

Spectrum sharing method in satellite and terrestrial coexisting networks

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I. BACKGROUND

What is a wireless communications?

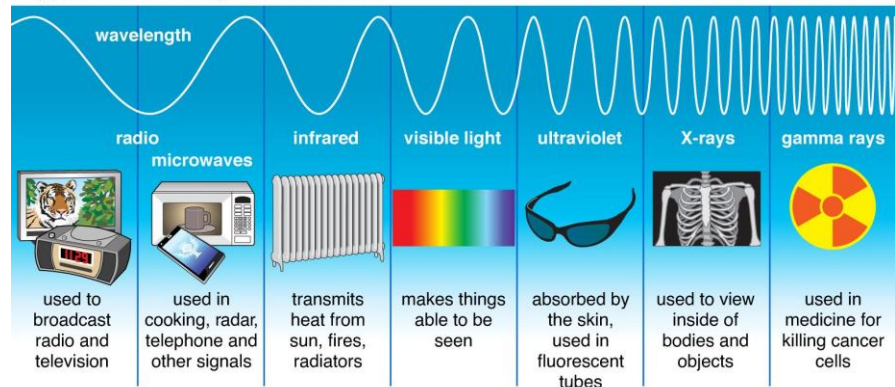
- **Communication**
 - Exchange of information through a wireless channel
- **Communications**
 - Technology that enables communication



Sound Wave

- Slow propagation [340 m/s]
- High attenuation

Types of Electromagnetic Radiation [2]



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Electromagnetic Wave (EM)

- Fast propagation [3×10^8 m/s]
- Relatively low attenuation

First wireless communication with EM

The first wireless communications with EM in human history invented in 2nd century BC, Egypt



Power of
reliable and fast
communications

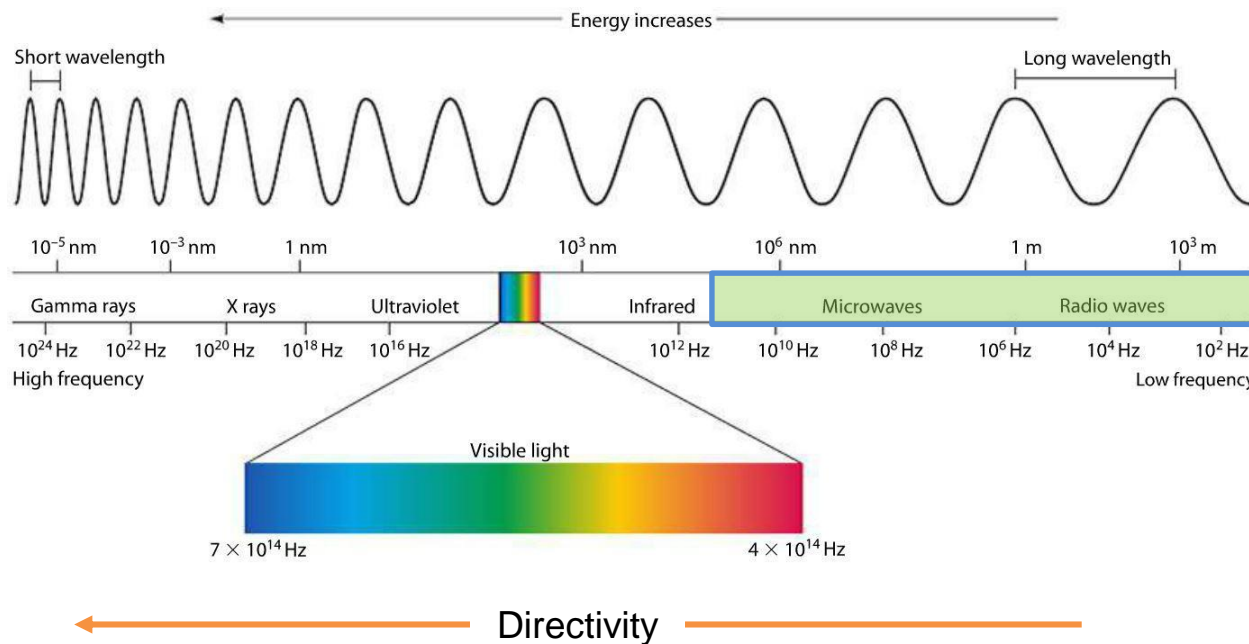
What does it mean reliable?

How do you define a performance of the communications system?

EM wave in wireless communication

- Electromagnetic wave is used as an information carrier

- $f = c/\lambda$
- f : frequency / c : speed of light / λ : wavelength
- EM wave 3 Hz to 300 GHz are exploited

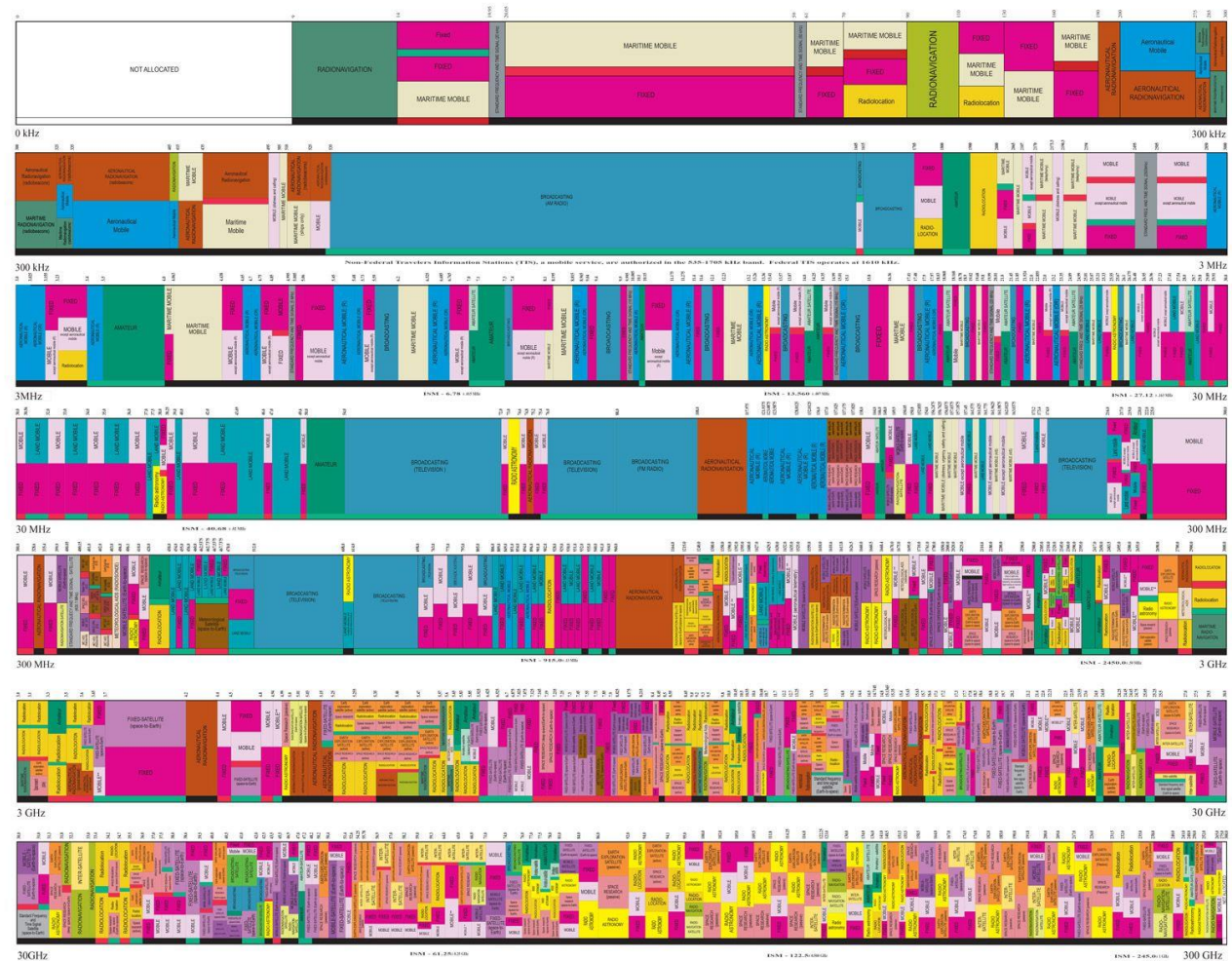


Frequency	IEEE ^[14]	EU, NATO, US ECM	ITU	
			no.	abbr.
3 Hz				
30 Hz			1	ELF
300 Hz			2	SLF
3 kHz			3	ULF
30 kHz		A	4	VLF
300 kHz			5	LF
3 MHz			6	MF
30 MHz	HF		7	HF
250 MHz	VHF		8	VHF
300 MHz		B		
500 MHz	UHF			
1 GHz	L	D	9	UHF
2 GHz		E		
3 GHz	S	F		
4 GHz		G		
6 GHz	C	H		
8 GHz		I		
10 GHz	X		10	SHF
12 GHz	K _u	J		
18 GHz				
20 GHz	K			
27 GHz		K		
30 GHz	K _a			
40 GHz		L		
60 GHz	V			
75 GHz		M	11	EHF
100 GHz	W			
110 GHz	mm			
300 GHz			12	THF
3 THz				

EM wave usage in US

- EM wave is a combination of licensed and unlicensed resources

UNITED STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM



EM wave is a limited resources

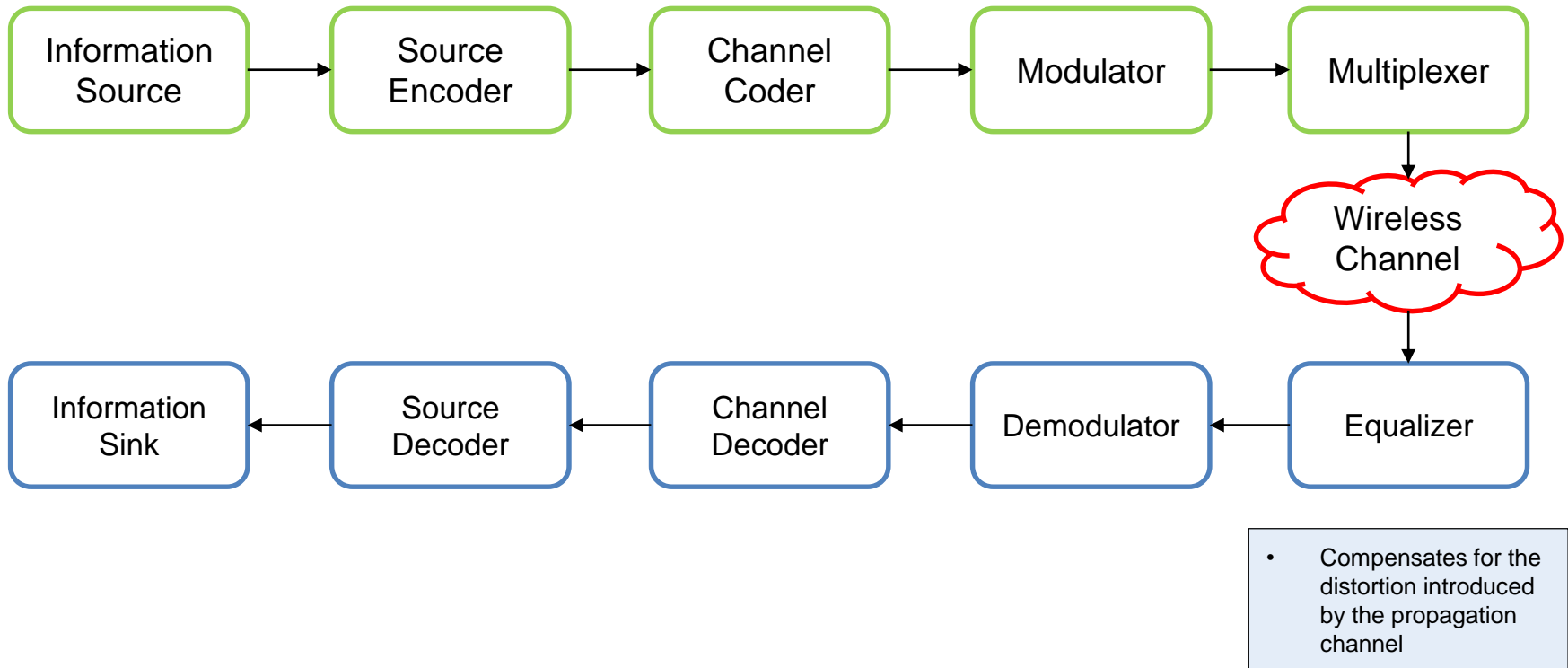
Frequency fees for radio reservation and radio license

A frequency fee will be collected for frequency reservations and radio licences based on the number of frequencies and other grounds for fees laid down in the decree of the Ministry of Transport and Communications on frequency fees. The fee is calculated using the formula for the general frequency fee for local mobile networks.

Frequency band	Bandwidth (MHz)	Frequency fee
2,300-2,320 MHz	5	€279.83
2,300-2,320 MHz	10	€559.66
2,300-2,320 MHz	20	€1,119.31
24.25-25.1 GHz	50	€310.92
24.25-25.1 GHz	100	€621.84
24.25-25.1 GHz	200	€1,243.68

Principles of wireless communications

<ul style="list-style-type: none">Contains the informationProduces information	<ul style="list-style-type: none">Compresses the dataReduce the amount of data by removing the redundancies in the data.	<ul style="list-style-type: none">Increase the reliability of the systemAdding the redundant bit (parity bit)	<ul style="list-style-type: none">Converts the coded message into a signalConverts digital data into analog signals.	<ul style="list-style-type: none">Multiple signals to a single composite signal.
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Principles of wireless communications

- Received signal in single input single output system



$$y = hx + n$$

Signal-to-Noise Ratio (SNR)

$$\text{SNR} = \frac{|h|^2 P_{tx} E\{|x|^2\}}{N_0}$$

h : complex channel gain

x : signal input

n : additive white gaussian noise $\mathcal{CN}(0, \sigma^2)$

N_0 : AWGN noise power, $N_0 = kT_0$

P_{tx} : Power of transmitter


Performance Metric

Efficiency

- Bandwidth/energy
- Bit/s/Hz
- Bits/channel use
- Bit/s/Joule

Reliability(Outage probability)

- Bit error rate (BER)
- Symbol error rate (SER)
- Frame error rate (FER)


$$C = \log_2(1 + \text{SNR})$$

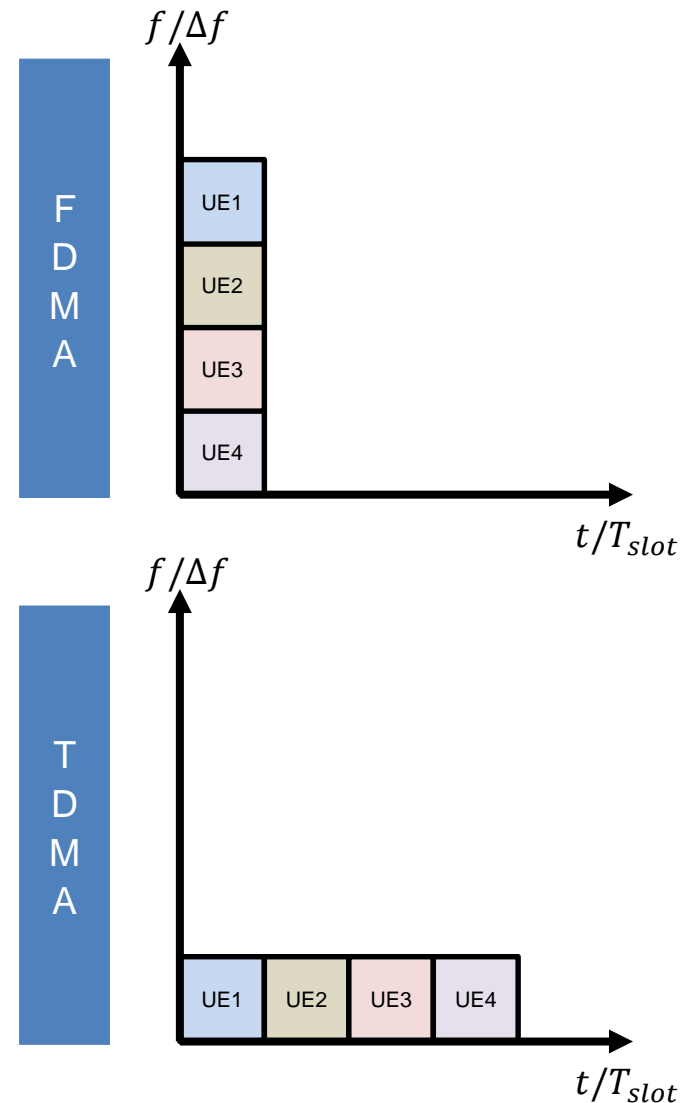
Principles of wireless communications

❖ Resource block(UE)

- Fundamental unit of the wireless spectrum used to transmit data
- Specific amount of time and frequency resources, typically in a grid-like fashion

❖ Multiple access

- Orthogonal multiple access
 - Frequency division multiple access (FDMA)
 - Time division multiple access (TDMA)
- Non-orthogonal multiple access (NOMA)



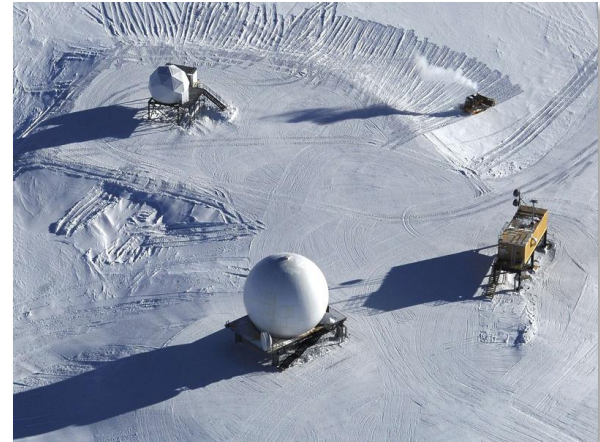
II. NON-TERRESTRIAL NETWORK

Start of star link service



Ubiquitous wireless communications on Earth

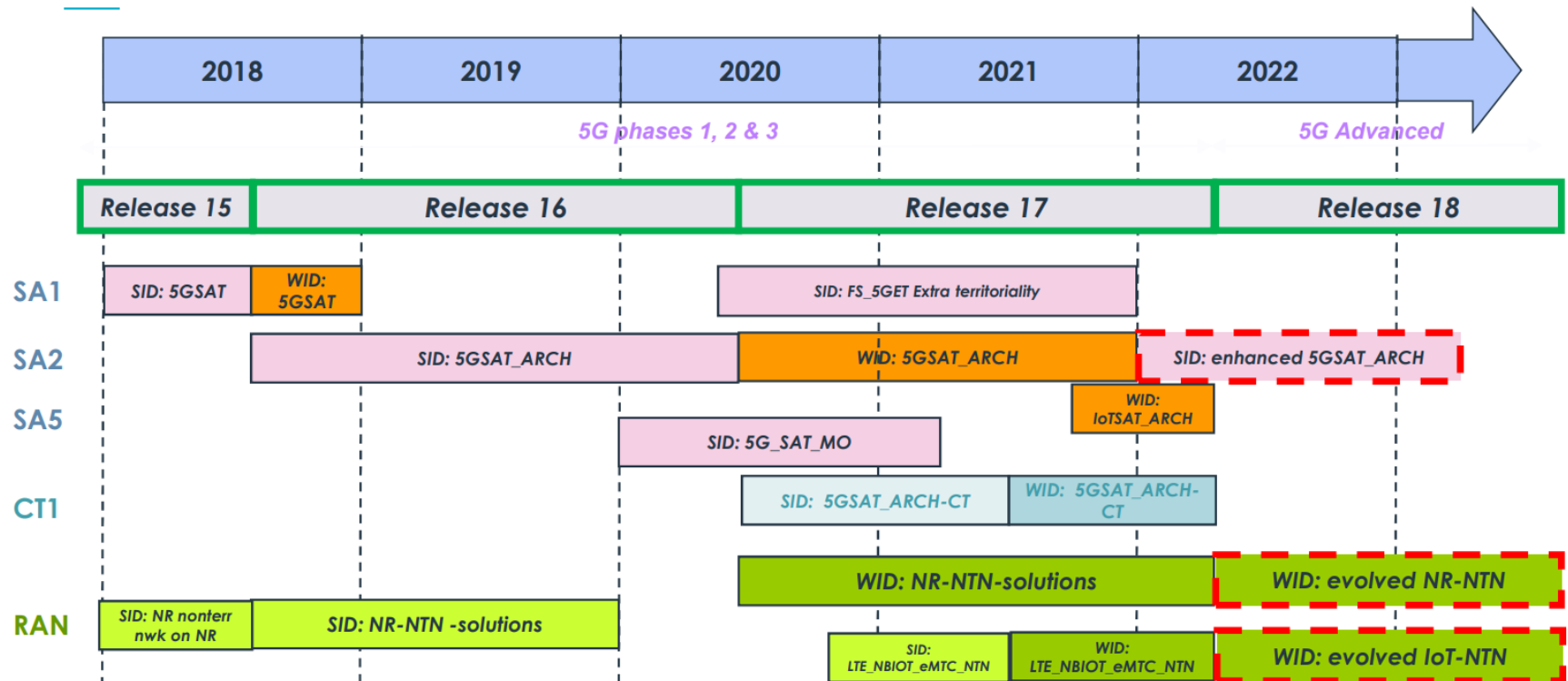
Non-terrestrial network is a communication network that operates beyond Earth's surface. It uses satellites, drones, or other space-based technology to provide connectivity, often for remote or hard-to-reach areas, and can be used for purposes like internet access, navigation, and data transmission.



Non-terrestrial network



3rd Generation Partnership Project (3GPP) is an organization that plays a crucial role in the development and standardization of technologies for wireless mobile networks

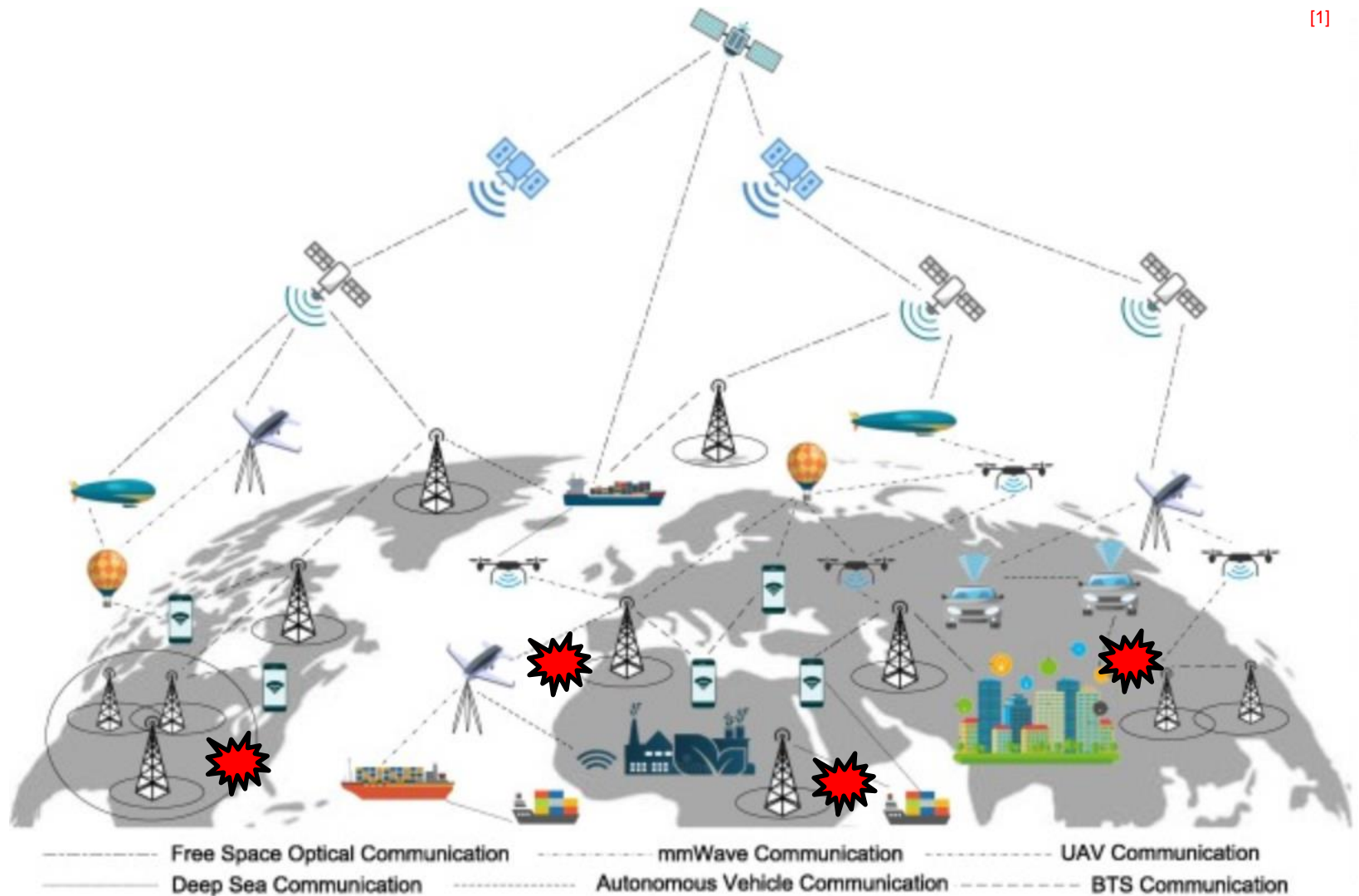


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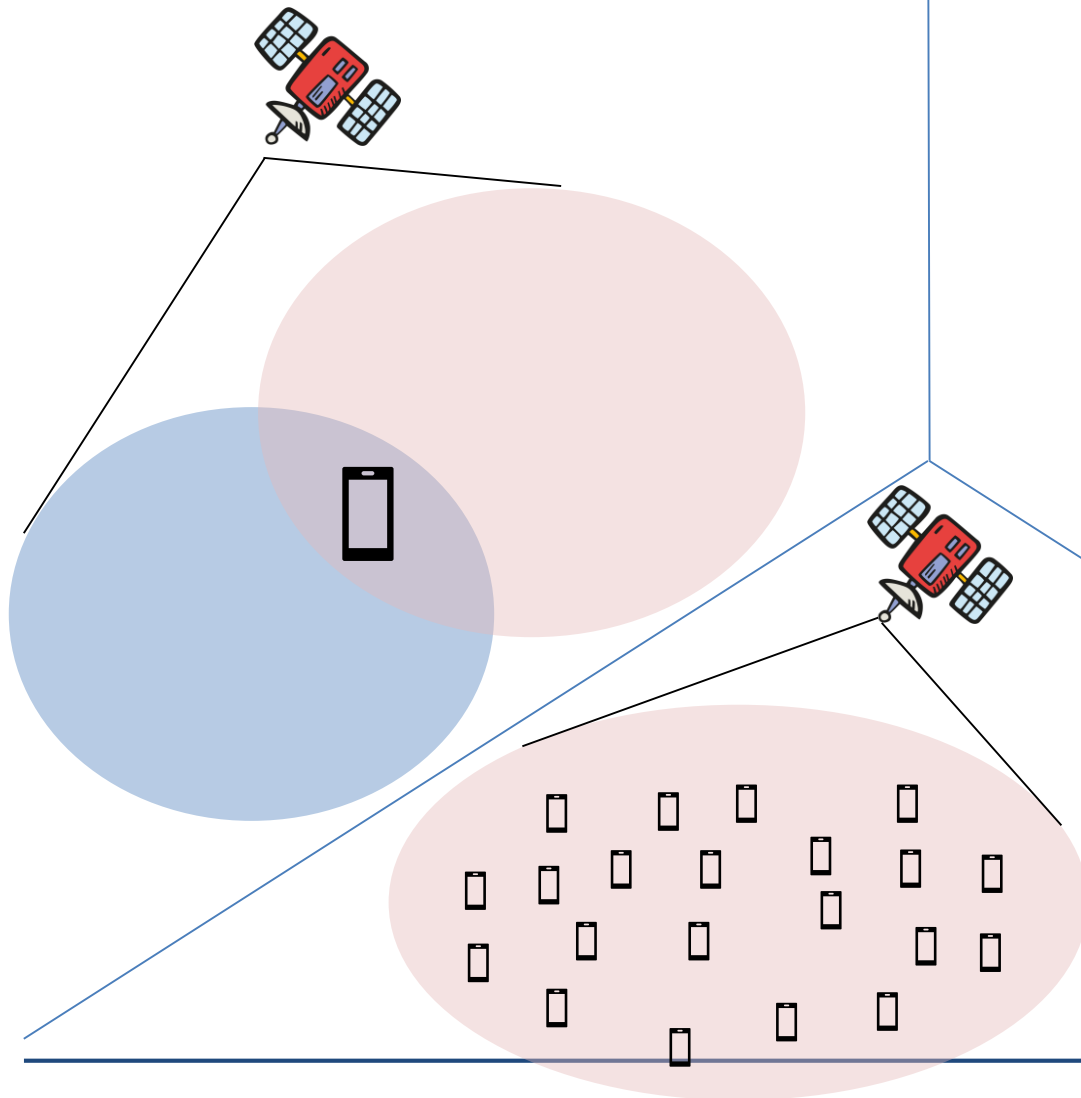
Future of wireless communications network

[1]

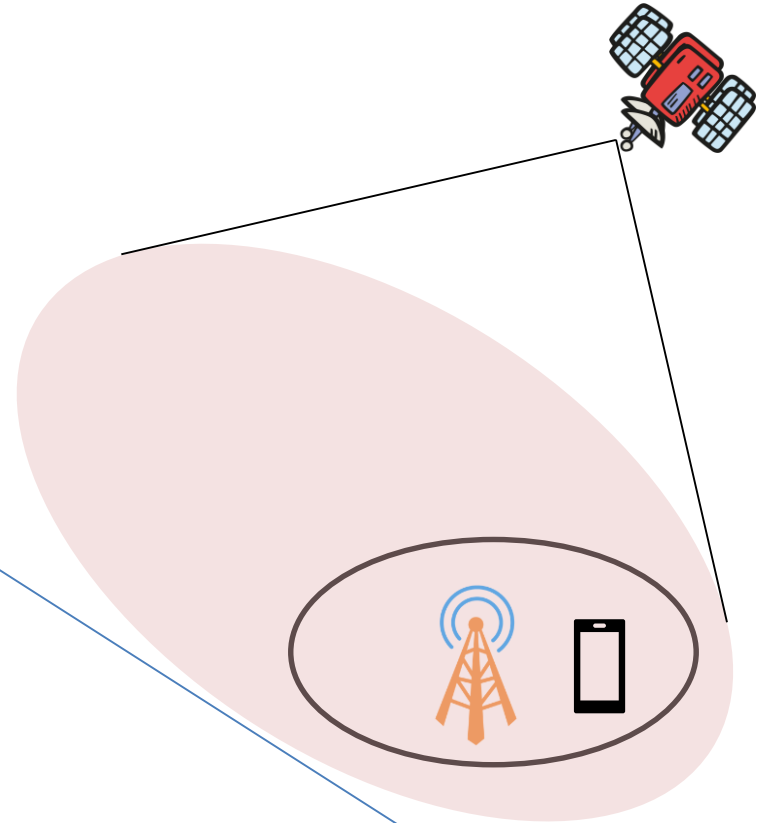


Interferences in integrated terrestrial satellite network

Inter-beam interference



Inter-system interference

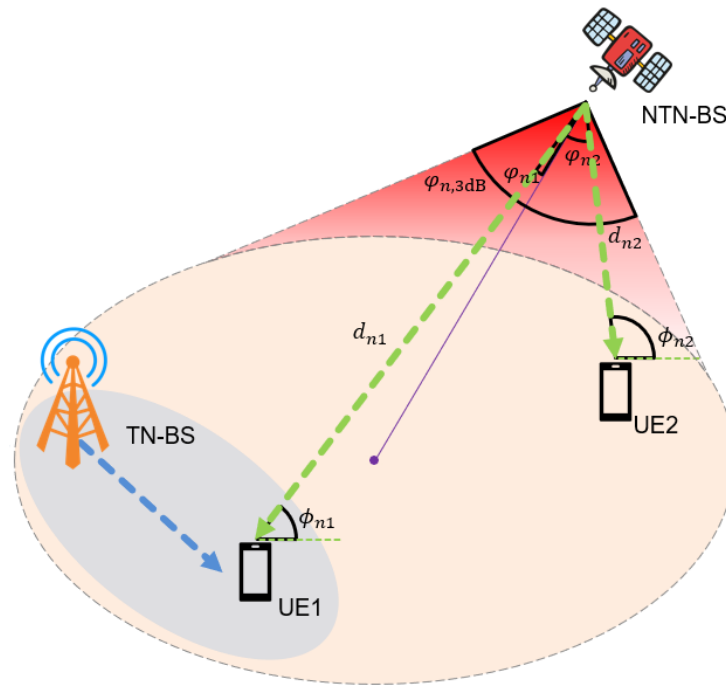


Inter-user interference

Interference mitigation technologies in ISTN

Interference type	Interference mitigation schemes	Related works
Inter-beam interference	Beamforming design	[3,5]
	FFR-based precoding	[2,8,9]
	Frame-based user scheduling	[8,9]
Inter-user interference	Downlink NOMA transmission	[4,5]
	Multicast transmission	[6,8,9]
	Downlink MIMO transmission	[7]
Inter-system interference	Joint precoding and resource allocation	[3,9]
	Joint beamforming and power allocation	[5,7]
	Cooperative multicast transmission	[10,11]

In next presentation...



Non-orthogonal multiple access

ISI Mitigation

Coordinated multiple point

References

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Thank you
