XG Mobile Promotion Forum

6G Radio Technology Project Repeater, metasurface, and RIS/IRS WG

September 30, 2025

Construction of White Paper

- Title: Repeater, Metasurface, and RIS/IRS
  - Sec.1: Introduction
  - Sec.2: Use cases and scenarios
  - Sec.3: Technology trend survey
  - Sec.4: Standardization survey
  - Sec.5: Recent activities in Japan
  - Sec.6: Summary

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Section II
Use cases and scenarios

II. Use case and Scenario

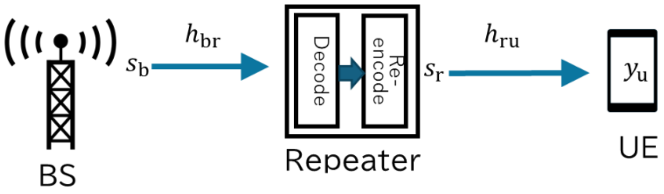
Outline of use cases and scenarios concerning to repeater, metasurfaces, and IRS/RIS

Table of Contents

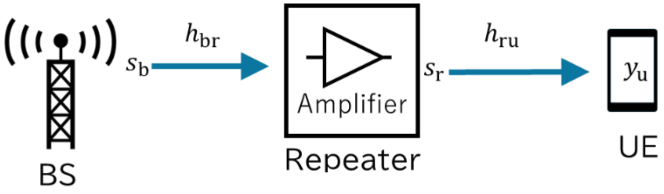
Repeater Operating mode

- **Decode and forward :**
  - It decodes the received signal to remove noise and re-encodes and forwards to the destination.
  - Compared to amplify-and-forward relaying, it effectively prevents degradation in wireless signal quality.
- **Amplify and forward :**
  - It directly amplifies the received signal and forwards to the destination.
  - Compared to decode-and-forward relaying, it features a simpler circuit design and achieves lower latency.
- **Beamforming :**
  - The signal strength along the relay path can be improved.
  - It is applicable to both decode-and-forward and amplify-and-forward relaying schemes.

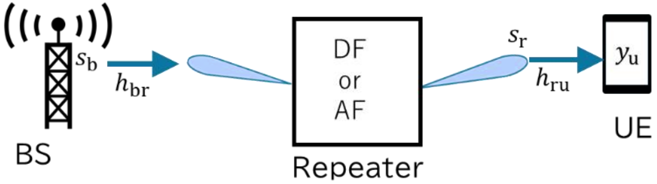
Decode and forward



Amplify and forward



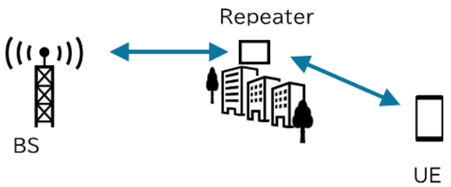
Beamforming



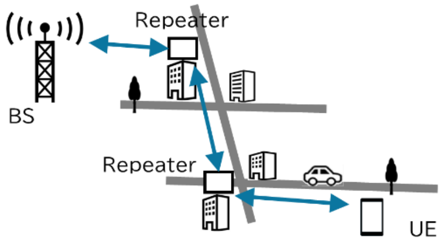
Repeater Use case（1）

- Coverage enhancement
  - To mitigate signal attenuation due to obstructions such as buildings, a repeater enables coverage extension.
  - Multi hop relaying is supported by incorporating multiple repeaters.

Single hop

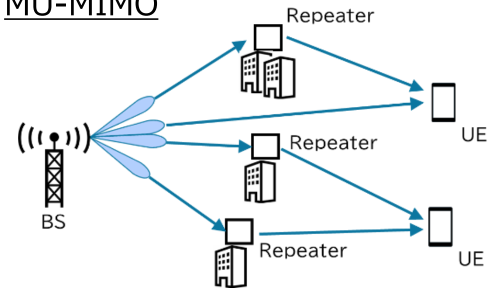


Multi hop

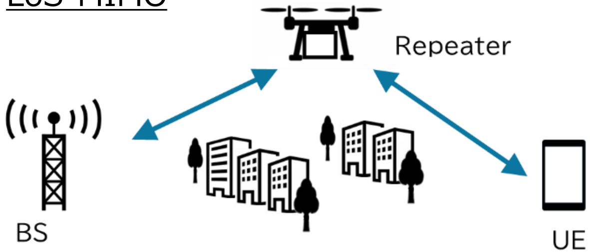


- MIMO
  - Spatial multiplexing is achieved through amplify-and-forward relaying
    - By deploying many repeaters and adaptively selecting them based on channel quality, MU-MIMO and SU-MIMO can be adopted.
  - Line-of-sight MIMO (LoS-MIMO) is realized by asymmetrically arranged antenna elements.
    - When a repeater is mounted on a drone or other mobile platforms, the system can maintain a high spatial multiplexing gain even as the distance between the repeater and the base station varies.

MU-MIMO



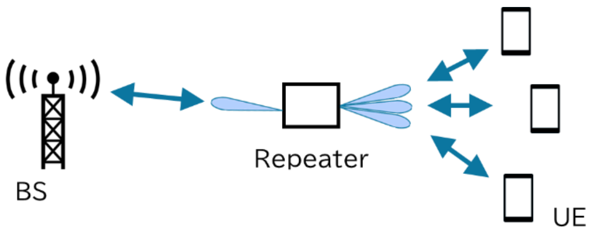
LoS-MIMO



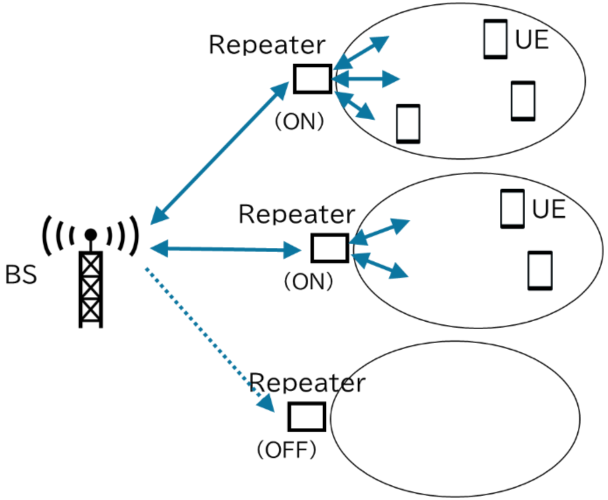
Repeater Use case （2）

- **AMC**
  - Compared to scenarios without repeaters, it ensures sufficient wireless signal quality, enabling the use of higher-order adaptive modulation schemes and thereby improving spectral efficiency.
- **Beamforming**
  - Adaptive beamforming based on wireless channel quality enables coverage extension and interference reduction.
- **Reliability**
  - By deploying many repeaters, multiple redundant communication paths are established, allowing users to maintain connectivity through diverse routing options.
- **Energy efficiency**
  - Energy efficiency can be improved by implementing ON/OFF control, which deactivates repeaters when they are not required.

Beamforming

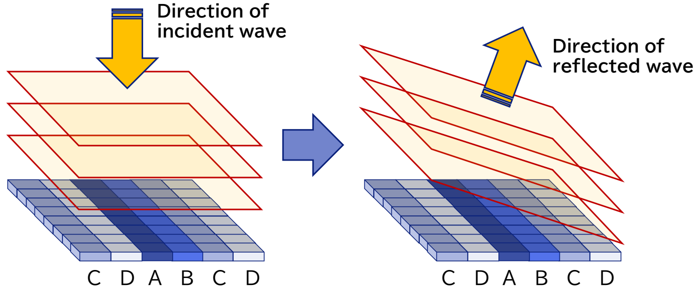


Energy efficiency



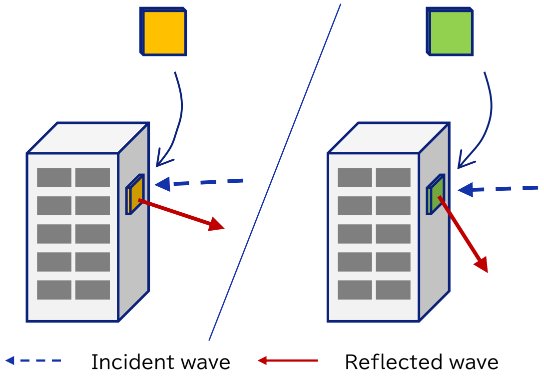
Overview of Metasurface and RIS/IRS

- The devices that control the direction of propagation of electromagnetic waves by reflection or refraction (or transmission) is called Metasurface or RIS/IRS.
- Multiple elements (meta-atoms) arranged within the device plane control the reflected wavefront (or transmitted wavefront) by having appropriate reflection phases (or transmission phases) each .



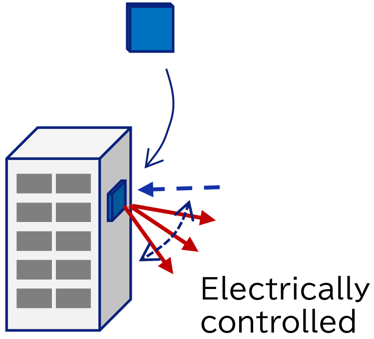
<u>Metasurface</u>

-Multiple elements arranged within the device plane control the reflected direction (or transmitted direction)



<u>RIS/IRS</u>

-Reflection(transmission) characteristics can be changed using electrical means

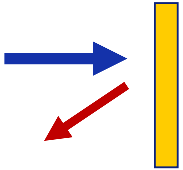


IRS（Intelligent Reflecting Surface）、
RIS（Reconfigurable Intelligent Surface）

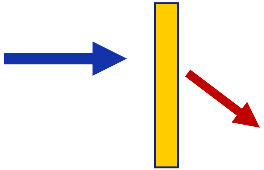
Metasurface and RIS/IRS Operating mode

● Passive
- Reflection mode
- Refraction mode
  (Transmission mode)
- Absorption mode
- Omni Surface/STAR-RIS

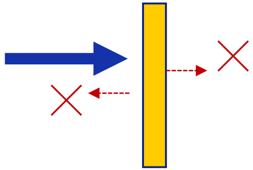
Reflection mode



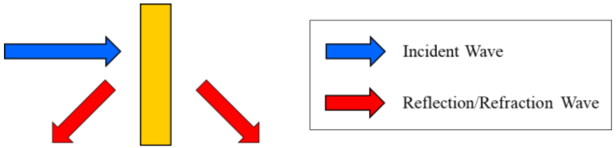
Reflaction mode



Absorption mode

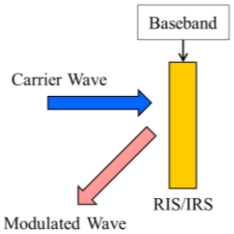


Omni Surface / STAR-RIS

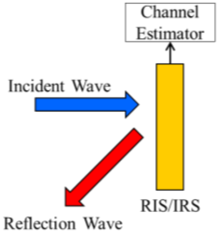


● Active and hybrid※
- Transmitting
- Receiving
- Transceiver

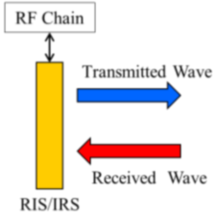
Transmitter mode



Receiver mode



Transceiver mode

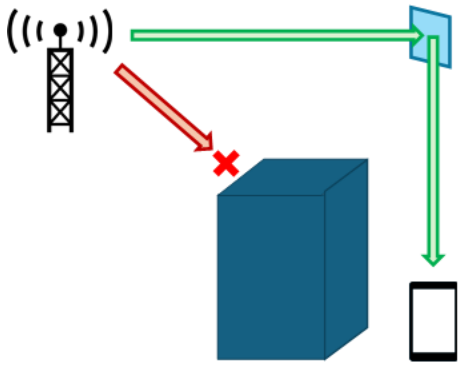


*In this white paper, RIS/IRS with elements having amplification functions are classified as active, while those with only some elements having amplification functions are classified as hybrid.

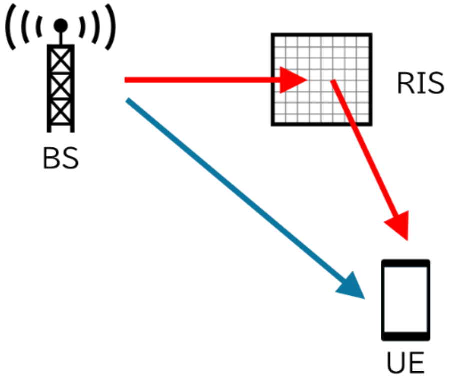
Metasurface and IRS/RIS Use case(1)

- Coverage enhancement
  - By placing a reflector at a position where both the transmitting and receiving antennas have LOS (Line-of-Sight), a propagation path that avoids attenuation due to the obstacle can be established.
- MIMO
  - By introducing RIS, multipaths arriving from various angles can be added to the channel, and the number of spatial multiplexing can be increased.
- Beam Manipulation
  - Beam manipulation is a fundamental capability of RIS technology, enabling precise control over the direction, shape, and focus of electromagnetic waves.

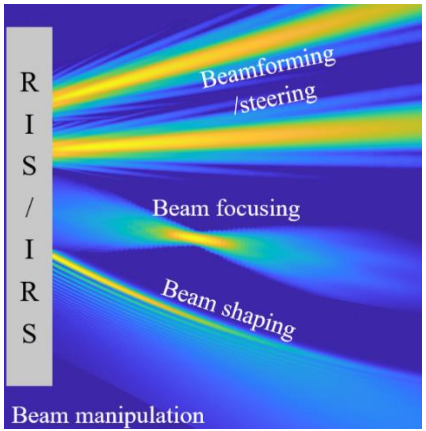
Coverage enhancement



MIMO



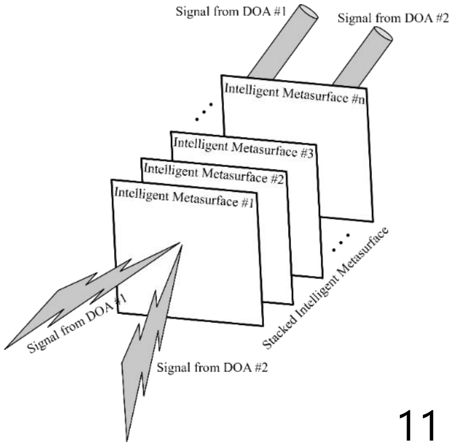
Beam Manipulation



Metasurface and IRS/RIS Use case(2)

- Reliability
  - By implementing metasurface and IRS/RIS technologies, even in the event of temporary obstructions, alternative paths can be established, thereby enhancing the reliability of wireless communication.
- Physical layer security
  - Due to uncontrollable propagation characteristics in wireless communication, this increases the risks of leakage of confidential signals to eavesdroppers. By using RIS to control the reflection direction of confidential signals to secure space, the risks of the leakage can be reduced to enhance the physical security.
- Sensing capabilities
  - RIS can provide artificial LOS (Line-of-Sight) links, the sensing capabilities will be enhanced by collaborating these technologies and sensing systems.
- Energy efficiency
  - By utilizing passive RIS, which does not include any amplifier, the coverage can be enhanced with low power consumption compared to other relay node such as wireless repeater.
  - RIS can control the direction of electromagnetic (EM) waves, it has capabilities to enhance wireless power transfer efficiency of the NLOS links between transmitter and energy harvesting devices.
- Link management
  - RIS can be deployed inside or inter racks of servers in a data center. RIS controls links between servers with millimeter wave or Terahertz to alleviate the cabling cost and decrease the connection complexity.
- Wave domain Processing
  - Wave Domain Processing enables direct manipulation of electromagnetic waves at the wavefront level, which provides real-time control over wave properties, reducing latency and improving system performance.
  - One major advancement in Wave Domain Processing is the use of Stacked Intelligent Metasurfaces(SIMs). These multi-layered metasurfaces enable independent wave control across different layers, allowing for beamforming, interference suppression, and signal enhancement at the wavefront level.
  - Direction of Arrival (DOA) estimation can be effectively performed using SIMs. By leveraging 2D Discrete Fourier Transform (DFT) operations in the wave domain, SIMs archive faster and more accurate DOA estimation than convectional methods.

Wave domain processing of Direction of Arrival (DOA) estimation using SIMs.



Operating environment and deployment scenarios

- Operating environment
  - Indoor :
    - Such as corridors, corners, and staircases.
  - Outdoor :
    - Solutions for signal obstruction caused by buildings and trees, particularly requiring fast beam tracking for vehicles like cars and trains.
  - Hybrid :
    - To address the issue of outdoor base station signals attenuating when penetrating indoors through walls and windows, installing repeaters or metasurface and IRS/RIS near exterior walls and windows can improve indoor coverage.

- Deployment scenarios
  - Static :
    - Similar to base stations, these can be installed on rooftops or streetlights
  - Nomadic :
    - Mounted on UAVs or vehicles to temporarily address obstructions or provide coverage at event venues

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Section III
Technology trend survey

Outline of Technology Trend

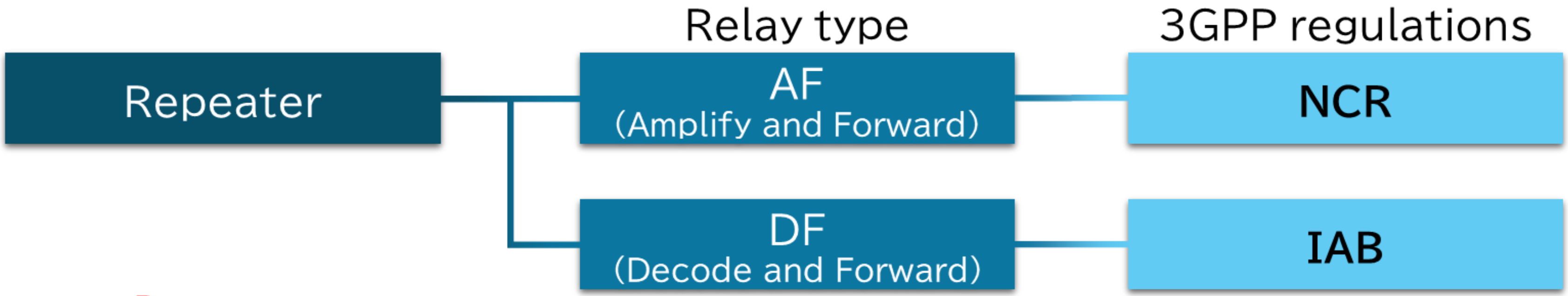
1. Category Classification of Repeater, Metasurface, and RIS/IRS

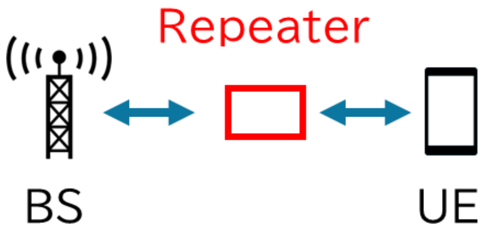
2. Technology Trend Observed in Recent Papers and Articles

3. Individual Technology Trends
   - Repeater
   - Metasurface
   - RIS/IRS

Category Classification of Repeater

- Repeaters are broadly classified into AF (Amplify-and-Forward) and DF (Decode-and-Forward) methods.
- Standardization is currently being promoted within the 3GPP under two key categories: NCR and IAB.





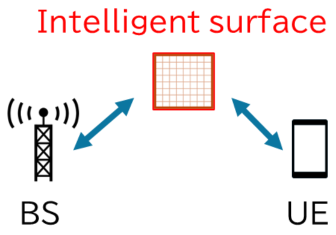
NCR: Network Controlled Repeater
IAB: Integrated Access and Backhaul

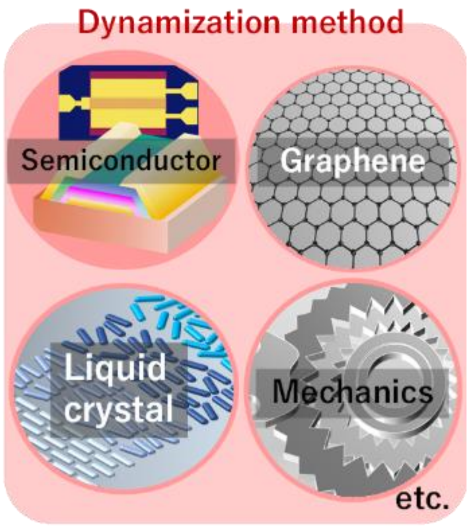
Relay type	Details	Noise reduction	Latency	Complexity
AF	Amplification	×	Good	Good
DF	Decode	○	Bad	Bad

Category Classification of Metasurface, RIS/IRS

- The main components of RIS/IRS are diodes, liquid crystal, mechanical, and graphene.
- Merasureface components are classified into flexible materials and others.

	Surface type	Structure/Materials
Intelligent surface	RIS/IRS	Diode (pin, varactor)
		Liquid crystal
		MEMS
		Graphene/Others
	Metasurface	Flexible (film, sheet, etc.)
		Rigid (FR4, glass, etc.)





RIS: Reconfigurable Intelligent Surface
IRS: Intelligent Reflecting Surface
MEMS: Micro Electro Mechanical Systems

Ref: Repeater's latest papers and articles

- Repeater-related papers and articles from 2010 onwards organized by frequency.
- For details, see the 6G Radio Technology Project White Paper.

Type	Frequency	
AF	Up to 24GHz	[III.3-23][III.3-39]
	24 to 100GHz	[III.3-26][III.3-29][III.3-31][III.3-37][III.3-40][III.3-41][III.3-47][III.3-50][III.3-51][III.3-53][III.3-54][III.3-57][III.3-86][III.3-89]
	Above 100GHz	
	NA	[III.3-30][III.3-34][III.3-42][III.3-46][III.3-55][III.3-68][III.3-75][III.3-76][III.3-81][III.3-83]
DF	Up to 24GHz	[III.3-78][III.3-84]
	24 to 100GHz	[III.3-66]
	Above 100GHz	
	NA	[III.3-34][III.3-43][III.3-49][III.3-58][III.3-59][III.3-60][III.3-63][III.3-71][III.3-72][III.3-79][III.3-80][III.3-82]
NCR	Up to 24GHz	[III.3-91]
	24 to 100GHz	[III.3-1][III.3-2][III.3-3][III.3-4][III.3-5][III.3-11][III.3-22][III.3-27][III.3-28][III.3-38][III.3-87][III.3-88][III.3-90]
	Above 100GHz	
	NA	[III.3-6][III.3-7][III.3-21][III.3-24][III.3-25]
IAB	Up to 24GHz	
	24 to 100GHz	[III.3-3][III.3-4][III.3-5][III.3-15][III.3-16][III.3-17][III.3-28][III.3-32][III.3-35][III.3-36][III.3-45][III.3-48][III.3-52][III.3-56][III.3-65][III.3-67][III.3-69][III.3-70][III.3-74][III.3-90]
	Above 100GHz	[III.3-33][III.3-36][III.3-77]
	NA	[III.3-6][III.3-12][III.3-14][III.3-18][III.3-19][III.3-20][III.3-25][III.3-44][III.3-61][III.3-62][III.3-64][III.3-73][III.3-85]
Others	Up to 24GHz	
	24 to 100GHz	[III.3-8]
	Above 100GHz	
	NA	[III.3-9][III.3-10][III.3-13]

Ref: Metasurface's and RIS/IRS's latest papers and articles

- Metasurface, RIS/IRS related papers and articles from 2010 onwards organized by frequency.
- For details, see the 6G Radio Technology Project White Paper.

Type	Frequency	
Metasurface	Up to 24GHz	[III.3-96][III.3-104][III.3-106][III.3-118][III.3-127][III.3-128][III.3-130][III.3-132][III.3-133][III.3-134]
	24 to 100GHz	[III.3-94][III.3-100][III.3-101][III.3-103][III.3-108][III.3-109][III.3-110][III.3-111][III.3-112][III.3-113][III.3-114][III.3-116][III.3-117][III.3-119][III.3-121][III.3-122][III.3-123][III.3-131]
	Above 100GHz	[III.3-92][III.3-95][III.3-102][III.3-115][III.3-124][III.3-125][III.3-126][III.3-129]
	NA	[III.3-93][III.3-97][III.3-98][III.3-99][III.3-105][III.3-107][III.3-120]
RIS/IRS	Up to 24GHz	[III.3-138][III.3-145][III.3-147][III.3-149][III.3-153][III.3-154][III.3-168][III.3-169][III.3-170][III.3-175][III.3-176][III.3-177][III.3-184][III.3-186][III.3-189][III.3-193][III.3-194][III.3-195][III.3-196][III.3-198][III.3-201][III.3-202][III.3-208][III.3-209][III.3-210][III.3-211][III.3-212][III.3-218][III.3-223][III.3-224][III.3-225][III.3-226][III.3-227][III.3-228]
	24 to 100GHz	[III.3-135][III.3-136][III.3-137][III.3-140][III.3-141][III.3-150][III.3-151][III.3-152][III.3-155][III.3-156][III.3-157][III.3-158][III.3-159][III.3-160][III.3-161][III.3-162][III.3-163][III.3-164][III.3-165][III.3-172][III.3-173][III.3-174][III.3-178][III.3-179][III.3-180][III.3-181][III.3-182][III.3-183][III.3-185][III.3-187][III.3-188][III.3-190][III.3-191][III.3-192][III.3-216][III.3-217][III.3-221]
	Above 100GHz	[III.3-139][III.3-142][III.3-143][III.3-144][III.3-146][III.3-148][III.3-171][III.3-197][III.3-204][III.3-205][III.3-206][III.3-207][III.3-213][III.3-214][III.3-215][III.3-219][III.3-220][III.3-229]
	NA	[III.3-166][III.3-167][III.3-199][III.3-200][III.3-203]

* LC: Yellow
* Diode: Green
* Graphene: Light Blue
* MEMS: Pink
* Others or Simulation: White

Relationship with Use Cases

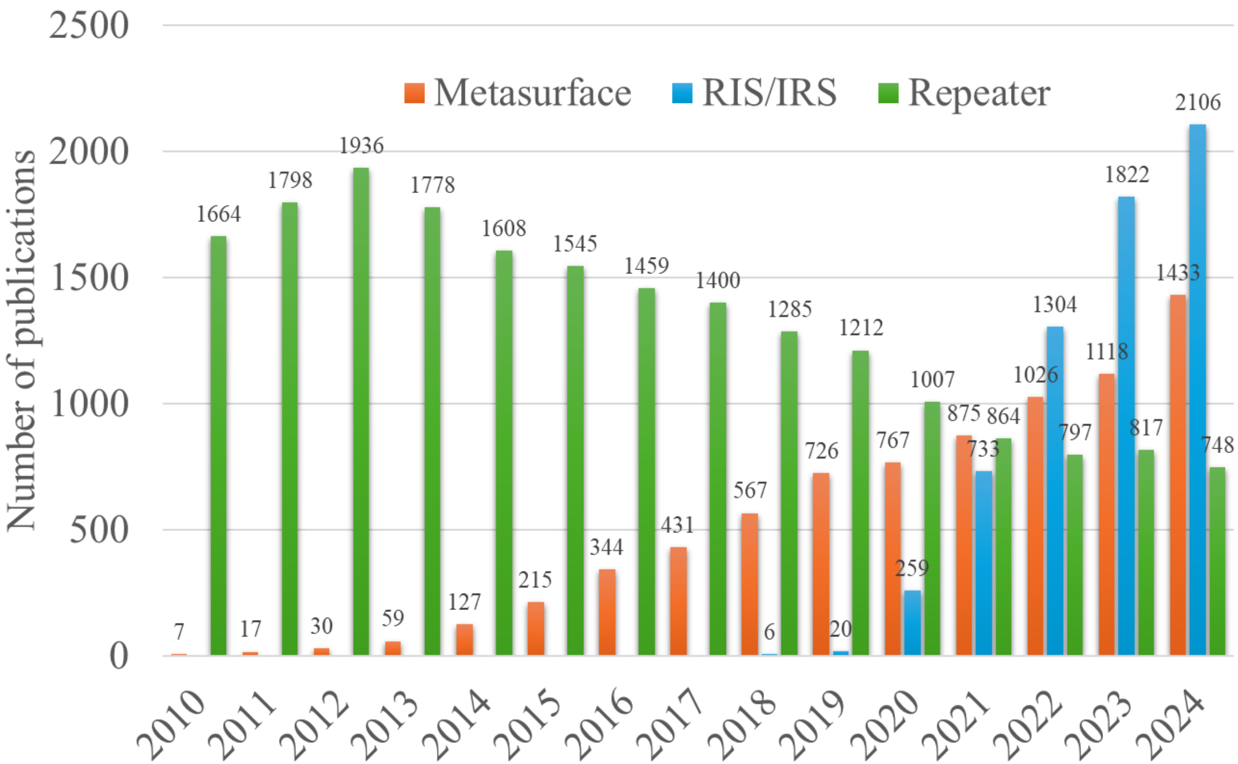
- Research and development of "Repeater" and "RIS/IRS" is being carried out for various use cases.
- "Metasurface" is dominated by research and development into coverage expansion.

Category	Use case		
Repeater	Coverage enhancement	Single hop	23
		Multi hop	12
	Spectral efficiency	MIMO	6
		AMC	9
		Reliability	11
	Others	-	10
Metasurface	Coverage enhancement	-	41
	Spectral efficiency	MIMO	0
		Beam Manipulation	0
	Others	Reliability	0
		Physical layer security	0
		Sensing capabilities	0
		Energy efficiency	1
		Link management	0
		Wave domain processing	0
		Others	1

Category	Use case		
RIS/IRS	Coverage enhancement	-	21
	Spectral efficiency	MIMO	6
		Beam Manipulation	13
	Others	Reliability	4
		Physical layer security	3
		Sensing capabilities	2
		Energy efficiency	1
		Link management	3
		Wave domain processing	20
		Others	21

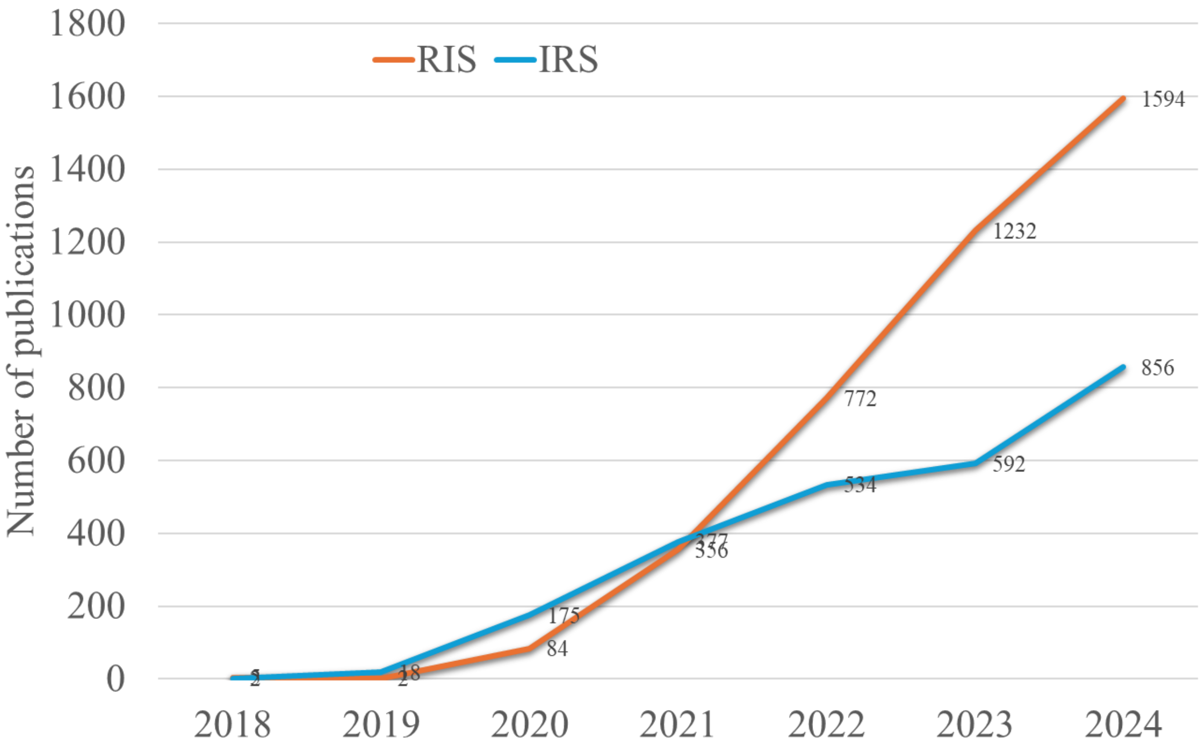
Changes in the number of publications

- Extracted papers with each keyword in the title from papers published in IEEE Xplore since 2010.
- Repeater is on the decline, while RIS/IRS and Metasurface are increasing rapidly.



RIS? IRS?

- The number of publication papers in RIS is about twice that of IRS, but both terms are used.

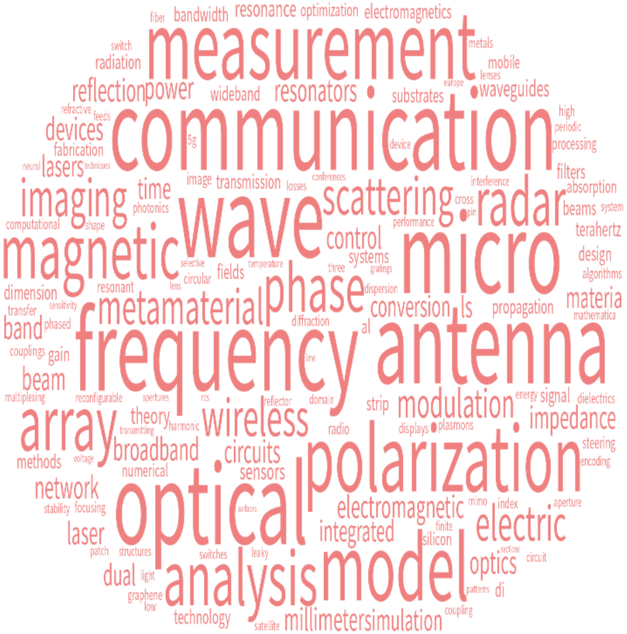


Related technical terms for relay technology

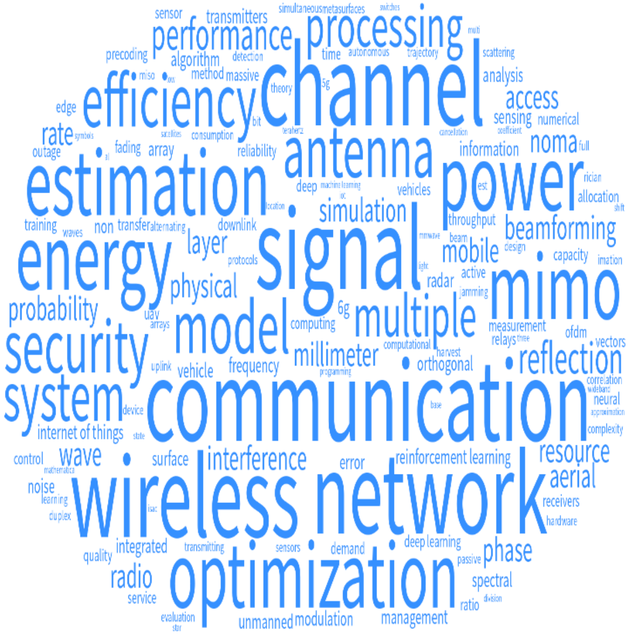
- Count the technical words registered on IEEE Xplore in the extracted papers.
- Visualize based on frequency of occurrence (depends on font size).

Repeater

Metasuface



RIS/IRS



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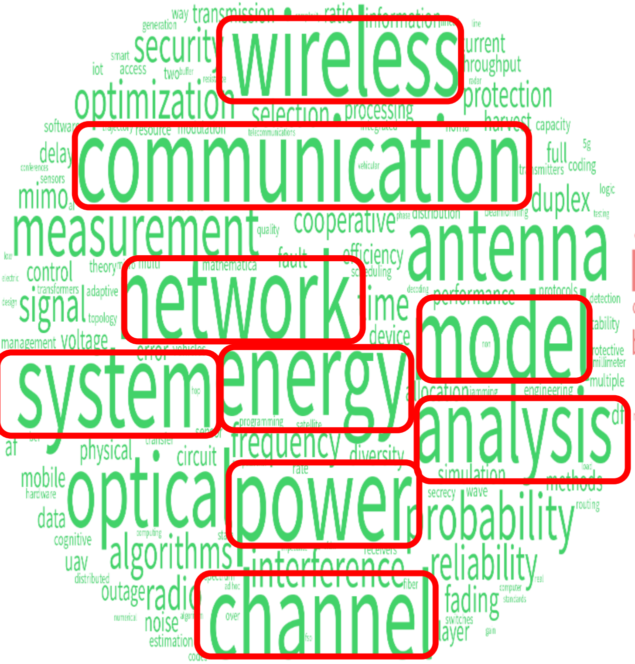
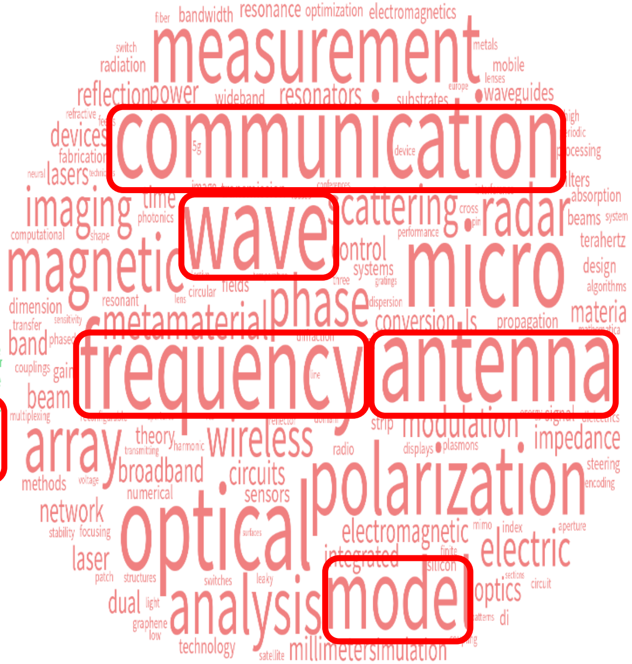
Key technical terms

- Technical terms that describe wireless communication (such as "wireless" and "communication") are common

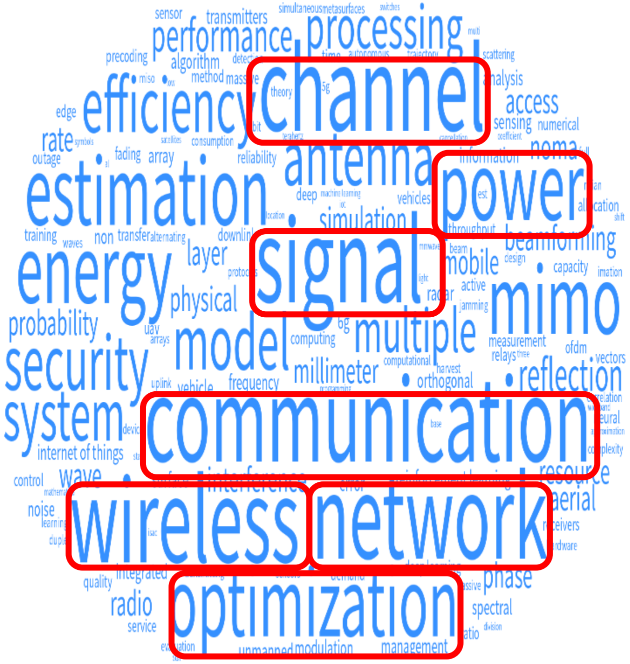
Repeater



Metasuface

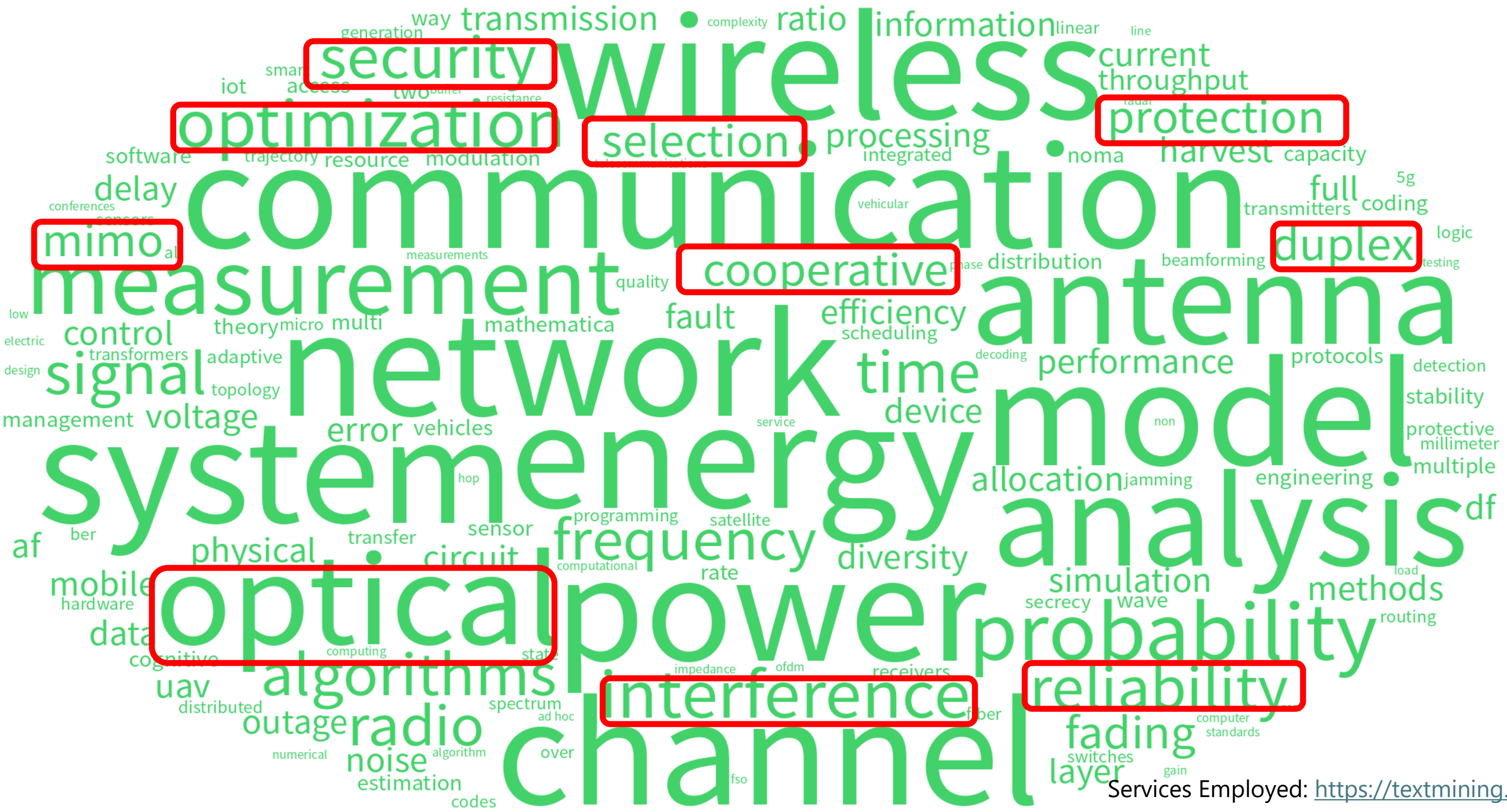


RIS/IRS



Individual technical terms ~Repeater~

- There is a tendency for higher-layer technical words to be more prevalent than lower-layer technical words.



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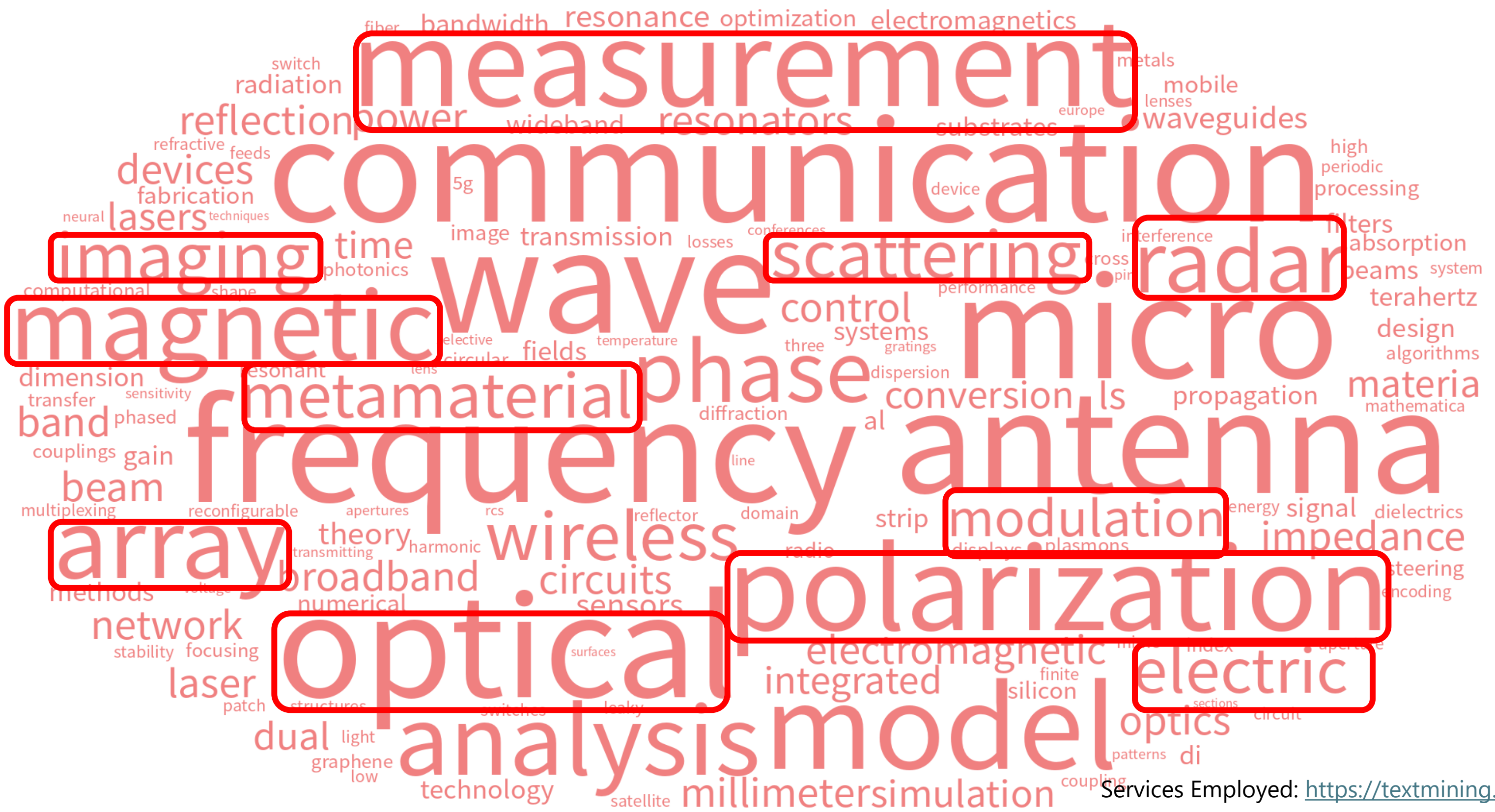
Individual technical terms ~Metasurface~

- There is a tendency for many technical terms related to the elements and use cases that make up Metasurface.



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Individual technical terms ~RIS/IRS~

- In addition to the main technical terms, there tends to be a wide variety of technical terms.

Outline of Technology Trend

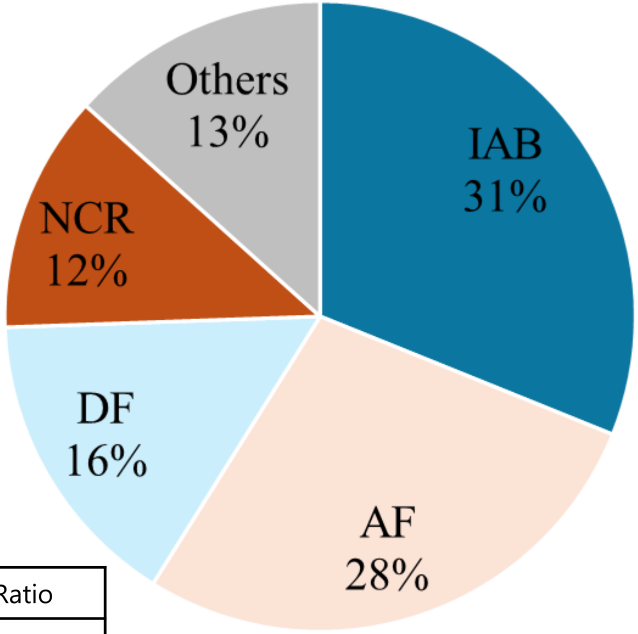
1. Category Classification of Repeater, Metasurface, and RIS/IRS

2. Technology Trend Observed in Recent Papers and Articles

3. Individual Technology Trends
   - Repeater
   - Metasurface
   - RIS/IRS

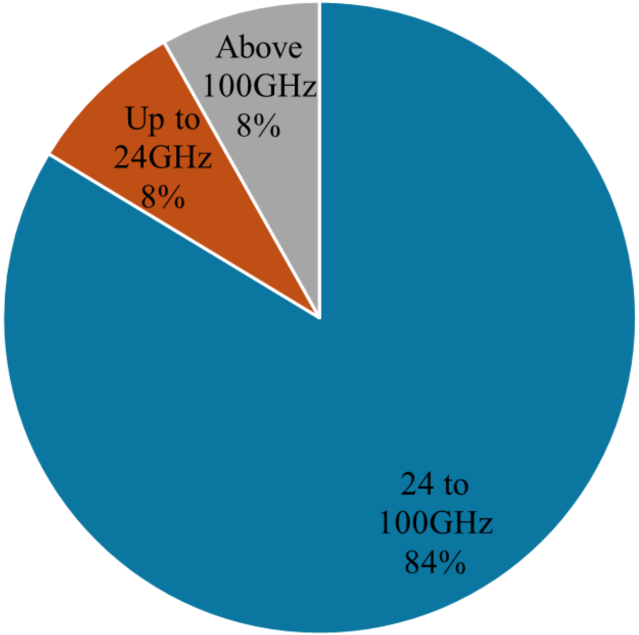
Individual Technology Trends of Repeater

- There is no significant difference in the number of papers on AF (including NCR) and DF (including IAB).
- Most of the papers are on frequencies above 24GHz.



Relay type	Ratio
AF(NCR)	43%
DF(IAB)	44%

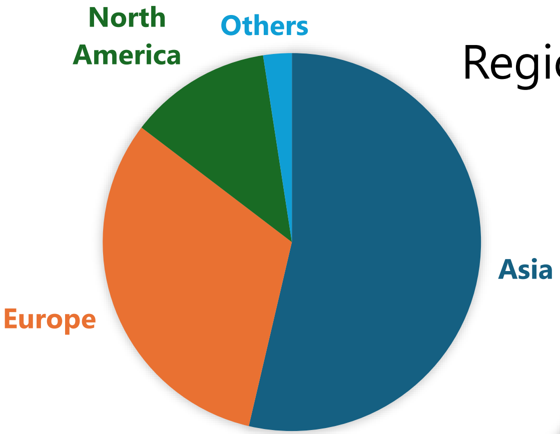
Technical category



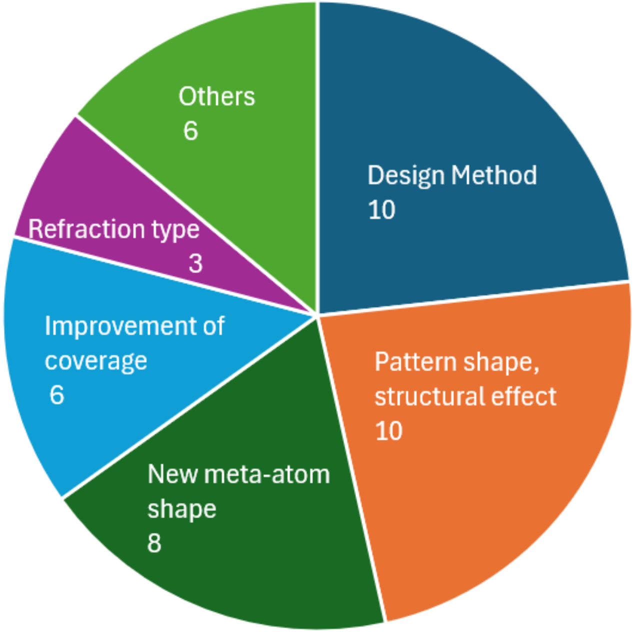
Frequency category

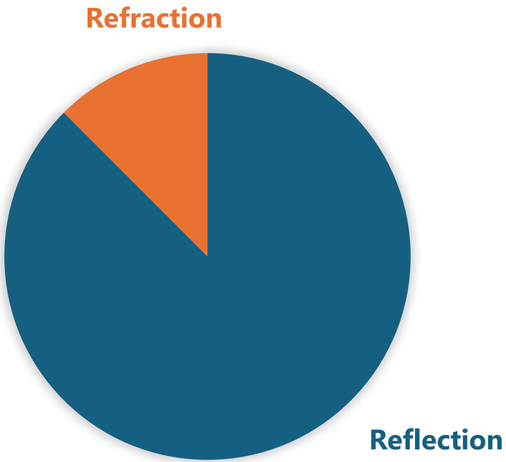
Individual Technology Trends of Metasurface

- 80% of the papers are from Asia and Europe, and studies of reflection are more popular than refraction.
- The majority of papers are about structures.



Regional publication



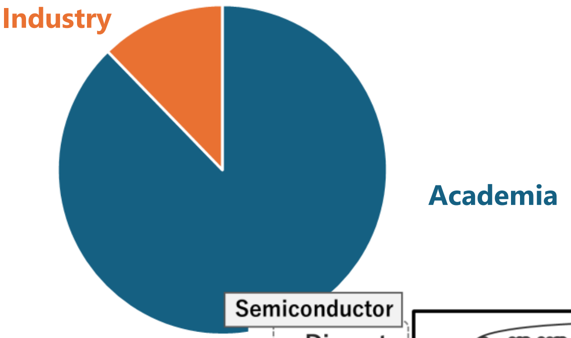


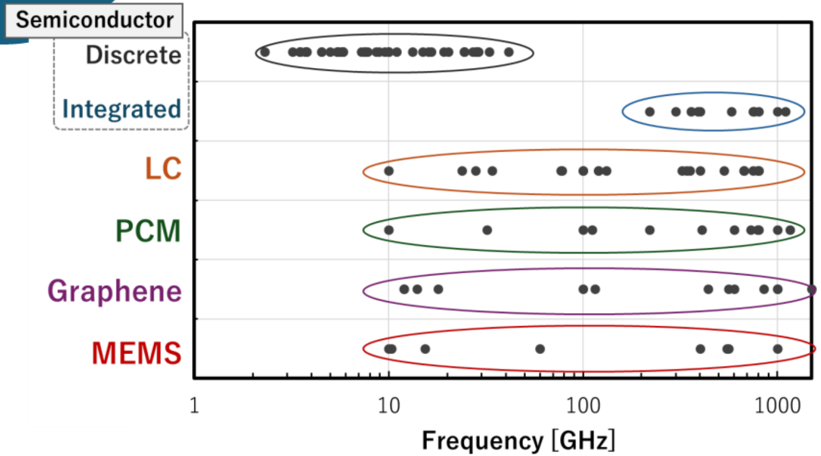
Technical category

Research Area

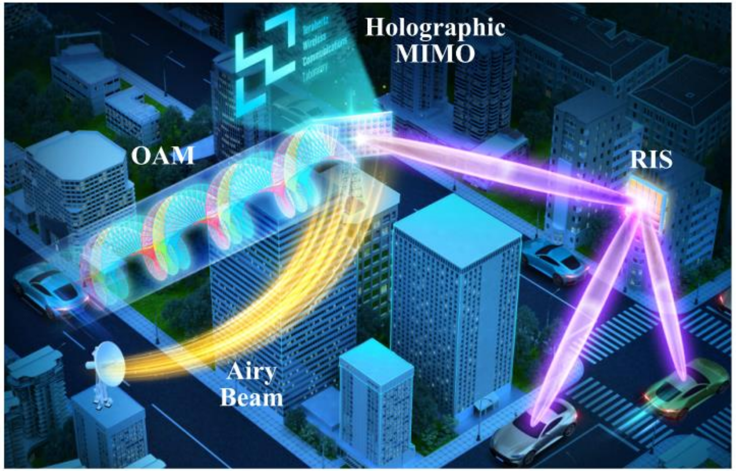
Individual Technology Trends of RIS/IRS

- The majority of papers are from academia rather than from companies. Various structures are being considered.
- RIS/IRS considerations shift from "structure" to "beam manipulation"





Beam Manipulation



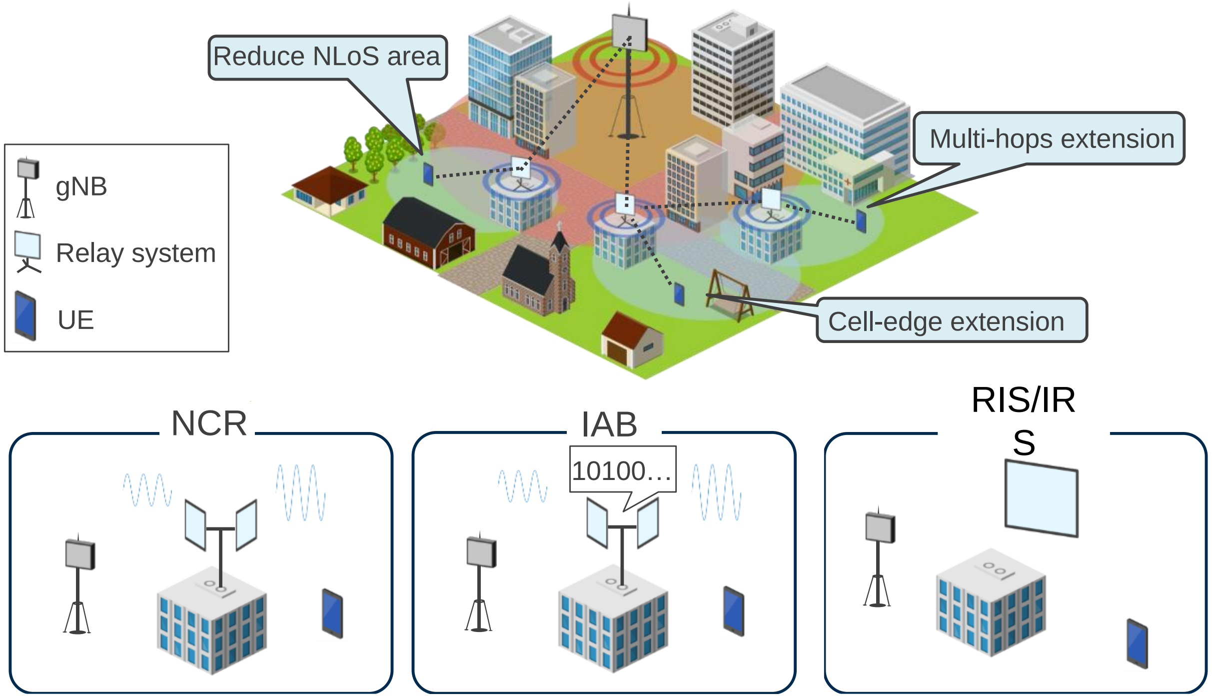
Li, Mingxiang, et al. "Beam Manipulation for Terahertz Communications: A New Quality Productive Force." *arXiv preprint arXiv:2503.22158* (2025).

Section IV
Standardization survey

Overview of Standardization Trends

Explain the standardization trends in wireless relay and reflector technology.

Mainly, focusing on the discussion and standardization in 3GPP, ETSI, IEEE.



Standardization Trends of NCR

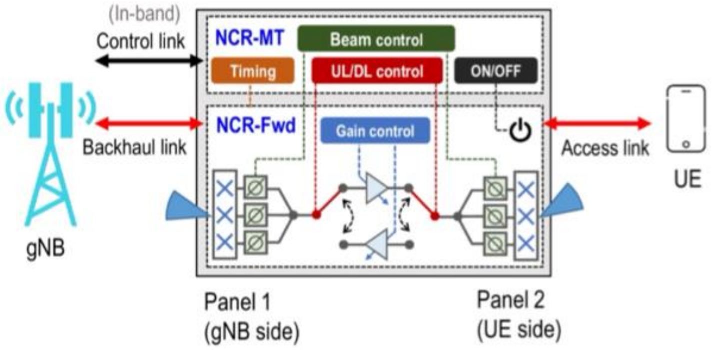
- NCR (Network-Controlled Repeater)
  - ✓ Extend coverage by non-regenerative relaying of analog signal from base station
  - ✓ Discussions have been started from 3GPP Release 17, and TS began in 3GPP Release 19 38106. Trends for 38.806 are summarized in the table below.

Item	Release 17	Release 18	Release 19
Target	RF Repeaters (Type 1-C, 2-O)	RF Repeaters (Type 1-C, 2-O)	NCR added (Type 1-H, 2-O)
Feature Enhancements	Basic RF characteristics defined	Some minor enhancements and clarifications	New functions for NCR: Beam Control, TDD Timing Control, ON-OFF Control, and Mobility Management
Scope	FR1/FR2 repeaters	FR1/FR2 repeaters	Enhanced operations for FR2 (millimeter-wave) networks
New Concepts	None	None	New nodes like NCR-MT (Mobile Terminal) and NCR-Fwd (Forward Node) introduced
Structural Difference	Focused on basic transmission/reception specs	Same structure with slight additions	Network-interaction specifications such as SCI, beam management, timing adjustment, and dynamic activation
Specification Expansion	RF performance focus	RF performance with minor supplements	Detailed NCR behaviors including link monitoring, re-establishment, Timing Advance control, etc.

Detailed NCR Standardization Trends

The functional specifications standardized in 3GPP Release 18 are summarized.

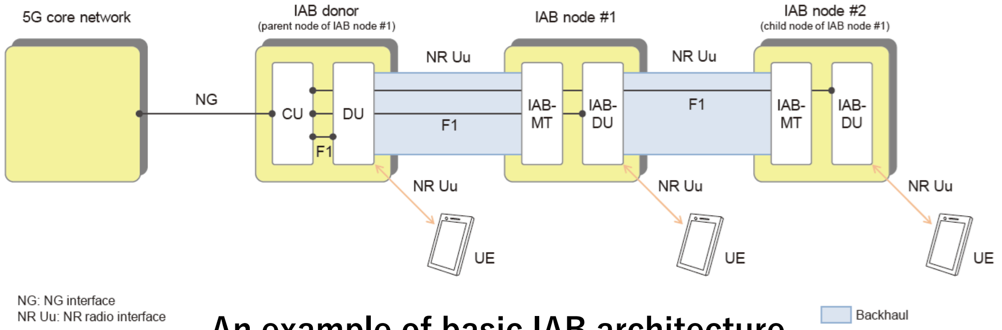
- **Gain Control (Side Control Information):**
  Information used to control NCR operation, aiming to suppress noise and improve directionality.
- **Beam Control:**
  Dynamic control of transmit/receive beams in response to user movement and channel variations.
- **Timing and UL/DL Control:**
  Properly controls the timing of uplink/downlink communication and TDD settings.
- **ON-OFF Control:**
  Interference suppression and power saving by switching NCR on/off according to usage conditions.



Basic configuration in NCR

Standardization Trends of IAB

- IAB (Integrated Access Backhaul):
  - ✓ Integrating wireless access and backhaul to enable efficient data communication
- Standardization is mainly being conducted in 3GPP Releases 16, 17, and 18
  - ✓ Rel-16: fundamental architecture of IAB has been proposed, emphasizing the importance of end-to-end (E2E) connectivity and core network (CN) management
  - ✓ Rel-17: functionalities of multi-hop communication and QoS (Quality of Service) management have been enhanced, and new IAB nodes have been introduced
  - ✓ Rel-18: (Currently in progress) integration of AI and automation technologies is making network management efficient. Improving energy efficiency and enhancing security are important themes



An example of basic IAB architecture

Detailed IAB Standardization Trends

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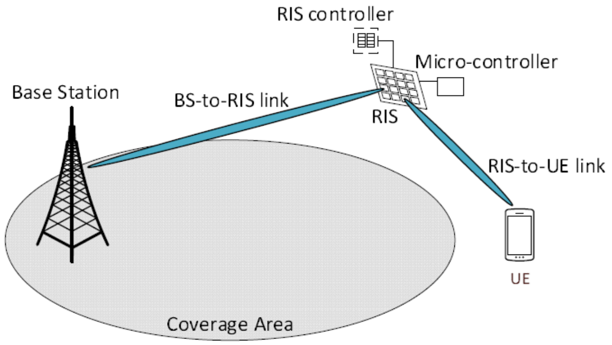
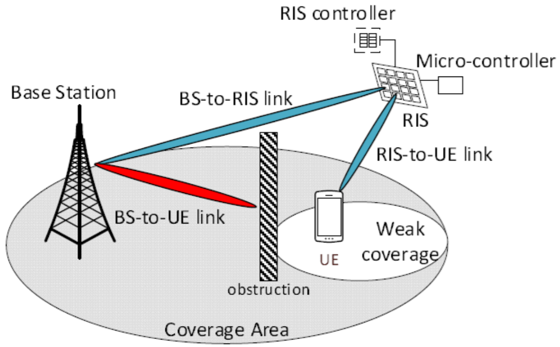
- Rel-16:
  - ✓ Aimed at optimizing data communication between remote RAN and CN
  - ✓ IAB nodes integrate the functionalities of wireless access and backhaul
  - ✓ Supports various types of wireless interfaces
  - ✓ Deployment is envisioned in areas where new infrastructure cannot be built or where rapid deployment is required. It also allows for flexible responses to temporary increases in demand
- Rel-17:
  - ✓ More flexible connections between different types of IAB nodes
  - ✓ Multi-hop communication that allows data to be transmitted through multiple nodes
  - ✓ Enhanced architecture, advanced management features, and security requirements
  - ✓ Enables network deployments suitable for various use cases

Detailed RIS/IRS Standardization Trends

- ESTI ISG RIS published three Group Report (GR).
  - ✓ ETSI GR RIS 001 V1.1.1 (2023-04) Reconfigurable Intelligent Surfaces (RIS); Use Cases, Deployment Scenarios and Requirements
  - ✓ ETSI GR RIS 002 V1.1.1 (2023-08) Reconfigurable Intelligent Surfaces (RIS); Technological challenges, architecture and impact on standardization
  - ✓ ETSI GR RIS 003 V1.1.1 (2023-06) Reconfigurable Intelligent Surfaces (RIS); Communication Models, Channel Models, Channel Estimation and Evaluation Methodology



(a) coverage hole in an outdoor scenario



(b) weak coverage that can happen in both outdoor and indoor scenarios

Example of scenario of RIS-integrated network for coverage enhancement [7].

Topics to be discussed about RIS/IRS

- For developing specifications of specific wireless communication networks incorporating RIS/IRS, several topics will be discussed in detail. Possible discussion topics are as follows.
  - ✓ Use cases of RIS/IRS: Does RIS/IRS need to change its beam direction according to the position or movement of UE(s). (Is tracking of UE(s) necessary?)
  - ✓ Configurations of RIS/IRS: Do we need to specify the number, size and arrangement of RIS/IRS elements?
  - ✓ How to indicate the beam shape: Do we indicate the weight of each RIS/IRS element or codebook index of RIS weights?

Summary

Standardization status of NCR, IAB, and RIS/IRS

	NCR	IAB	RIS/IRS
Use Case / Deployment Scenario	Supported [1]	Supported [5]	Discussed [7, 8]
Channel Model	Discussed [2]	Discussed [2]	Discussed [9]
Control/Signaling	Supported and Discussed [1, 3, 4]	Supported [6]	Discussed [7]
Interference Management	Not Yet	Not yet	Not yet

Supported: Specified items in TS.
Discussed: Described items in other documents.

Reference List

[1]. 3GPP, “NR Repeater Radio Transmission and Reception,” 3rd Generation Partnership Project (3GPP), TS 38.806, Mar. 2025, v. 19.0.0. [Online]. Available: (visited on 04/28/2025)

[2] 3GPP, “Study on channel model for frequencies from 0.5 to 100 GHz,” 3rd Generation Partnership Project (3GPP), TR 38.901, Mar. 2022, v.17.0.0. [Online]. Available: http://www.3gpp.org/DynaReport/38901.htm (visited on 09/26/2017).

[3] 3GPP TR 38.867 V18.0.0, “Study on NR network-controlled repeaters,” September 2022.

[4] 3GPP TR 38.867 V1.0.0, “Study on NR Network-Controlled Repeaters,” September 2022.

[5] 3GPP TS 38.300, “NR; NR and NG-RAN Overall description: Stage 2,” Dec. 2024.

[6] 3GPP TS 38.174, “NR; Integrated Access and Backhaul (IAB) radio transmission and reception,” Dec. 2024.

[7] ETSI GR RIS 002 V1.1.1, “Reconfigurable Intelligent Surfaces (RIS); technological challenges, architecture and impact on standardization,” August 2023.

[8] ETSI GR RIS 001 V1.1.1, “Reconfigurable Intelligent Surfaces (RIS); Use Cases, Deployment Scenarios and Requirements,” April 2023.

[9] Qualcomm Incorporated, Xiaomi, "Rel-19 Views on Additional Topology Enhancements," 3GPP TSG RAN Meeting #102 RP-233021, Dec. 2023. [Online]. Available: https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_102/Docs (visited on 09/26/2017).

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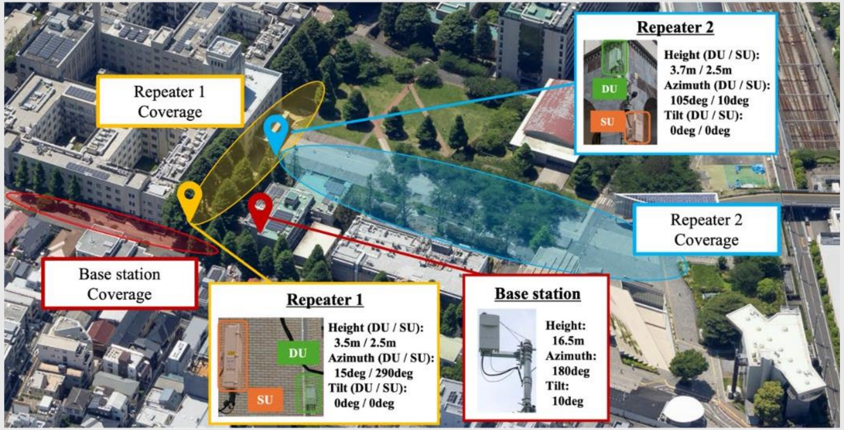
Section IV
Recent activities in Japan

Repeater, metasurface, and RIS/IRS Working Group

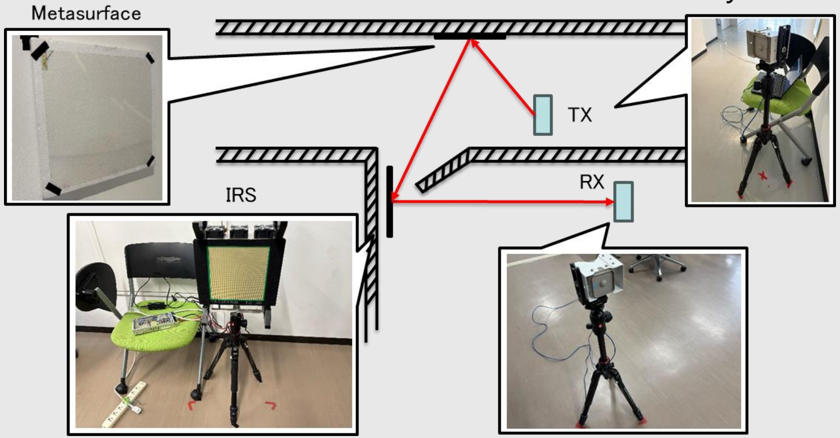
- **Organization of WG**
  - Chair: K. Sakaguchi (Science Tokyo), Vice chair: Yuichi Kawamoto (Tohoku Univ.)
  - 40 Members
- **Objectives of WG**
  - Engage in discussions regarding domestic and international technological trends, standardization activities related to repeater, metasurface, and RIS/IRS as well as use cases and scenarios of practical application.
  - Propose directions for repeater, metasurface, and RIS/IRS technologies toward 6G.

Various field experiments using repeater, metasaurface, and RIS/IRS are studied.

Network Deployment of 5G mmWave Base Station and Repeater at Ookayama Campus of Science Tokyo



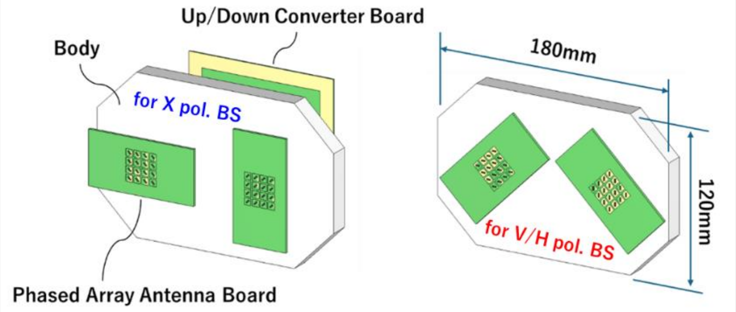
Field Experiments using 60GHz mmWave with IRS and Metasurface at Tohoku Uinversity.



Repeater, metasurface, and RIS/IRS Working Group

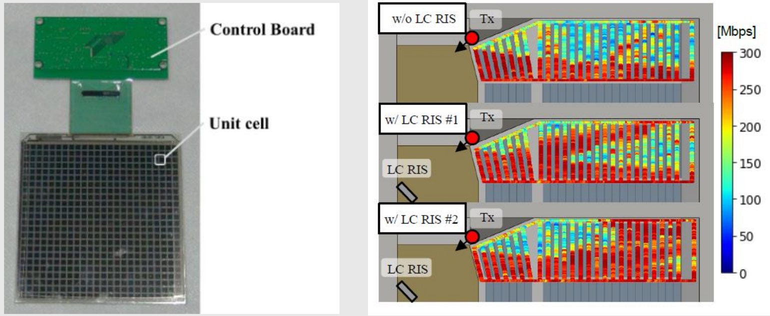
Recent activities regarding Repeater, metasurface, and RIS/IRS in Japan.

Phased array antenna system for proposed repeater system.



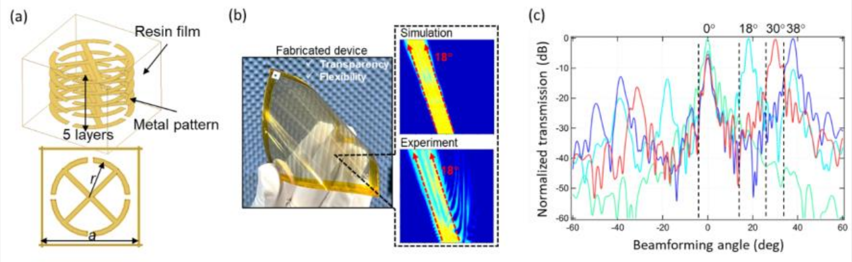
DKK Co., Ltd.

Liquid Crystal Reconfigurable Intelligent Surface.



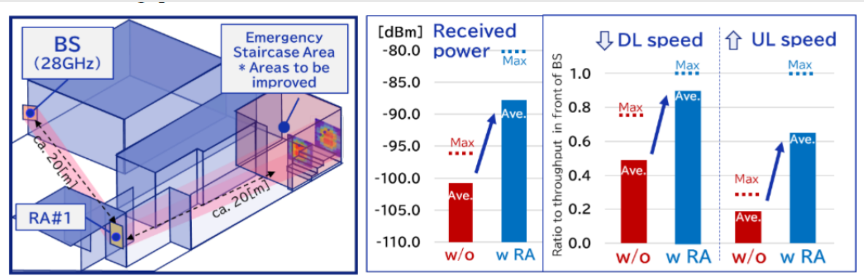
KDDI Research Inc.

(a) Multilayer metamaterial cell for 2π controllability.
(b) Fabricated gradient metasurface and beamforming results.
(c) Far-field results for gradient metasurfaces.



NTT Corporation

Verification of Reflectarray for millimeter waves in the Local 5G Open Lab.



Dai Nippon Printing Co., Ltd.