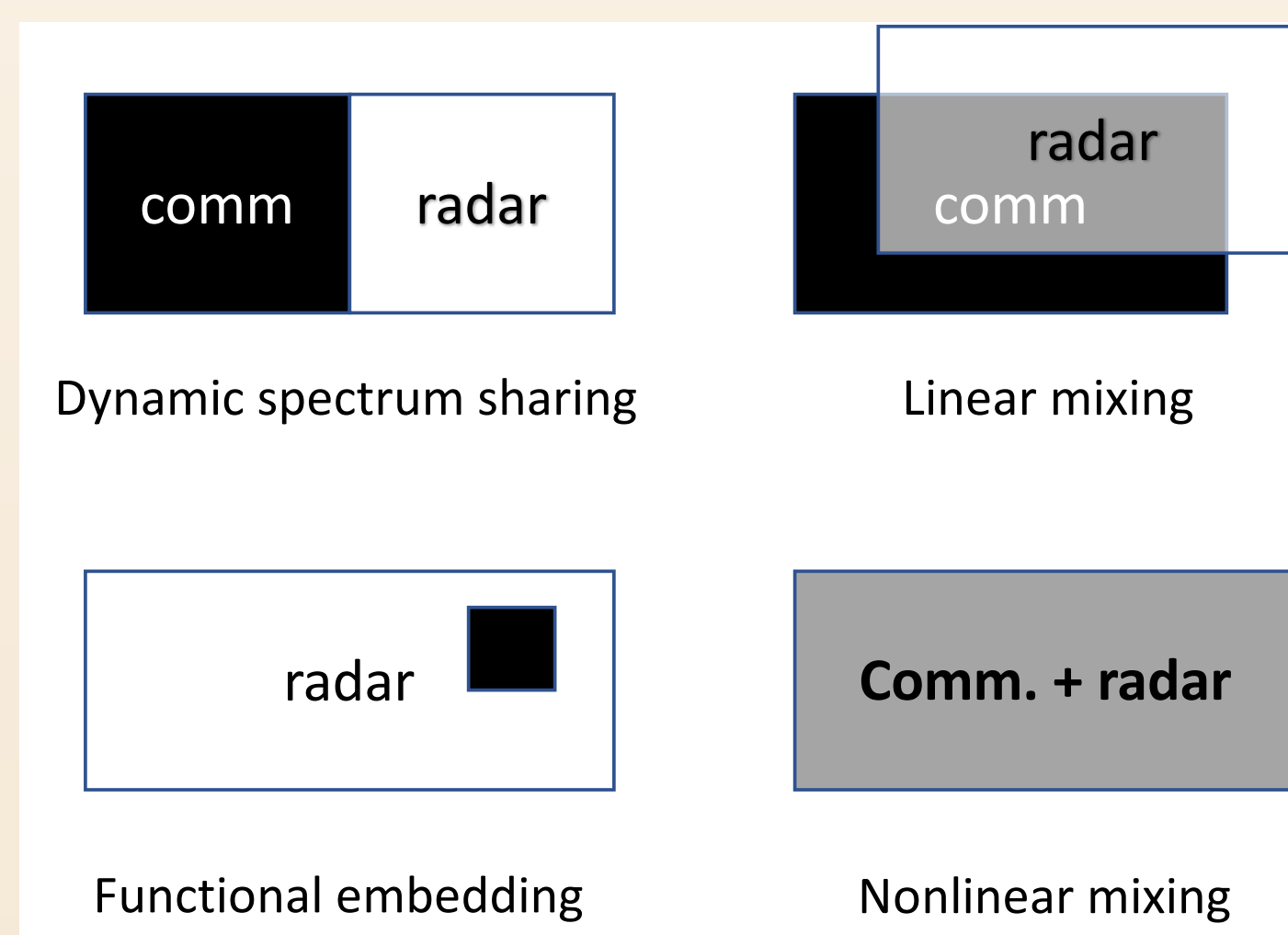




Nonlinear and Inseparable Radar And Data Transmission Framework for Efficient Spectrum Access Networks, CNS-2128368

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Purpose of Project



Why Marry Communications and Sensing?

- Similar signal structure
- Similar hardware and frequency band
- Forward propagation for communications and backward propagation for sensing

Need a Unified Framework

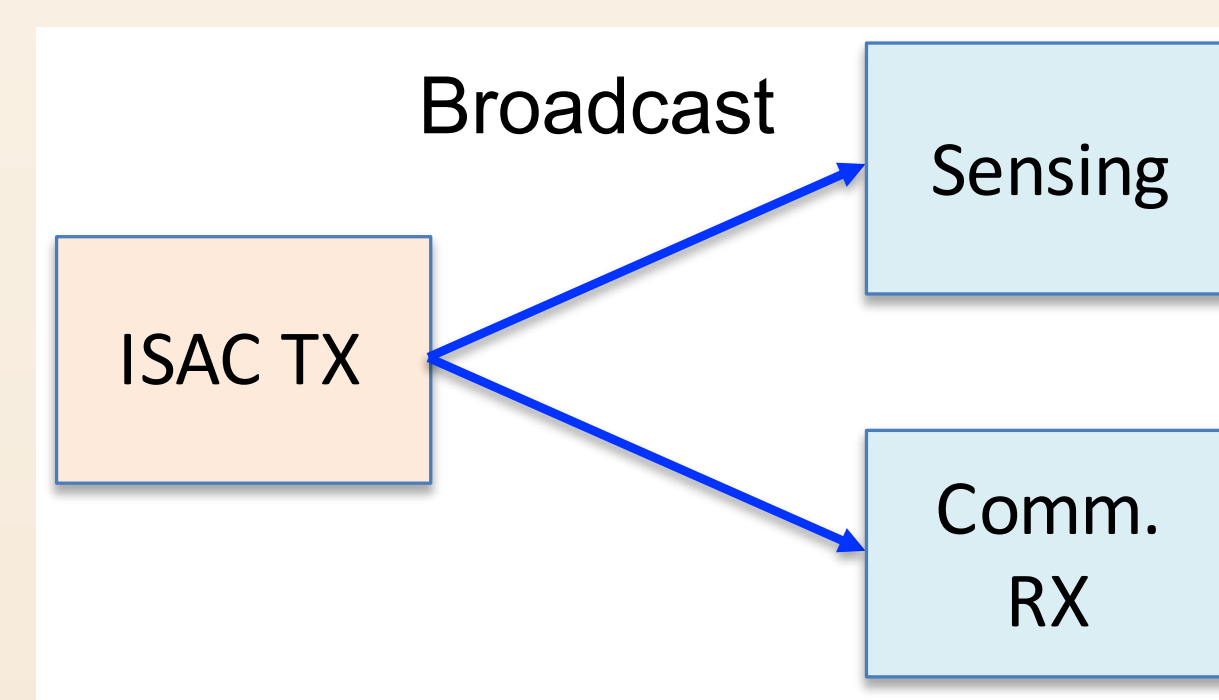
- Comm and radar are developed independently.
- They have different functions and features.
- Need a mathematically elegant framework for the integration

Conflict and Trade-off



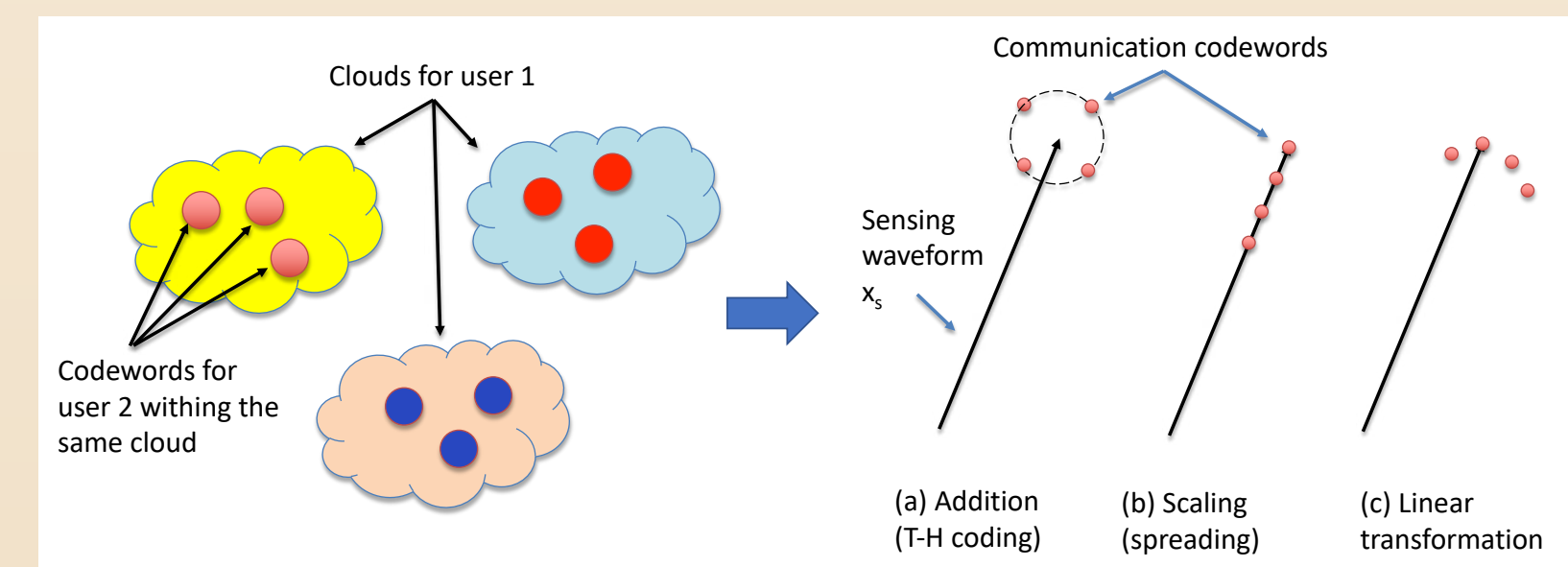
- Randomness-Determinism
- Subspace conflict
- Environmental conflict: DoF of EM field
- PSD desirability conflict
- ...

Broadcast Framework



Broadcast Channel Framework

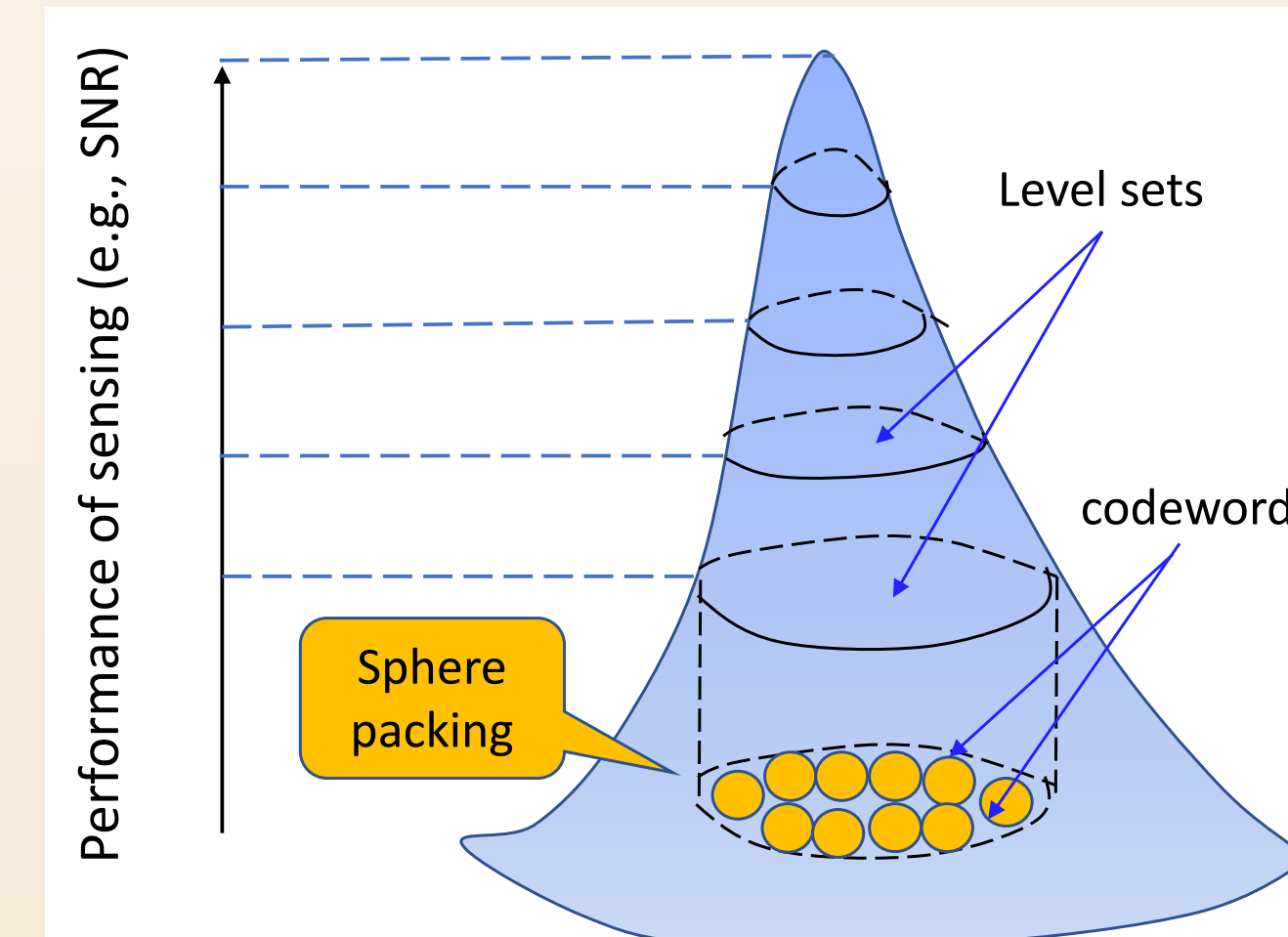
- We consider sensing as a virtual user and communication as genuine user. Therefore, integrated sensing & communication (ISAC) is a downlink broadcast.
- Many existing approaches in broadcast channels can be leveraged.



Superposition Coding Approach

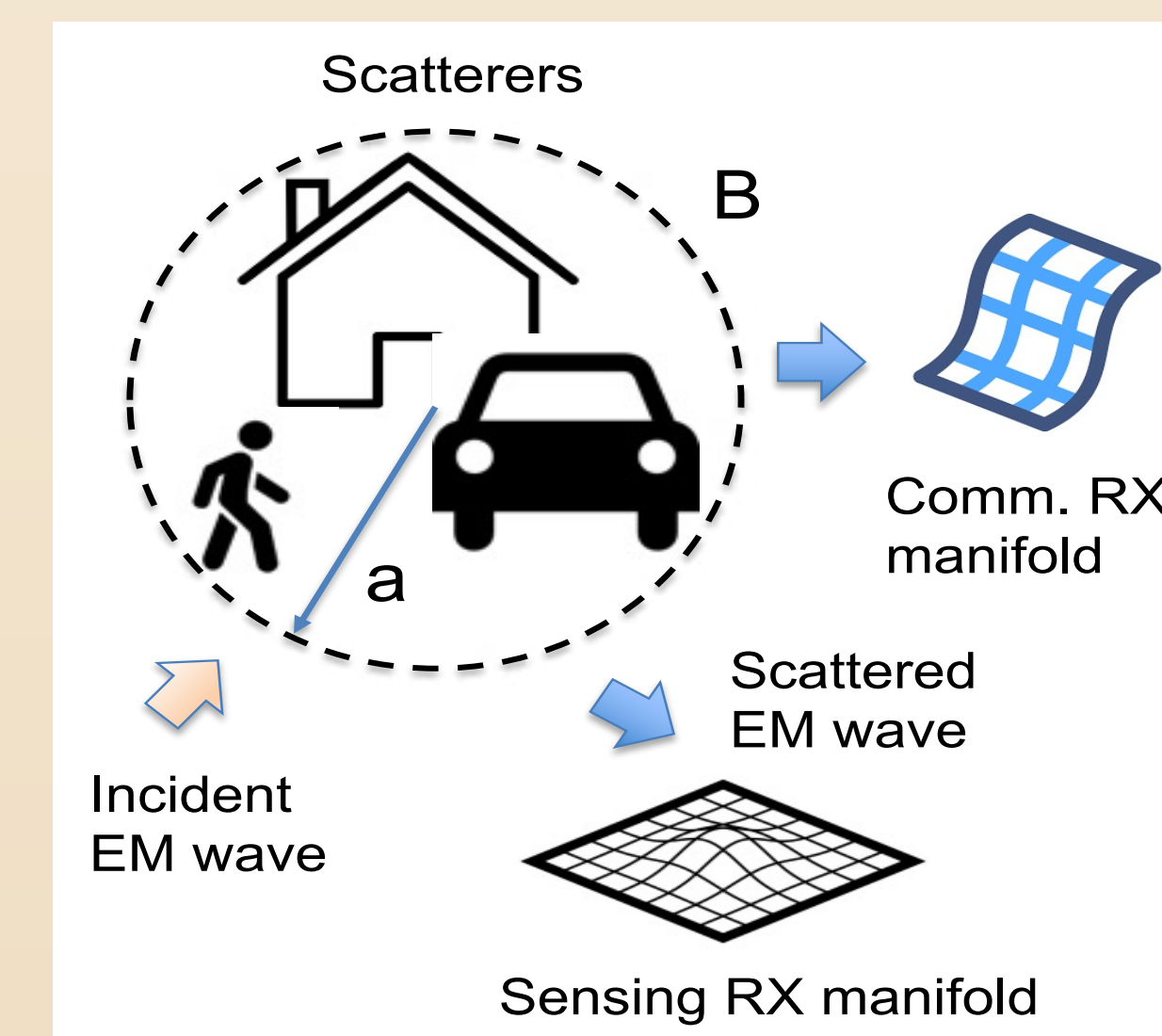
- We first generate the sensing waveform (e.g., FMCW waveform).
- The final waveform is generated using a transformation determined by the communication message:
 - ❖ Addition: dirty paper coding
 - ❖ Scaling: spread spectrum
 - ❖ Linear transformation: OFDM+PSK

Fundamental Trade-off



Sphere Packing

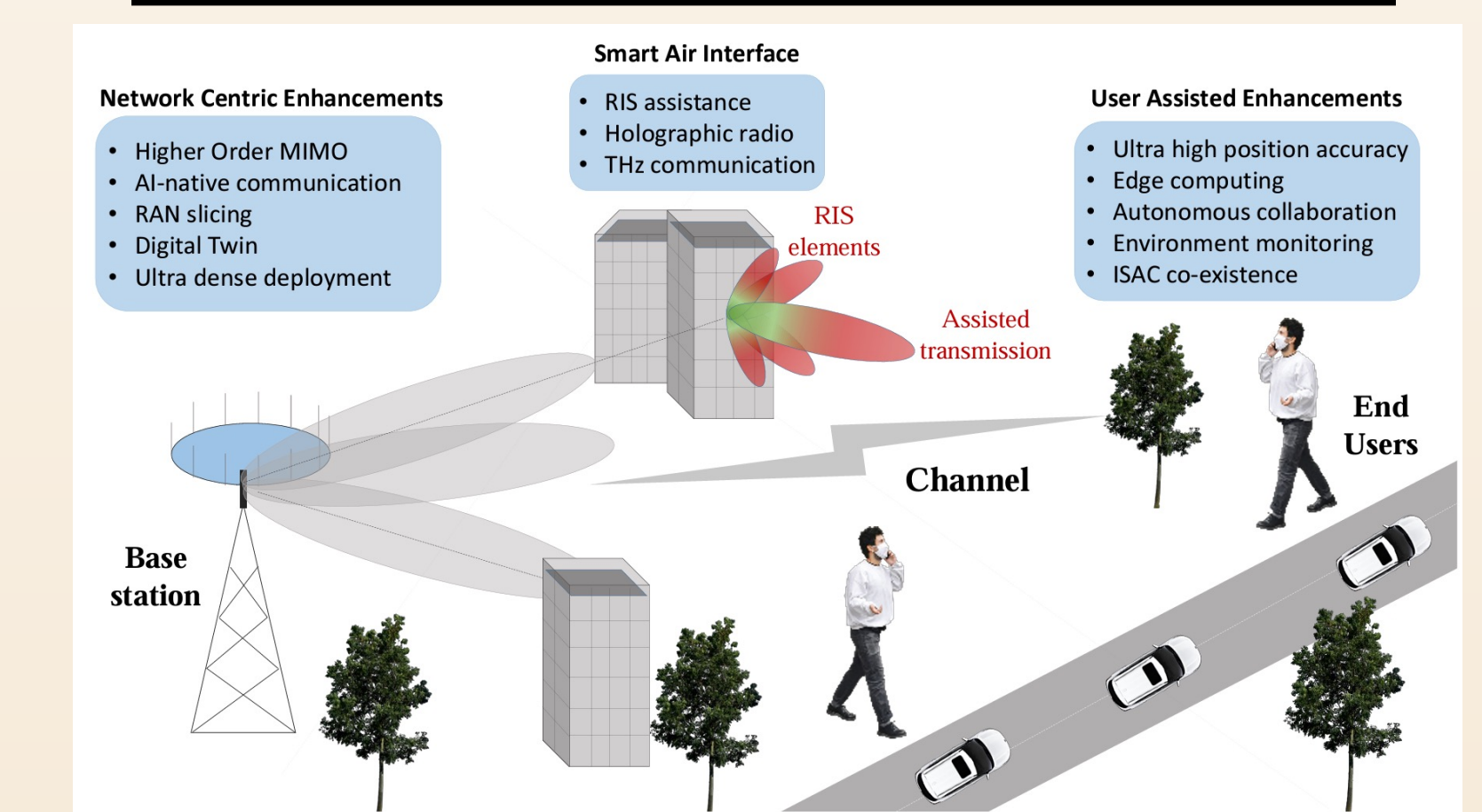
- We evaluate the volume of level sets of sensing performance metric in the waveform (codeword) space
- Sphere-packing argument is used to bound the number of codewords (data rate)



Sphere Packing

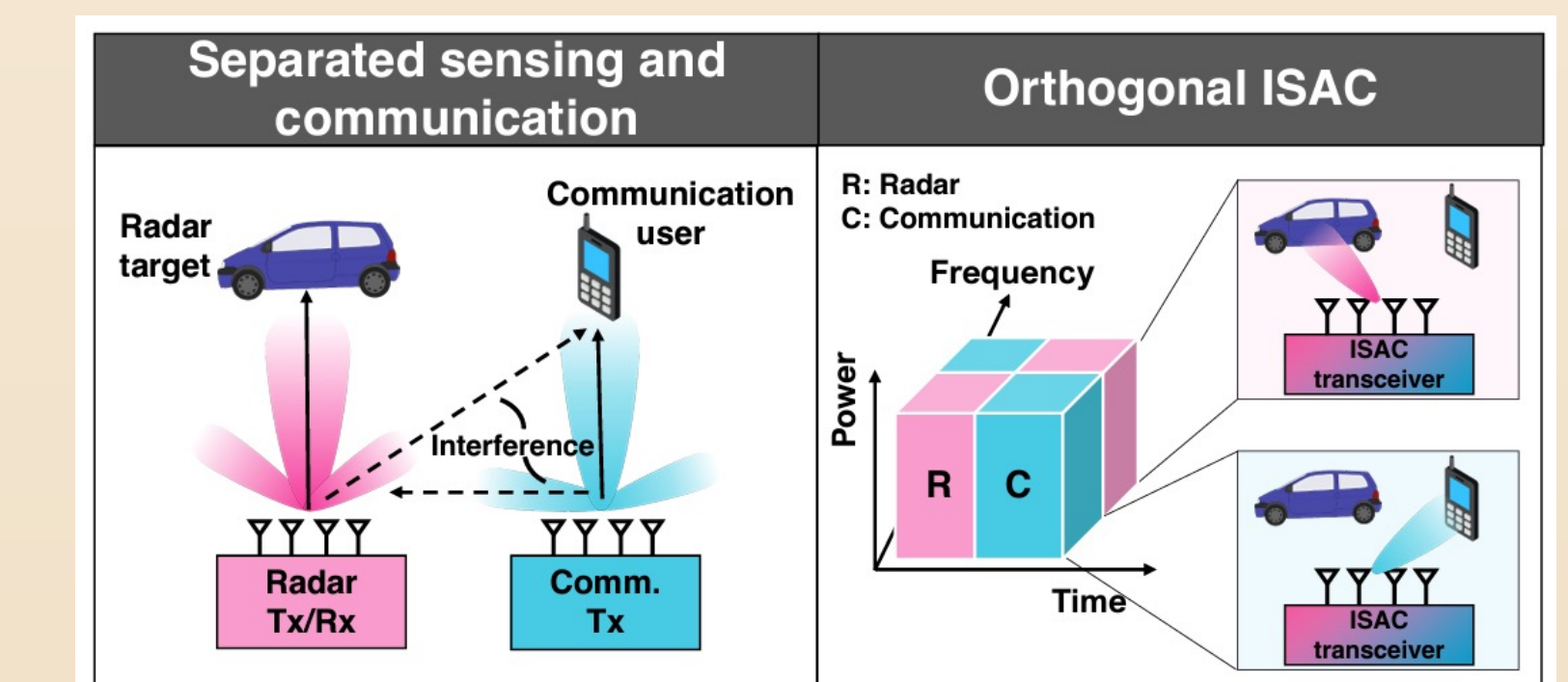
- The DoF of EM field depends on the scatterers
- Communications desire more DoF, while sensing does not.

Impact on 6G

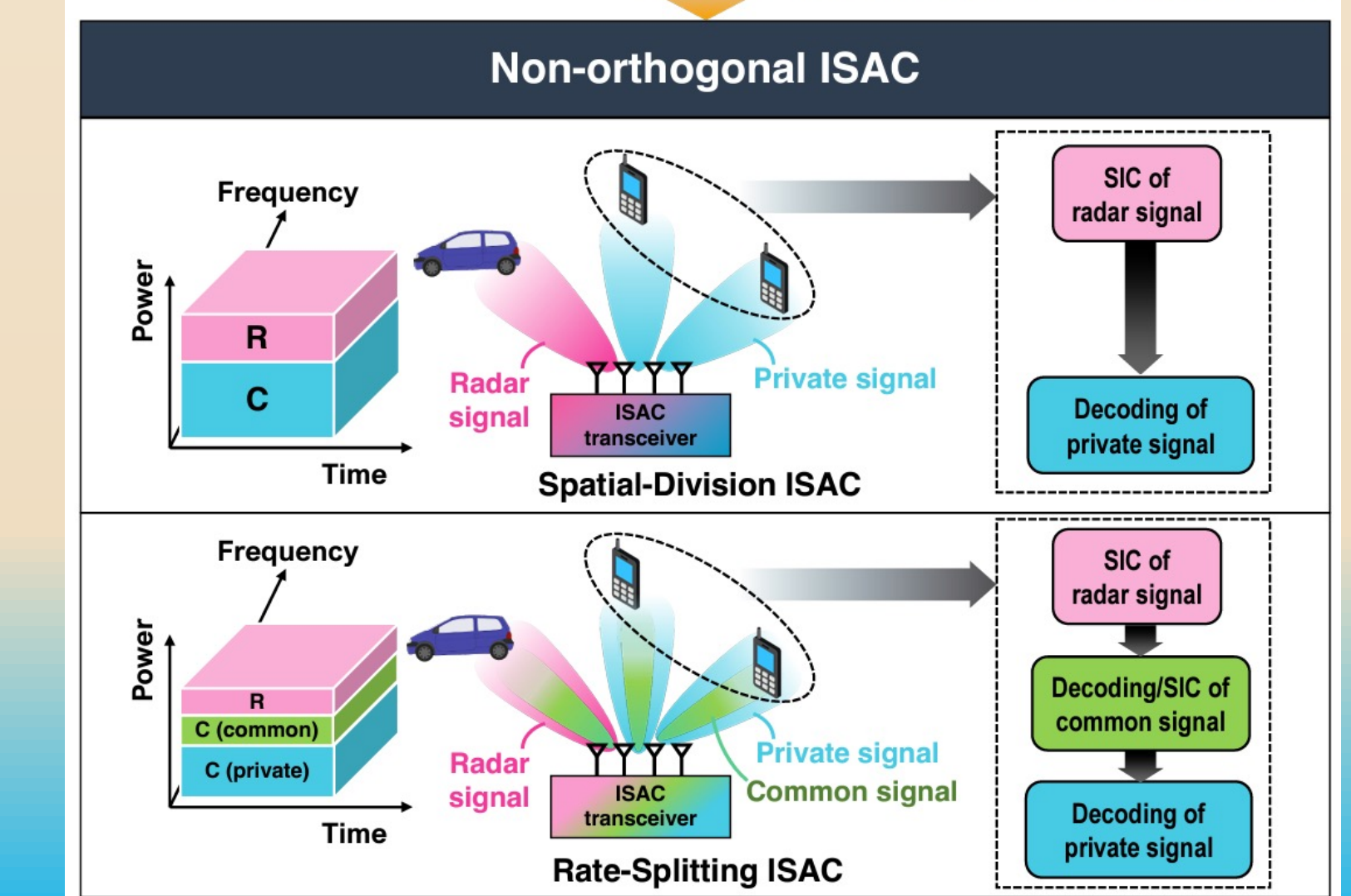


Orthogonal allocation of time or frequency resources manages interference between the two functions.

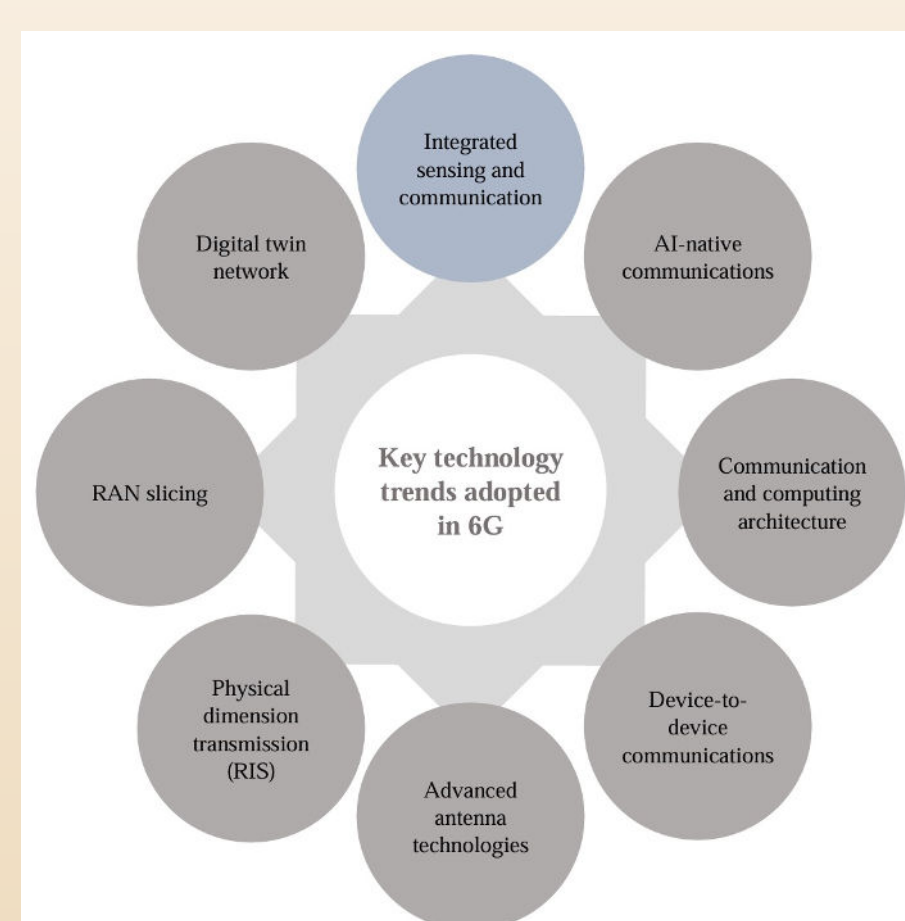
- In time-division integrated sensing & communication (ISAC), different waveforms can be utilized for communication and sensing in separate time slots.
- frequency-division ISAC employs OFDM waveform, with the allocation of distinct subcarriers for different functions to achieve interference mitigation



To fully enjoy integration gain

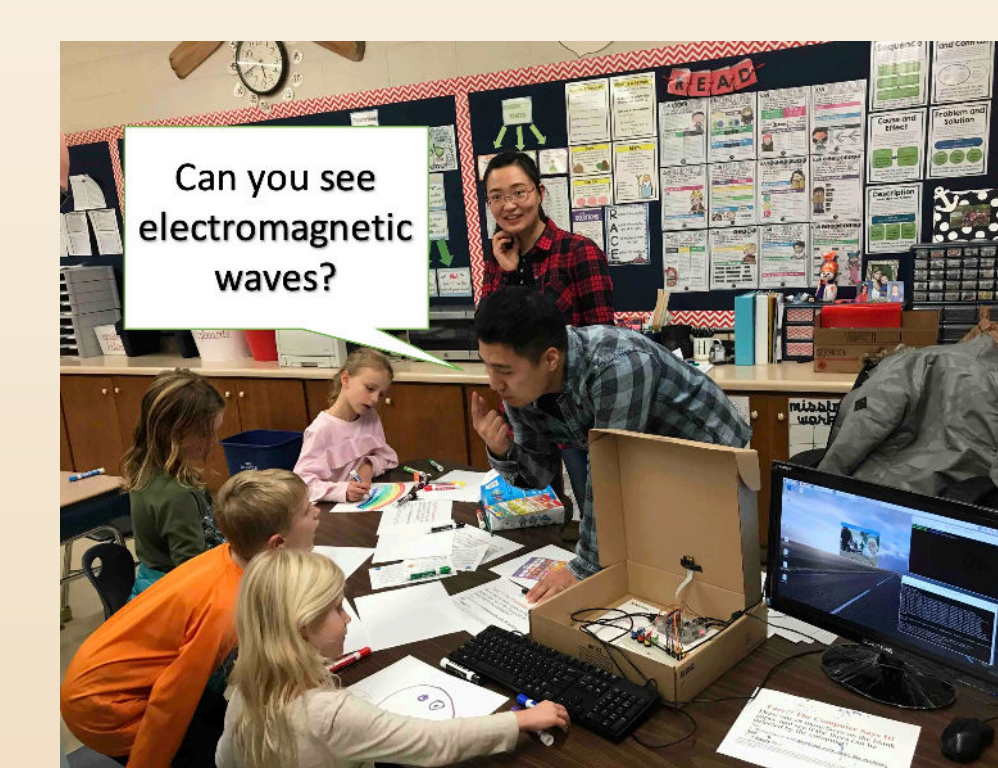


Future Plans



- Improve theoretical modeling for Joint Radar and Data Transmission
- Design better waveform for ISAC beyond OTFS and ODDM
- Optimize network performance in DD domain spectrum access
- Integrate the proposed research into 6G such as space-terrestrial integration and aerial access networks
- Find application in Metaverse and augmented reality
- Implement the prototype and then conduct industrial outreach
- Provide tutorials in conference to disseminate research
- Educate workforce for US economy and conduct outreach

Outreach and Broader Impacts



Students tutoring in Sequoyah elementary school



K12 outreach talk for high school students



UH minority Ph.D. student to present research in NASA



High school Balloon project to conduct experiment in space