UEC747: ANTENNA AND WAVE PROPAGATION

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Lecture 1: Introduction to Course

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and

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Course Objective:

Students will be able to understand vector theory, antenna basic parameters, linear wire antennas, antenna arrays and their patterns, folded dipole, Yagi Uda, loop and Microstrip antenna, wave propagation over ground, through troposphere and ionosphere.

Course Learning Outcomes (CLOs): The student will be able to:

1. identify basic antenna parameters
2. design and analyze wire antennas
3. design and analyze antenna arrays
4. to identify characteristics of radio wave propagation
5. perform various antenna measurements

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SYLLABUS

- **Review of vector theory:** Vector algebra, Cartesian coordinate system, dot product, cross product, other coordinate systems.
- **Introduction to Basic Antenna parameters:** Radiation pattern, Radiation intensity, Beam width, Gain, Directivity, Polarization, Bandwidth, Efficiency, Side lobes, Side lobe level, Antenna Vector Effective Length and Equivalent Areas, Maximum Directivity and Maximum Effective Area, Friss Transmission Equation and Radar Range Equation, Plane wave and Properties of uniform plane waves.
- **Radiation Integrals and Auxiliary Potential Functions**: Retarded vector and scalar potential, Vector Potential A for an Electric Current Source J, Vector Potential F for a Magnetic Current Source M, Electric and Magnetic Fields for Electric (J) and Magnetic (M) Current Sources.
- **Linear Wire Antennas:** Radiation from an infinitesimal small current element, Radiation from an elementary dipole (Hertzian dipole), Small Dipole, Finite length dipole, Half wave dipole,Linear Elements Near or on Infinite Perfect Conductors, Monopole antenna, Folded dipole and Yagi Uda antenna.
- **Antenna Arrays:** Two-Element Array, Broadside arrays, End fire arrays. N-Element Linear Array: Uniform Amplitude and Spacing, N-Element Linear Array: Directivity, N-Element Linear Array: Uniform Spacing, Non uniform Amplitude, Binomial Array, Chebyshev Arrays, Principle of pattern multiplication. Array pattern Synthesis.
- Microstrip Antennas: Microstrip Antennas & their advantages, Media: Dielectric effect, Dielectric Loss Tangent- tan δ, Substrates,
- **Propagation of Radio Waves:** Different modes of propagation: Ground waves, Space waves, Space wave propagation over flat and curved earth, Surface waves and Troposphere waves, Wave propagation in the Ionosphere, Critical frequency, Maximum usable frequency (MUF), Skip distance, Virtual height

Laboratory Work

Drive antenna by voltage, Radiation pattern of half wave dipole, Radiation pattern of monopole, Effective height of antenna, Radiation pattern of capacitance and inductive loaded antenna, Directional radiation from two composite antennas, Radiation from conducting sheet with slot, Matching stub in antenna, Measure the SWR, Radiation polar diagram of directional antenna.

Assignments as Homework

Homeworks:

Homework is an important part of learning the subject !

Why is homework important?

Homework → Practicing, developing research skills

Homework → Self-discipline & responsibility

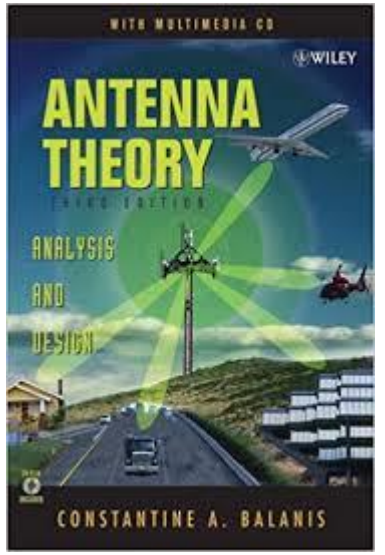
Homework → **"Achievement"**

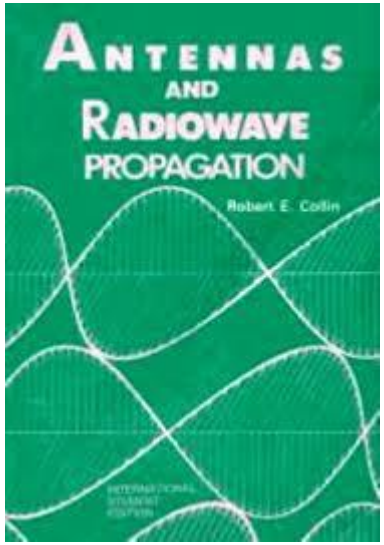
Self-confidence → **Love the course**

Literature

Text Books:

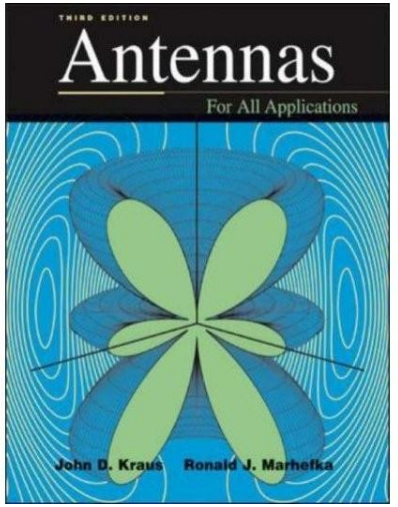
1. *Antenna Theory, Balanis, John Wiley & Sons, 2003.*
2. *Antennas and Radio Propagation, Collins, R. E, McGraw-Hill,1987.*



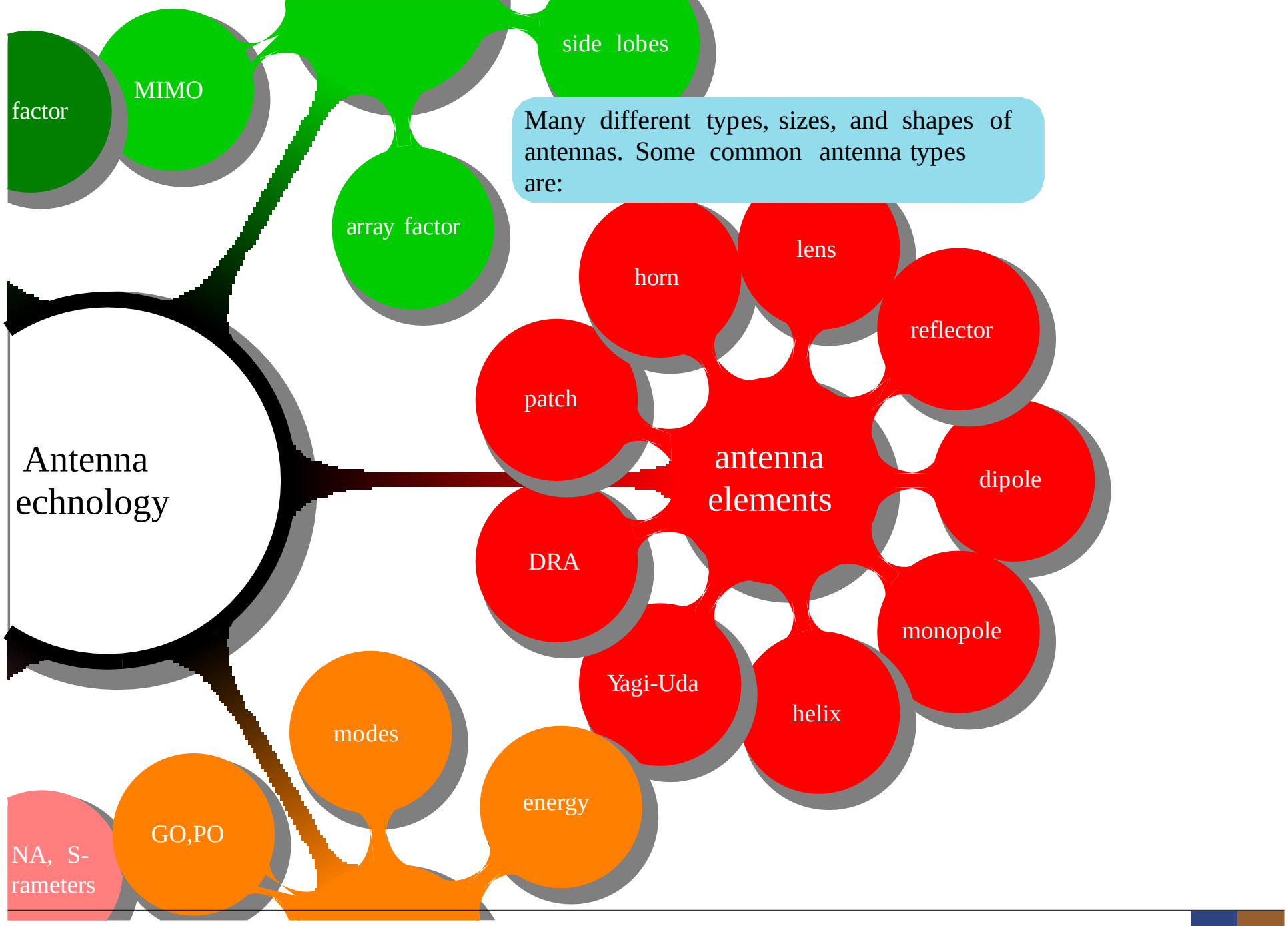


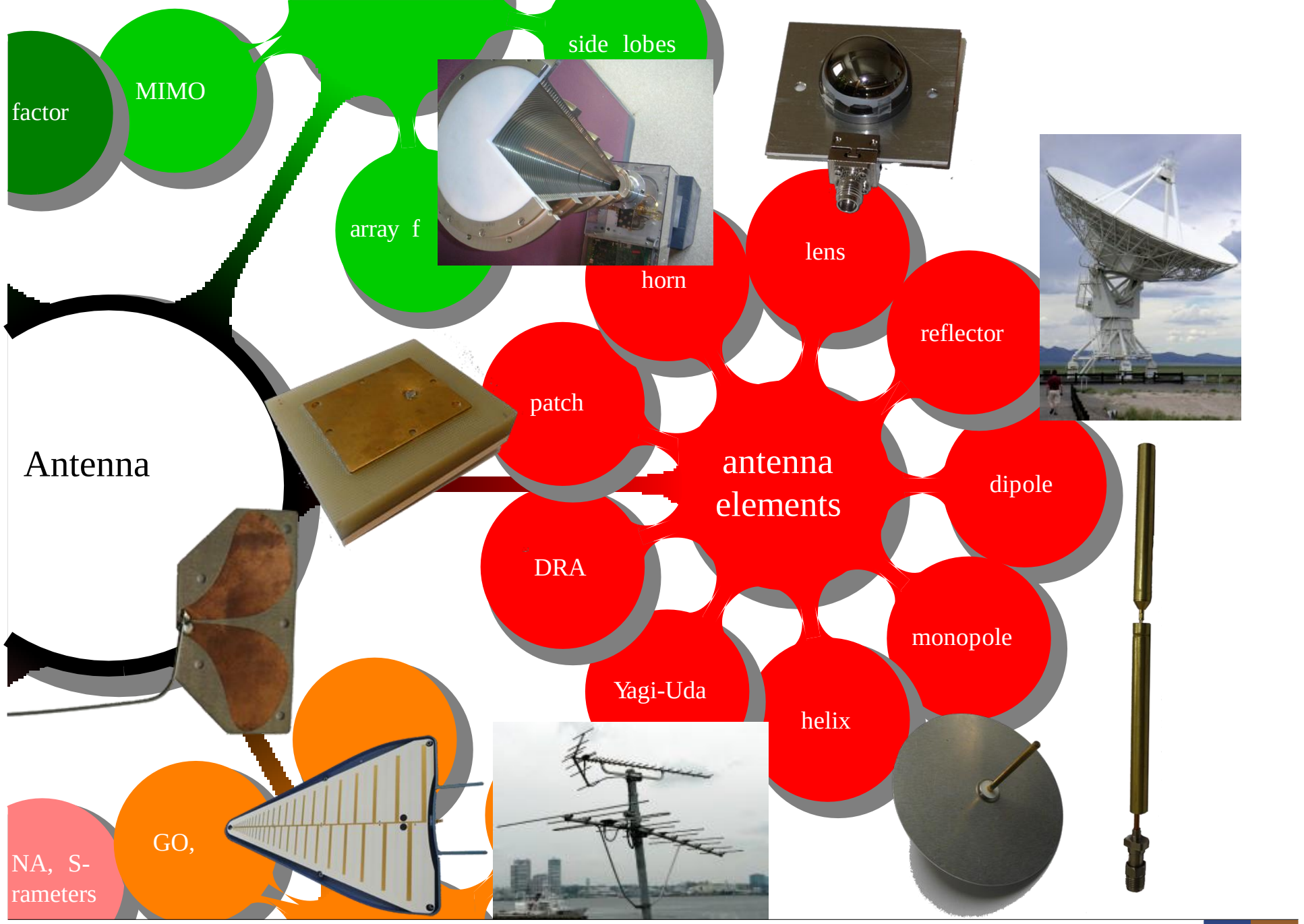
Reference Books:

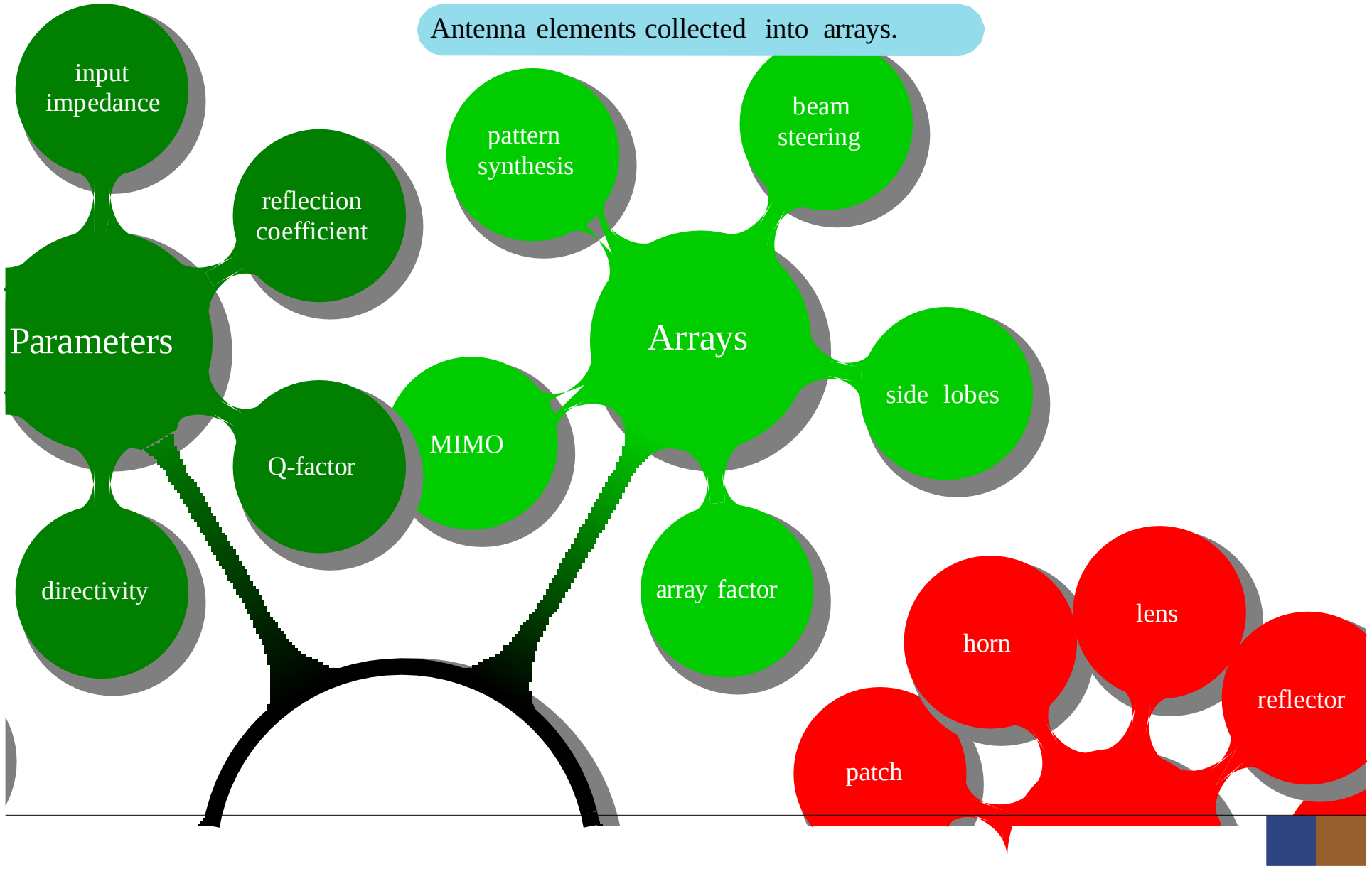
1. *Antennas, Kraus and Ronalatory Marhefka, John D., Tata McGraw-Hill, 2002.*
2. *Microwave & RF Design, Michael Steer, Sci.Tech Publishing, 2009*

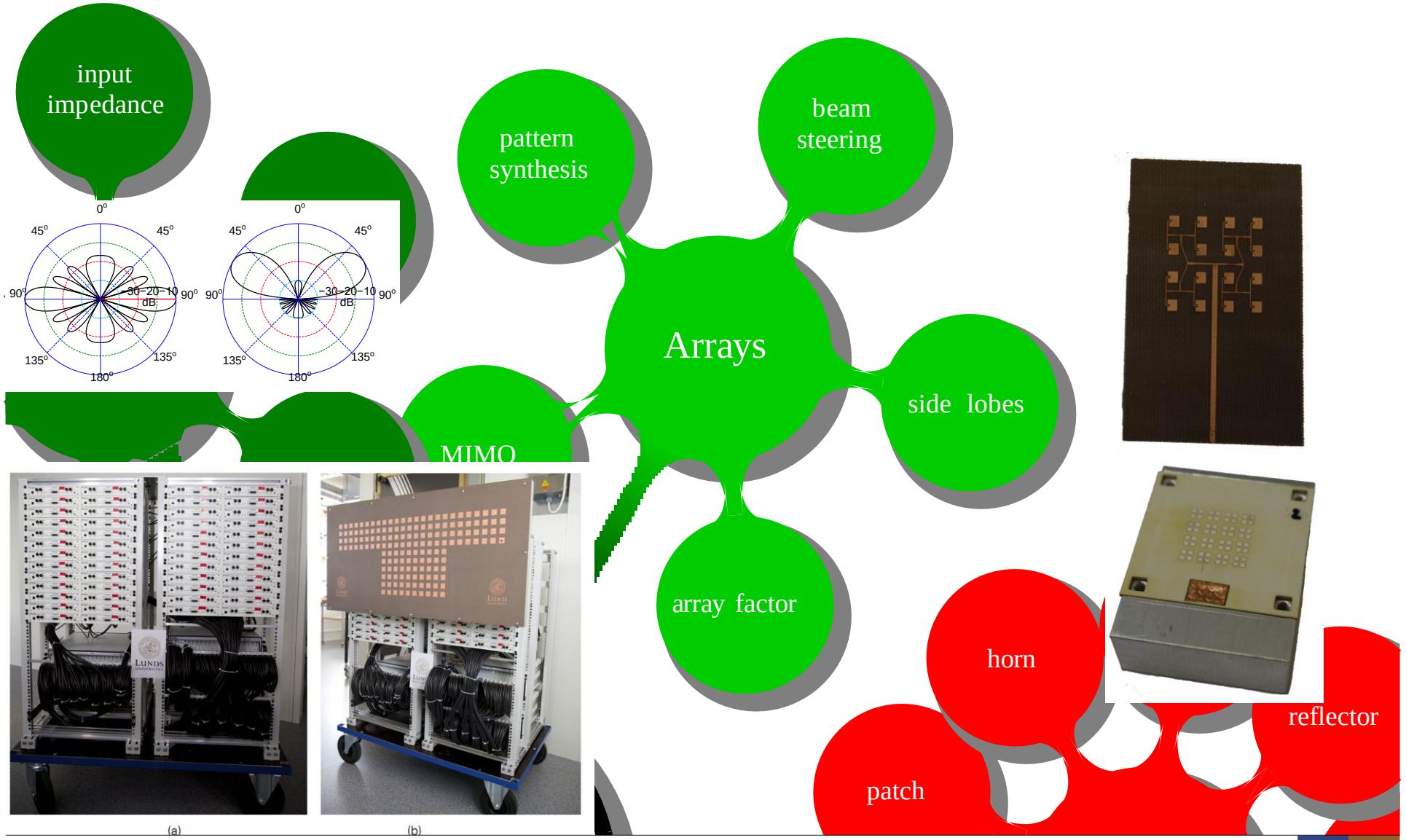



Antenna technology
Parameters
input impedance
efficiency
reflection coefficient
gain
Q-factor
directivity
Arrays
pattern synthesis
beam steering
MIMO
side lobes
array factor
Applica-tions
power transfer
mobile phones
radio, TV
radar
astronomy
nano, optics
RFID
antenna elements
horn
lens
reflector
patch
dipole
DRA
monopole
Yagi-Uda
helix
Measure-ments
anechoic chamber
VNA, S-parameters
near field
far field
SAR
Analysis
modes
energy
GO,PO
current to far field
FEM
FDTD
MoM

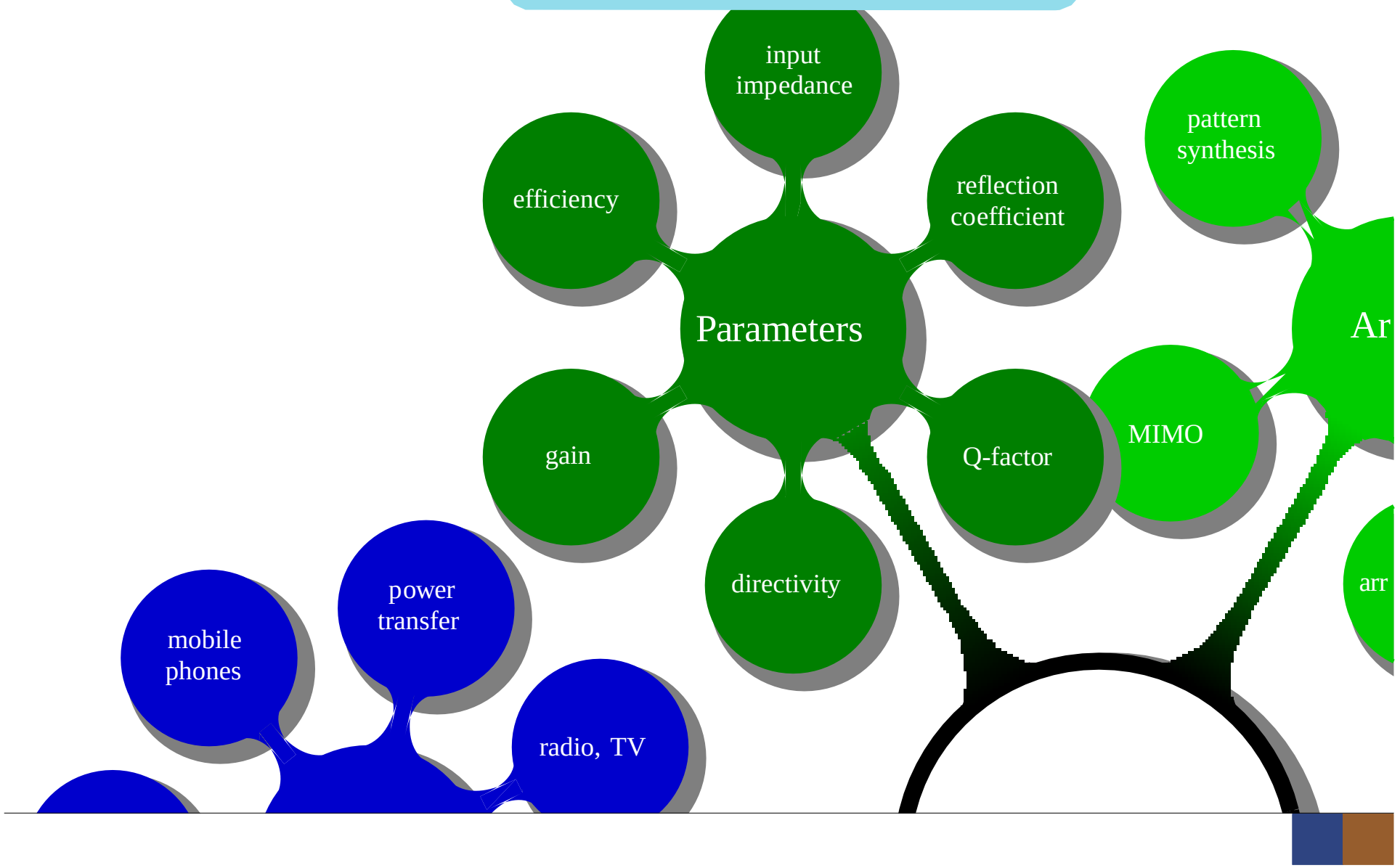

Many different types, sizes, and shapes of antennas. Some common antenna types are:
Antenna echnology
antenna elements
horn
lens
reflector
patch
dipole
DRA
monopole
Yagi-Uda
helix
array factor
factor
MIMO
side lobes
modes
energy
GO,PO
NA, S-rameters

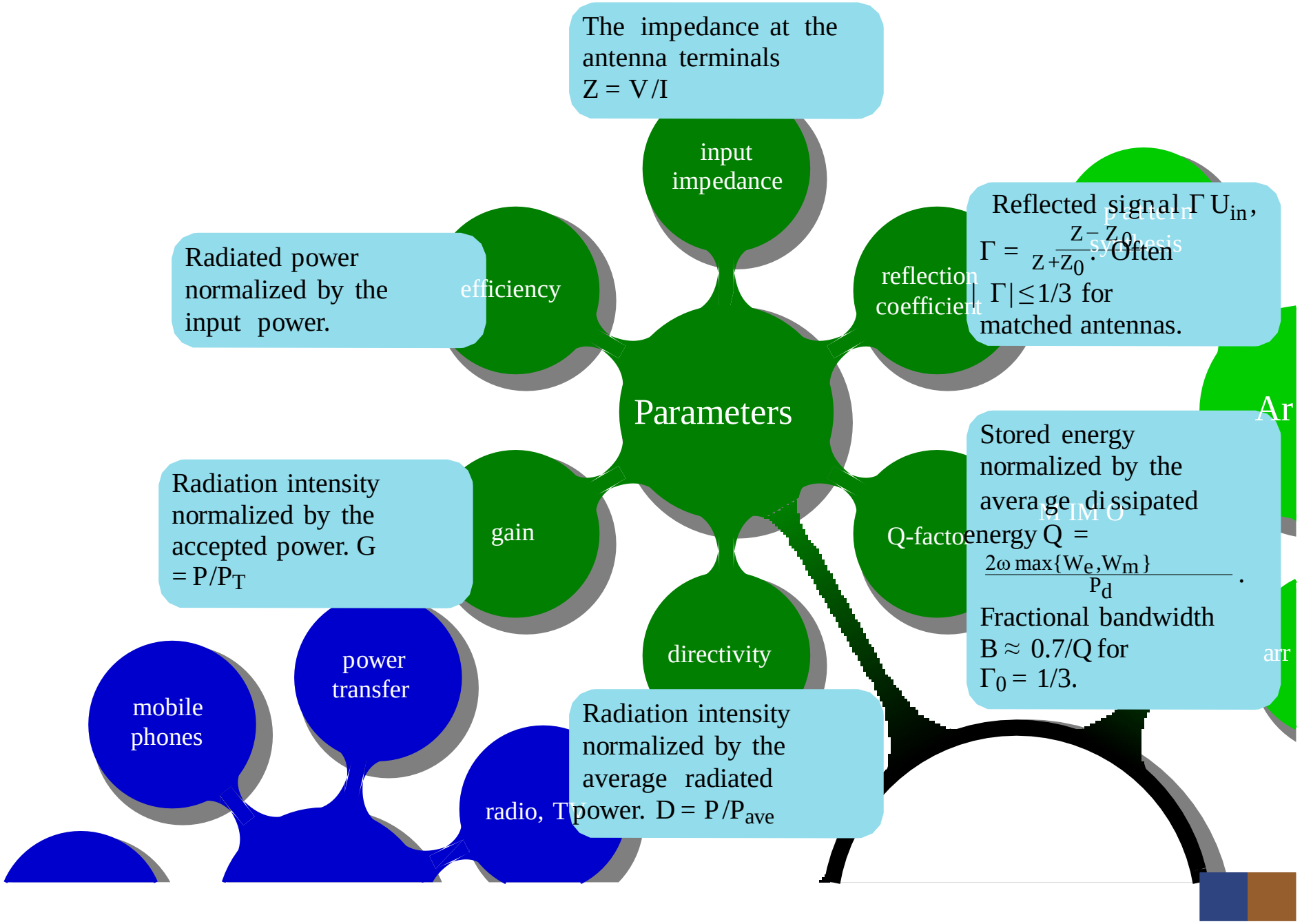

side lobes
MIMO
factor
array f
horn
lens
reflector
patch
Antenna
antenna elements
dipole
DRA
monopole
Yagi-Uda
helix
GO,
NA, S-rameters

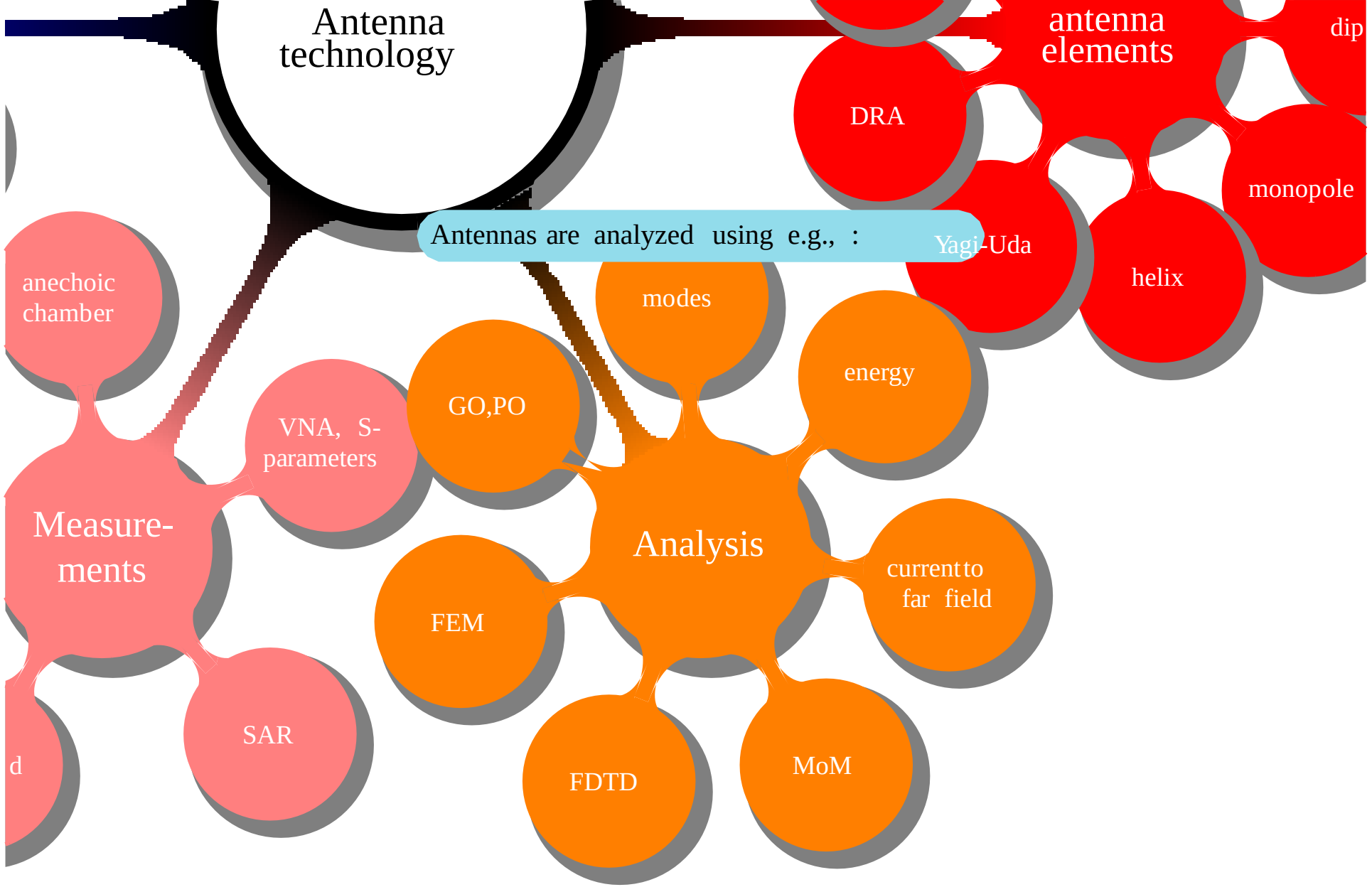

Antenna elements collected into arrays.
input impedance
reflection coefficient
Parameters
Q-factor
directivity
pattern synthesis
beam steering
Arrays
MIMO
side lobes
array factor
horn
lens
reflector
patch

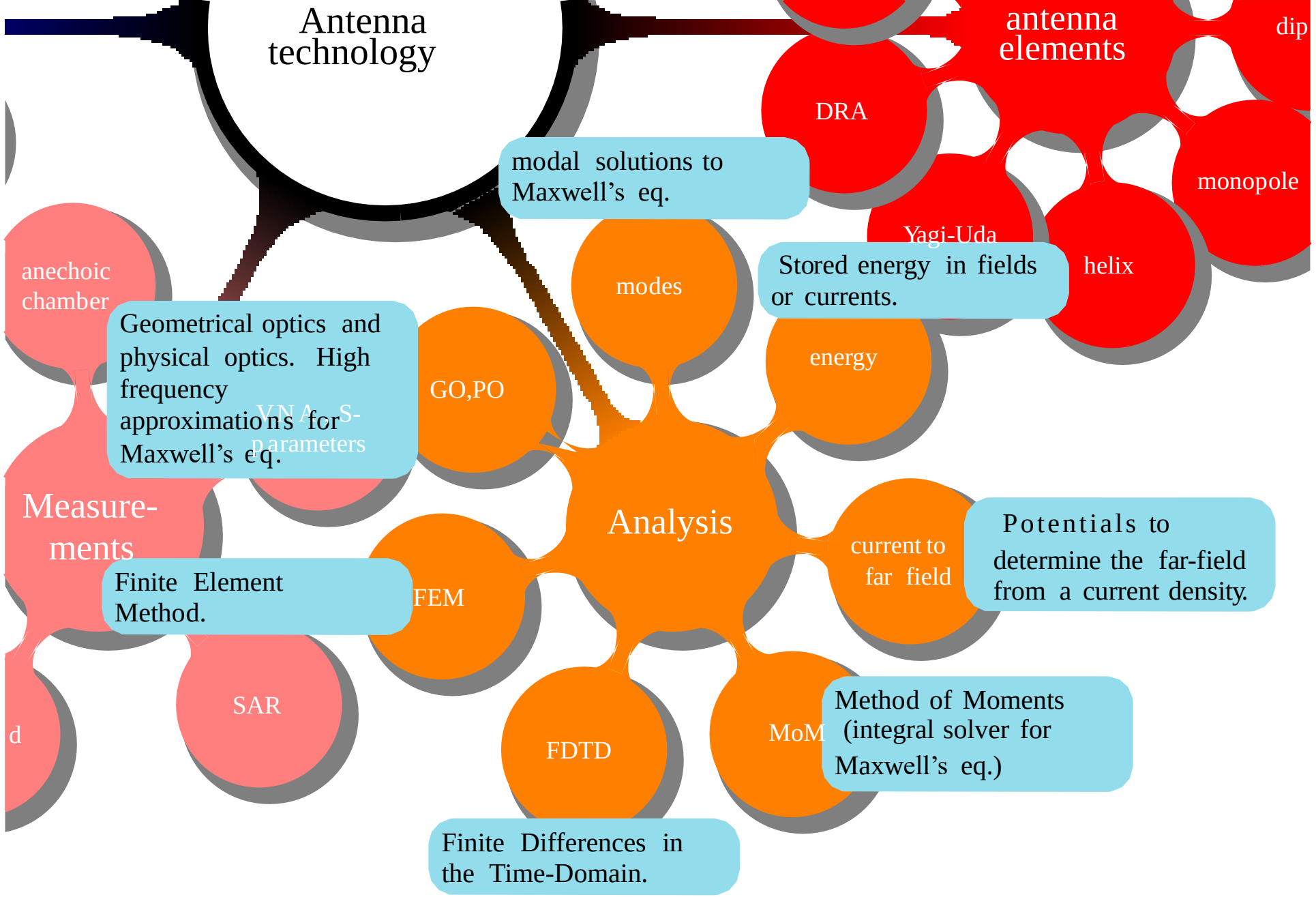

input impedance
pattern synthesis
beam steering
Arrays
side lobes
MIMO
array factor
horn
reflector
patch
0°
45°
90°
135°
180°
-30 -20 -10 dB
(a)
(b)

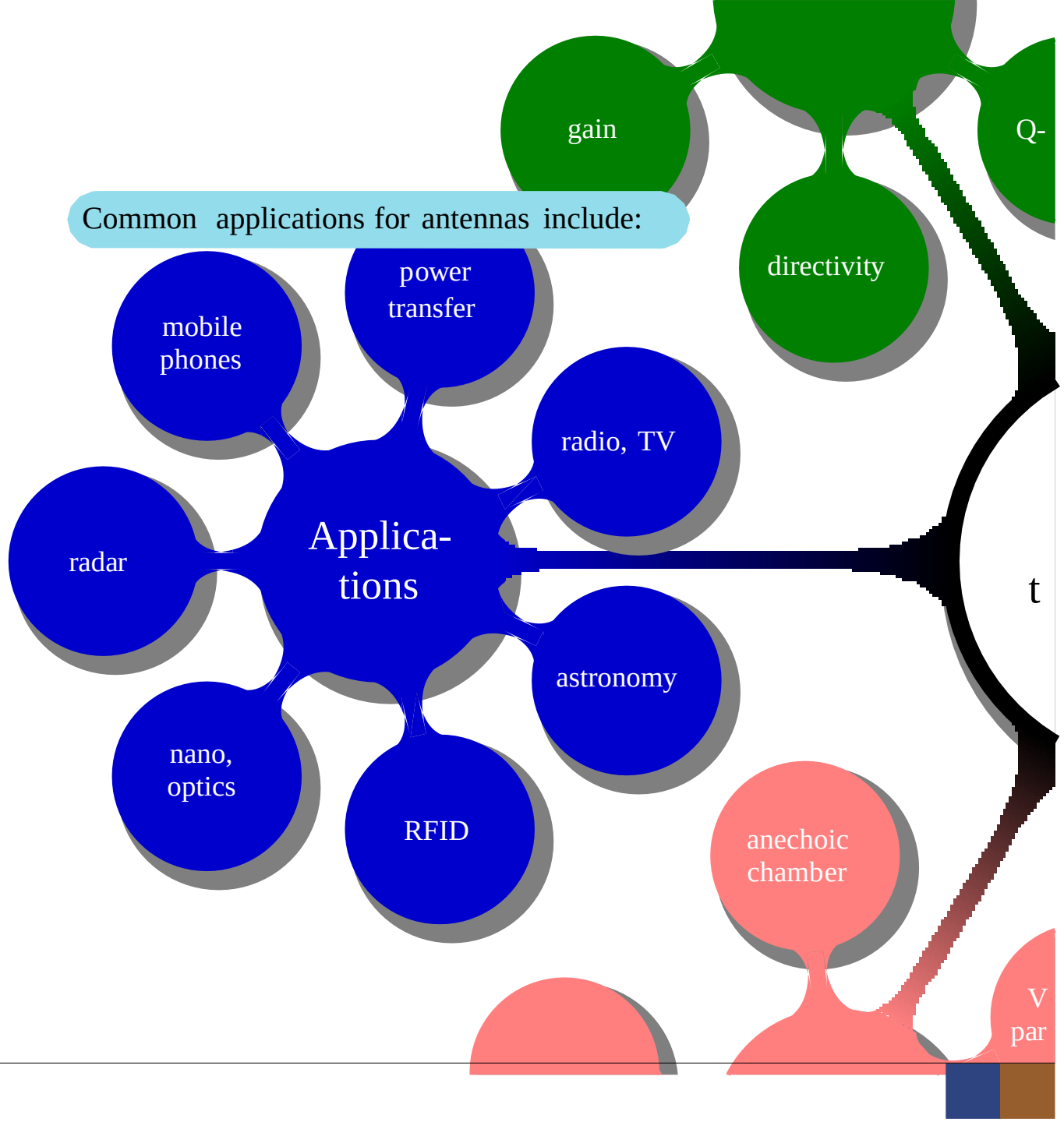
Parameters used to characterize antennas include:

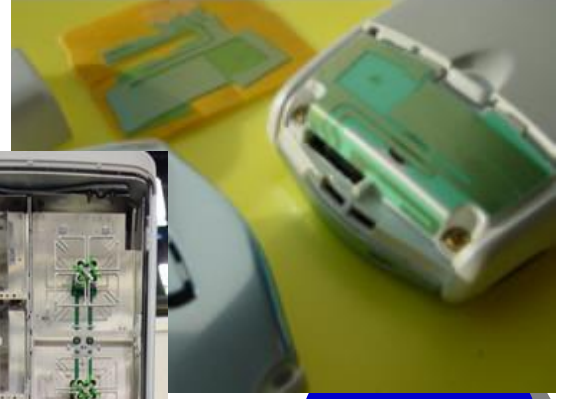



The impedance at the antenna terminals Z = V/I
input impedance
Radiated power normalized by the input power.
efficiency
Parameters
reflection coefficient
Reflected signal Γ U_in, Γ = (Z − Z0)/(Z + Z0). Often |Γ| ≤ 1/3 for matched antennas.
Radiation intensity normalized by the accepted power. G = P/P_T
gain
Q-factor
Stored energy normalized by the average dissipated energy Q = 2ω max{W_e, W_m} / P_d. Fractional bandwidth B ≈ 0.7/Q for Γ0 = 1/3.
directivity
Radiation intensity normalized by the average radiated power. D = P/P_ave
power transfer
mobile phones
radio, T


Antenna technology
antenna elements
dip
DRA
monopole
Yagi-Uda
helix
Antennas are analyzed using e.g., :
anechoic chamber
modes
energy
GO,PO
VNA, S-parameters
Measure-ments
Analysis
current to far field
FEM
SAR
d
FDTD
MoM


Antenna technology
antenna elements
dip
DRA
monopole
Yagi-Uda
helix
modal solutions to Maxwell's eq.
Stored energy in fields or currents.
modes
energy
anechoic chamber
Geometrical optics and physical optics. High frequency approximations for Maxwell's eq.
GO,PO
VNA
S-parameters
Measure-ments
Analysis
current to far field
Potentials to determine the far-field from a current density.
Finite Element Method.
FEM
SAR
d
FDTD
MoM
Method of Moments (integral solver for Maxwell's eq.)
Finite Differences in the Time-Domain.


gain
Q-
directivity
Common applications for antennas include:
power transfer
mobile phones
radio, TV
radar
Applica-tions
astronomy
nano, optics
RFID
anechoic chamber
t
V par



gain

power transfer

mobile phones

radio, TV

radar

Applica-tions

astronomy

nano, optics

RFID

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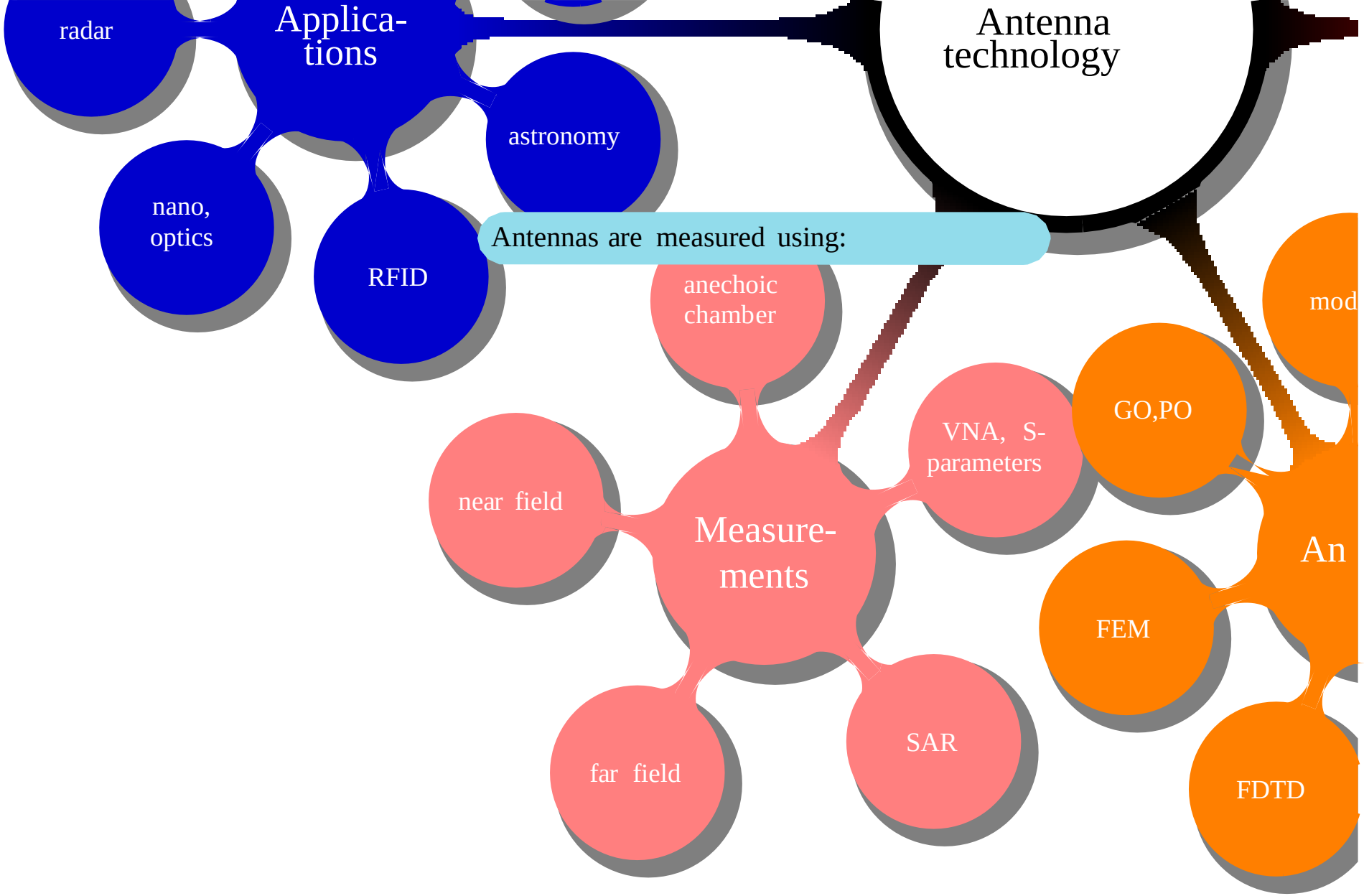
radar
Applica-
tions
astronomy
nano,
optics
RFID
Antenna
technology
Antennas are measured using:
anechoic
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near field
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radar

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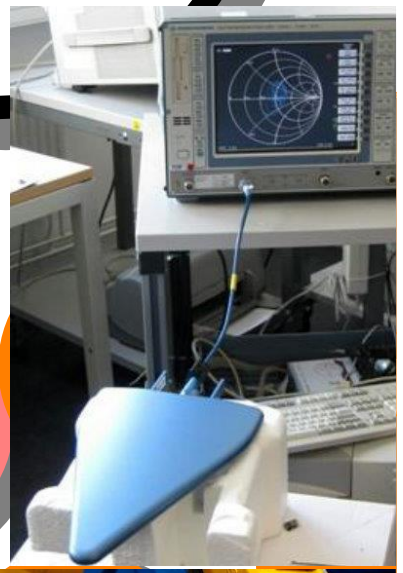
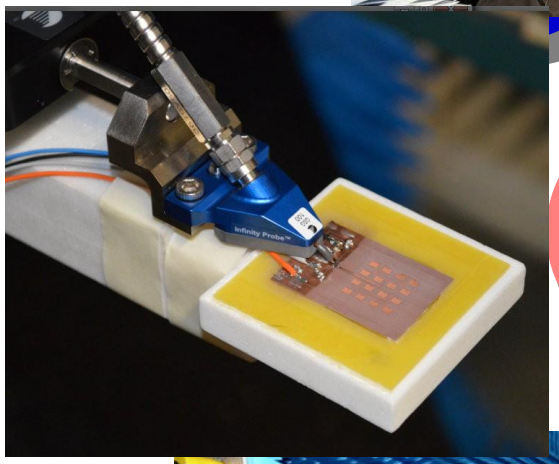
nano, optics

Antenna technology



anechoic chamber



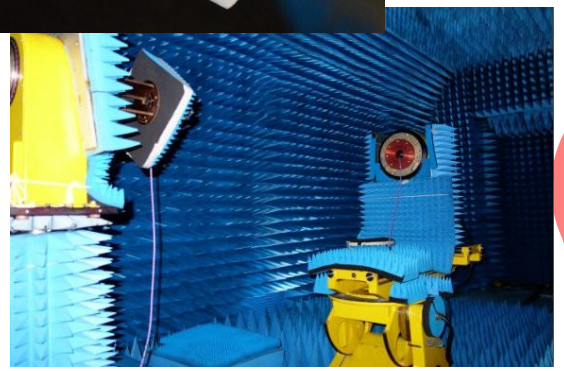
near field

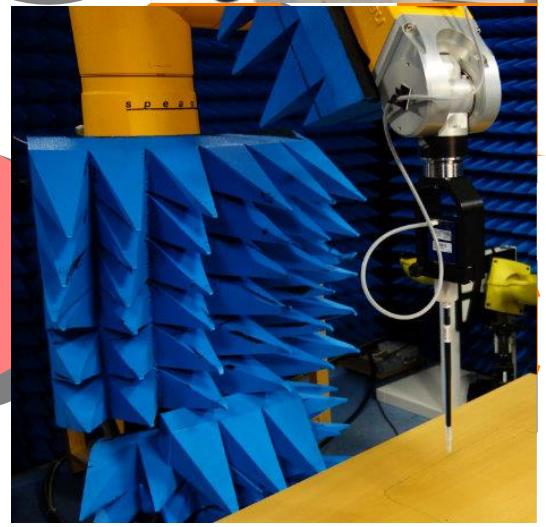
Measure-ments

VNA, S-parameters

far field

SAR



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Assignment

List various types antennas used in communication systems

THANKS