mbps; Ubiquitous 5Mbps to 10Mbps links for each UE
  - 5G cellular and 802.11ax systems can be the overlay at hotspots!
- Indian telecom operators will learn to work together 

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Thank You.

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