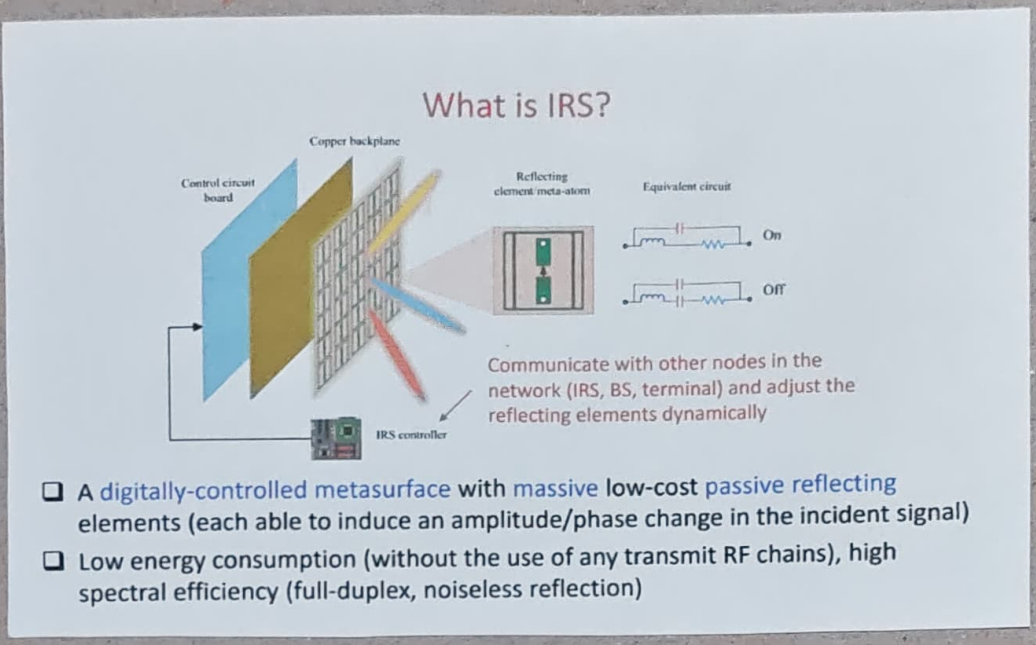
Projects 19, 20, 21, 22, 23, 24

Intelligent Reflective Surface (IRS)

IRS construction

IRS is a two dimensional (2D) array of reflecting elements, which interacts directly with incident signals.



Inner layer

Inner layer is a printed circuit connecting to the RIS controller, which can control the phase shifts of the IRS elements.

Middle layer

Middle layer is a plate (copper) which can prevent the signal energy leakage

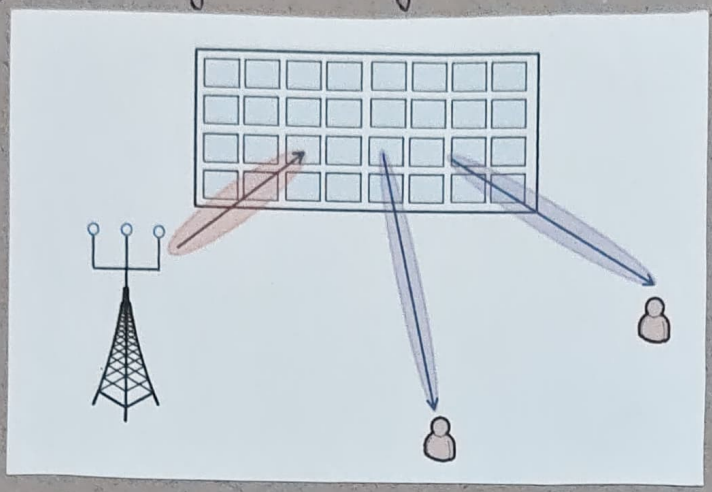
Definition : Metamaterials.

Metamaterials are synthetic materials that can achieve EM properties ... that do not occur naturally, such as negative index of refraction.

They have the ability to control the amplitude and phase of the reflected wave, ... as well as provide a High Gain for the propagation wave

IRS Working

- Each IRS element is
  - Low cost
  - sub-Wavelength programmable meta-material particle
- Working frequency can vary from sub-6 GHz to THz.



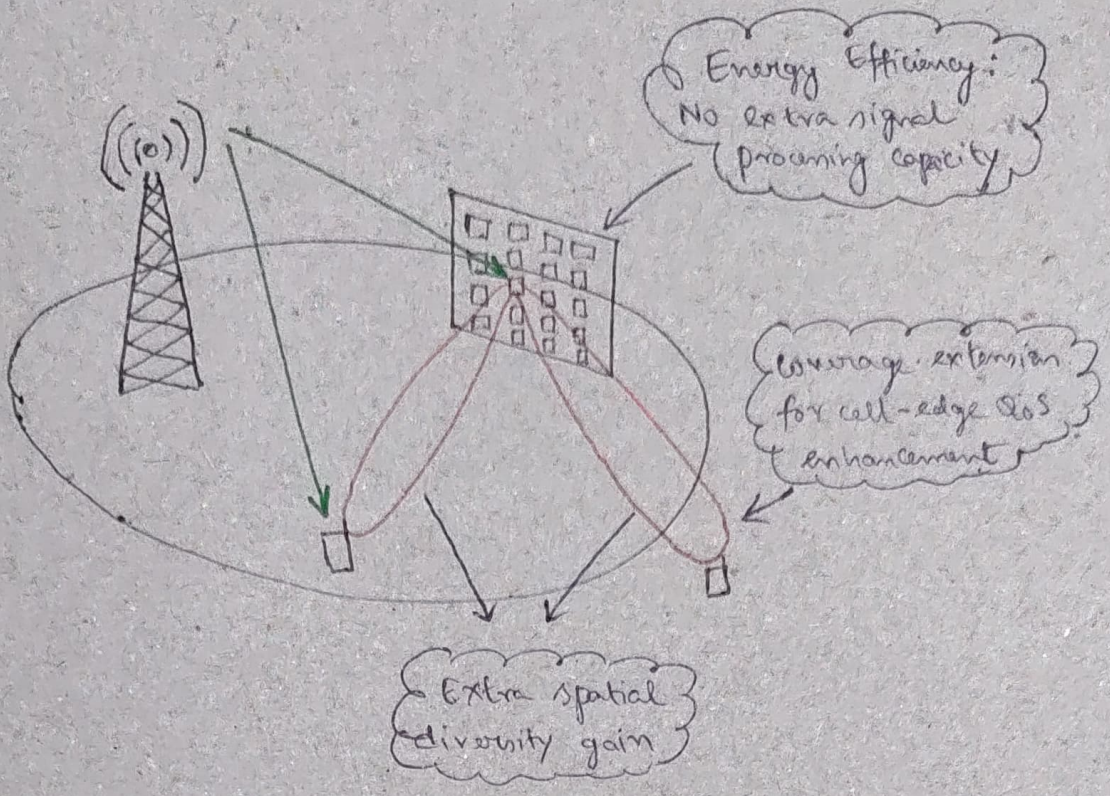
- When an EM wave impinges into the IRS element, a current is induced by the EM wave.
- And this is induced current emits another EM radiation, based on permittivity and permeability μ of the IRS.

IRS applications

(a) RIS-assisted UAV communication
(b) RIS-assisted mmWave communication
(c) RIS-assisted SWIPT
(d) RIS-assisted physical layer security
(e) RIS-assisted mobile edge computing
(f) RIS-assisted D2D system

Note:
SWIPT - Simultaneous Wireless Information and Power Transfer

Advantages of IRS



⊙ Spectrum efficiency

Each IRS element can provide an extra communication link, which enables Spatial diversity gain by exploiting these channels.

⊙ Energy efficiency

- IRS does not require extra energy consuming hardwares (Mixers / Amplifiers / Filters / DAC / ADC / ...), which improves energy efficiency by increasing the data rate with the same energy consumption.

⊙ Coverage extension

When Quality-of-service (QoS) of direct links between users and BS are not satisfactory, IRS at the cell-edge or near the dead zone can serve as passive relay to forward signals to these users.

Note:
The two dominant active relaying protocols
* Amplify-and-forward (AF)
* Decode-and-forward (DF)

IRS features :

- Once phase shifts of the IRS are fixed, the IRS will be transparent to the BS and users.
- An IRS will be compatible with existing communication systems.
- They are nearly passive, and ideally they do not need any dedicated energy source
- They are viewed as a contiguous surface, and any point can shape the wave impringing upon it, which is termed SOFT PROGRAMMING.
- They are not affected by receiver noise, since they do not need ADCs / DACs / Power amplifiers.
- They have full-band response, since they can work at any operating frequency.
- They can be easily deployed.

  Example: On the facades of buildings, ceilings of factories and indoor spaces, human clothing, etc.;