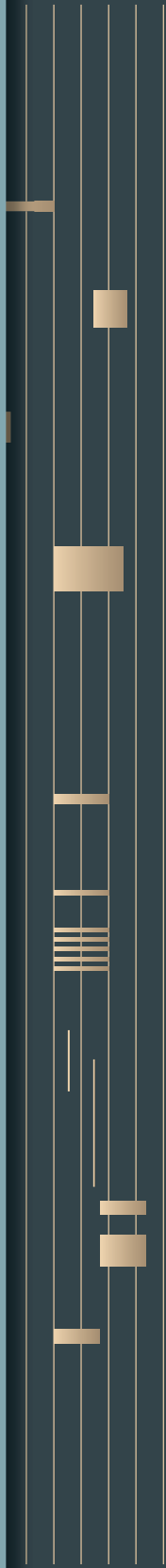
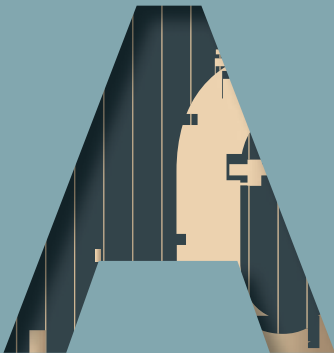


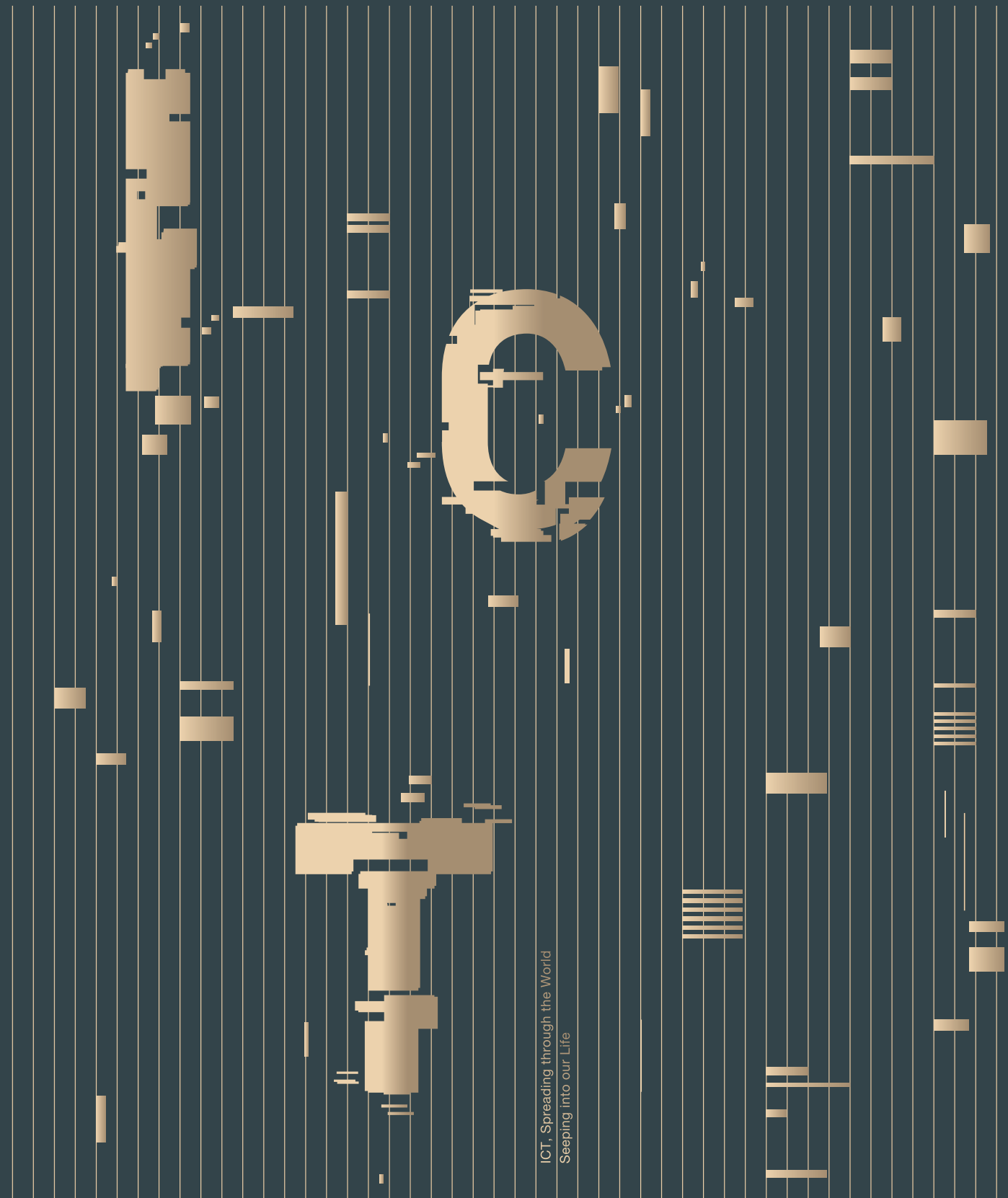
With ETRI,

Imagination

Begets Reality



# ICT



ICT, Spreading through the World  
Sleeping into our Life

National AI Research Institute



*x*+AI

## Groundbreaking ICT Innovator

### Smart life and Enjoy a new life

The 4th Industrial Revolution is starting from our daily lives  
It penetrates deep.

ETRI, a national comprehensive research institute that is creating a  
future society, A more comfortable everyday life for mankind through  
digital transformation, We strive to provide a happy tomorrow.

Moving beyond creating new values to the future  
ETRI's steps never stop.





$x+AI$

## Intelligentize the industry, Advance the future

The changes brought about by the 4th Industrial Revolution are already with us. The IoT technology that we dreamed of became a smart factory, Autonomous driving that accelerates freedom of movement has come to our side 5G connecting things and people has become our daily life.

Beyond technological innovation, the future of mankind  
ETRI's challenge to open does not stop.

## ETRI's ICT Innovation Trailblazes Onward



# President Message

Today, we are living in the age of a great revolution called the 4th Industrial Revolution. This revolution is sometimes also referred to as the “Age of Digital Transformation” or the “2nd Period of the Information Age.” Regardless of the term used, the key enabling technology is ICT. Collectively called ABCI, Artificial Intelligence(A), Big Data(B), Cloud computing(C), and Internet of Things(I) are all ICT.

Therefore, we at ETRI are aware of the immense responsibility because our organization presides over all ICT research and development efforts sponsored by the national government. As a tool of innovation, ICT is not only intellectualizing the structure of industries from manufacturing to defense, medical care, culture, education, and agriculture/livestock/fishing industries but will enhance the individual lives of people in safe, convenient ways. The approximately 2,260 employees of ETRI are diligently and strongly devoted to carrying out research to realize this national calling.

ETRI plans to acquire global technological competitiveness through further intellectualization of information technology and contribute to the innovative growth of the country. At the same time, based on ICT, we will contribute to the creation of a safe social environment that people can trust with peace of mind. We also wish to help build a nation that overflows with the spirit of caring through the development of “people-friendly” ICT that could be used in creating a people-oriented digital society.

ETRI is continuously committing its resources to R&D efforts that could lead to a better future, a safer environment, and a comfortable life. We will become a research institute beloved by the public, trusted by the government, and acknowledged by our customers.

We would appreciate your encouragement and advice in helping ETRI go beyond Korea to the rest of the whole world. Inspired by public expectations, we shall respond by becoming a national research institute that can lead the future of humanity and the country through collaborations with domestic and international experts. We intend to become a smart partner of the Korean people.

Thank you.

President of ETRI *Kim, Myung-Joon*

“  
To position Korea as a first-rate nation for AI technology, we shall focus on R&D of ICT and strive to see through the creation of ten world-class research groups within the oncoming decade.



1976

1976.12.30.

KERTI established

Established for electric research and testing

KIET established

Established for semi-conductors and computers

1976.12.31.

KECRI was founded as an affiliate of KIST

Established for R&D in telecommunications technology

Established KERTI, KIET and KECRI, the origins of ETRI

Dec. 30, 1976 : KIET(Korea Institute of Electronics Technology)was established

Dec. 30, 1976 : KERTI(Korea Electric Research and Testing Institute)was established

Dec. 31, 1976 : KECRI(Korea Electronics & Communi-cations Research Institute) was founded as an affiliate of KIST



1977.12.10.

KTRI established

KECRI became independent from KIST and KTRI was established on Dec 31, 1976 as a research institute specialized in telecommunications

Dec. 10, 1977 : Independent from KIST and renamed itself as KTRI



1980

1981.01.20.

KETRI established

(consolidation of KTRI and KERTI)

Established KETRI

Jan. 20, 1981 : KETRI(Korea Electrotechnology and Telecommunications Research Institute) was established in consolidation of KTRI and KERTI



1985.03.26.

ETRI established

ETRI Institute specialized in information and telecommunications(consolidation of KIET and KETRI)

Established ETRI

March 26, 1985 : ETRI, institute specialized in Information and Telecommunications was established(consolidation of KIET and KETRI) to meet with the emphasize on electronics field



1990

1996.01.01.

SERI transferred to ETRI

SERI, data process department of KIST, transferred to ETRI as an affiliate

Data process department of KIST transferred to ETRI as an affiliate

June 27, 1967 : SERI(Systems Engineering Research Institute) was opened as data process department of KIST. In accordance with, government restructuring of the Ministry of Science and Technology to the Ministry of Information and Communication SERI became affiliate of ETRI on January 1, 1996.

May 25, 1998 : Incorporated into ETRI



1997.01.31.

ETRI

ETRI's Korean name changed

ETRI's Korean name changed

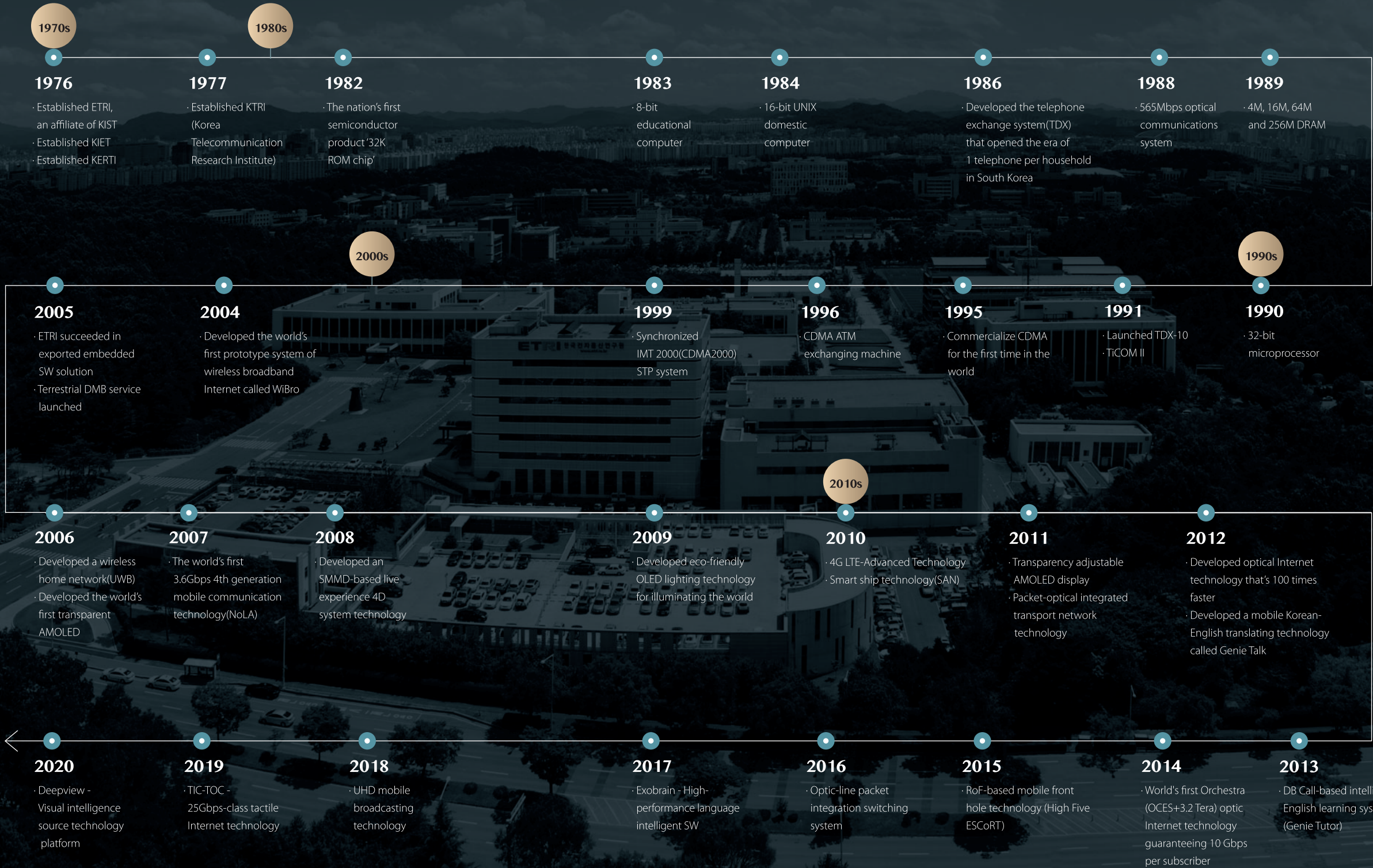
Jan. 31, 1997 : Based on regulations for electronics and telecommunications





R&D Major Achievement

**ETRI** makes contribution to the nation's economic and social development through research, development and distribution of industrial core technologies in the field of Information, Communications, Electronics, Broadcasting and Convergence technologies.





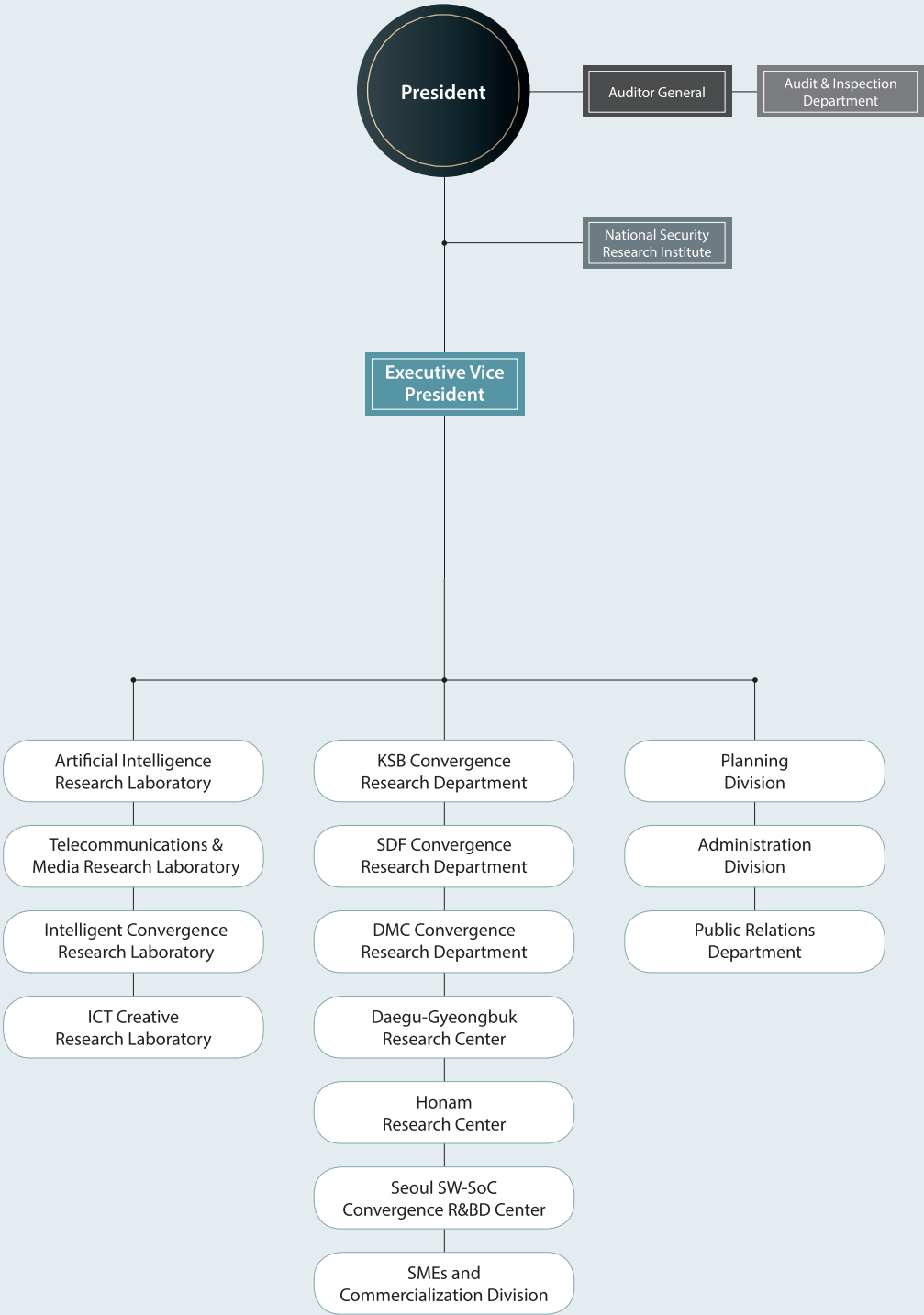
Vision



Management Principle



Organization



# Part 1

## The Main R&D Field

20	Artificial Intelligence Research Laboratory
30	Telecommunications & Media Research Laboratory
40	Intelligent Convergence Research Laboratory
50	ICT Creative Research Laboratory
60	KSB Convergence Research Department
62	SDF Convergence Research Department
64	Daegu-Gyeongbuk Research Center
66	Honam Research Center
68	Seoul SW-SoC Convergence R&BD Center
70	SMEs and Commercialization Division

# Artificial Intelligence Research Laboratory

The Artificial Intelligence Research Laboratory is conducting key research and development with a view to playing a pivotal role in ETRI's vision of becoming a 'National AI Research Institute'. It has established the strategic goal of laying the foundations for a super intelligent information society in which humans and artificial intelligence coexist harmoniously, and of realizing super-performance computing that overcomes the performance limitations of artificial intelligence.

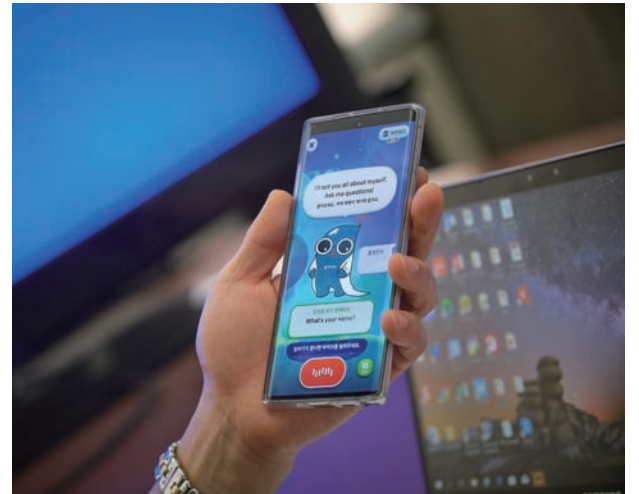
To achieve these goals, the Laboratory is developing key technologies such as complex AI, intelligent robots, autonomous unmanned vehicles, AI SoC, and AI supercomputers. It will pursue a hybrid R&D strategy encompassing core technology research and mission-based research, as well as enterprise support and the resolution of social problems. More than 450 researchers with masters and PhDs in the field of artificial intelligence and ICT are in charge of the core research and development, and are pursuing technological innovation through open R&D strategies, including joint research with universities and companies.



# Future-Oriented Talent Development through Cutting-Edge ICT

## Pilot Project for 'Technology in English Learning' for Public Elementary Schools Nationwide

If there were interactive AI that could understand human speech to the extent that it can conduct natural conversation with human beings, we could practice English speaking skills with computers. With the commercialization of such technology, it is not long before we can enjoy world-class AI-based education service technology without worrying about private education costs. Creative talented young people think for themselves, implement self-directed learning, and engage in proactive communication with others. Now is the time to help them grow with artificial intelligence.



Korean English learners generally face a number of restraints because they learn the language as an EFL (English as a Foreign Language). They have little or no opportunity to use English in their daily lives, which makes them uncomfortable in trying to speak English in particular.

In order to overcome such an obstacle involved with the EFL environment in Korea, English education experts in the country are paying attention to the technological progress that the 4th Industrial Revolution has made possible. Most notably, a chatbot designed to provide people with various communication experiences is emerging as a major educational engineering tool in the field of English education in Korea.

A chatbot which refers to a talking robot is a software application which can communicate with human users verbally and/or in written form. The most famous examples of chatbots are Siri on iPhones and Alexa developed by Amazon. They implement user requests while engaging in everyday conversation with users.

Compared to conversation with people, interaction with a chatbot has several advantages in foreign language learning. First, as a chatbot is free from time and space constraints, foreign language learners can chat with it anytime, anywhere. Thus a chatbot can be an easily accessible conversation path for EFL learners suffering from a shortage of opportunities to communicate in English.

In response to field complaints about the shortage, the Ministry of Education decided in 2019 to have an 'English speaking practice system' developed and distributed to elementary schools nationwide. The plan is designed to help bridge income gaps between regions in the country by providing equal opportunities for English study nationwide. Focus is placed on the regular English education starting

from the third grade of elementary school in Korea according to experts' opinion that elementary students' initial English learning experience impacts their learning motivation and academic achievements in their English class in middle and high schools.

Based on ETRI's technology, which secured AI-based education technology equal to or better than the world's best, the Ministry of Education has developed 'AI Feng Talk' and is launching a pilot service for major elementary schools this year, and official service will be provided to all elementary schools nationwide from 2021. Its major features include ▲ a natural two-way conversation on a given subject, ▲ high-accuracy speech recognition for non-native speakers, ▲ determination of fluency levels according to various presentation evaluation indicators, and ▲ correction of grammatical and expression errors.

Through the service, the ETRI plans to not only secure world-class AI-based education service technology but also contribute to solving social problems through the alleviation of private education tuitions burden, the resolution of the English gap, and the minimization of communication problems in multicultural families.

In the meantime, the ETRI has commercialized its English speaking practice service for major local institutions such as Visang, NCSOFT, EBS, NAVER (SNOW) and Samsung. The ETRI has also expanded its Korean language education service overseas including Vietnam, Thailand, and South America, among others. It is planning to achieve the commercialization of the service in 2020 in a bid to lay the foundation for the overseas expansion of the language service in full force.



## Create an All-Round Secretary Portrayed by SF Movies

### 'Exobrain,' a Natural Language In-Depth Response Technology

There was one thing as indispensable to our eternal hero 'Iron Man' as his suit. That was 'J.A.R.V.I.S,' his AI personal assistant. So many advances have been made in the area that the same features that J.A.R.V.I.S performed in SF movies are now available on smart phones. Still the current AI service is limited to a web search function to find documents or a response feature giving short answers. The 'Exobrain Project' designed for domestic researchers to overcome such technical limitations as one of the country's innovative growth engine projects has succeeded in commercializing cutting-edge AI technology in language learning. That in turn will enable the development of Korean-based AI services to gain momentum in areas such as AI assistance, Q/A in the natural language, intelligent search, and big data analysis.

Beyond the level of simple web search and short-answer response, such technological advances will make it possible for AI to answer questions in highly sophisticated sentences. The ETRI has already developed and commercialized relevant technology services such as the "In-depth Q/A Technology on General Knowledge" and the "In-depth Q/A Technology on Legal Knowledge."

The technologies go beyond web search based on word matches. Computers can now understand human language and infer correct answers to given questions.

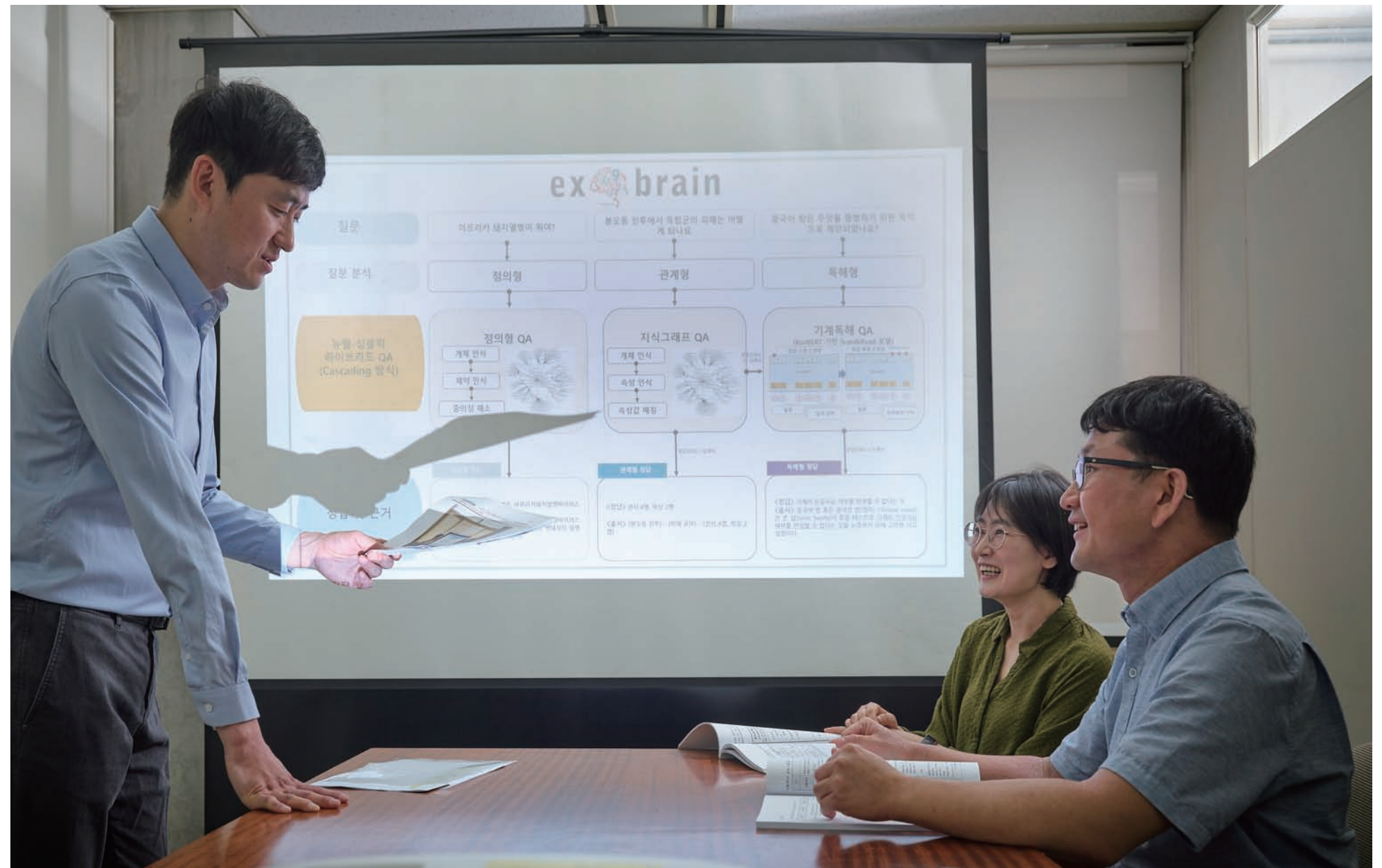
The local researchers have developed a neural-symbol hybrid Q/A technology tapping into the symbolic-based language understanding technology and the KorBERT deep learning (neural) language model technology and successfully applied it to general knowledge and legislation fields alike.

In the general knowledge field, Exobrain's Q/A technology identifies the question type by analyzing relevant Wikipedia contents and finds the correct answer by applying an optimized solution for each question type. It was installed as a knowledge search function in the latest 'Hancom Office 2020' released on September 10, 2019. Users can enter questions in the Hancom Knowledge Search while editing documents, obtain answers to them, and reflect them in their document editing. Hancom has announced that in the field of general knowledge, Exobrain has outperformed Google by more than 10%.

Exobrain's legislative Q/A technology enables a computer to fully understand local laws with many jargons and Sino-Korean vocabulary and come up with highly sophisticated narrative answers. With regards to the technology, the ETRI has successfully conducted trial tests together with National Assembly Library of Korea and the National Research Council of Science and Technology which are planning to adopt the relevant technological service by the end of 2020.

The researchers are planning to continue to develop the Exobrain technology so that users can have Q/A sessions with Exobrain through voice as well as text in a range of professional fields. The ETRI's efforts continue to make information and communications technology featured in science fiction movies a reality.

Following its win at the EBS Scholarship Quiz in 2016, Exobrain has earned 9.9 billion won in sales since 2017 from a total of 70 technology transfers and commercial projects. Recently, ETRI has succeeded in developing in-depth "question-answering technology" that enables Exobrain to give answers in not only words but also sentences. For example, if you ask Exobrain, "What is the regulated speed in child protection zones according to the 'Min-sik' Law," it answers, "It is 30 kilometers per hour." It adds, "The legal basis is the Road Traffic Act, Article 12: 'Designation and Management of Protection Areas for Children' in Chapter II: 'Ways of Pedestrians to Walk Roads.'"





## However Smart It Is, AI Becomes Useless If It Consumes Too Much Electricity?

### Power Efficient AI Processors

AlphaGo was the first computer to defeat the top-ranking professional human Go player Lee Se-dol in March 2016. AlphaGo's moves were determined based on a system capable of 30 trillion integer operations per second then. Behind the incredible computational power that beat a genius were backup servers with huge power consumption. Large capacity servers are equipped with AI semiconductor chips that can increase computers' arithmetic performance within limits from several factors including available power, therefore, it can be argued that the performance of AI semiconductors depends in large part on the power available for consumption. In March 2020, the ETRI developed an AI semiconductor that can perform 40 trillion operations per second while consuming less than one-third of the power required by other companies' semiconductors.



With the emergence of AI as a keyword in the 4th Industrial Revolution, competition is intensifying to develop technology that serves as the core brain. Central processing units (CPU, AP, etc.) were mainly used as the brains of computers and mobiles, but the semiconductors optimized for simple calculations demonstrated limitations in processing complex calculations such as deep learning.

Deep learning for artificial intelligence requires much larger computational intelligence. For example, a high level of computation is required to understand how an object moves in a place.

Local researchers succeeded in developing a chip called a neural processing unit (NPU) optimized for deep learning computation.

NPU is a semiconductor technology that reproduces and accelerates the process of human learning and reasoning, such as Google DeepMind Technologies' AlphaGo.

However, the key to the success of AI semiconductors is not their high computational capabilities. It is how little power they consume for their normal operations. To put it simply, we cannot apply an AI semiconductor to an autonomous vehicle if it consumes a lot of power and generates too much heat. However, researchers had a hard time developing a chip that could satisfy the needs of both power and heat with existing technologies.

To solve the problem, the ETRI has developed the NPU, which delivers high computing power consuming far less energy. It is like

killing two birds with one stone. The new semiconductor chip has a computing power of 40TFLOPS at 15W of power. Compared to existing commercial products, the chip has increased computational power per watt by 25 times while reducing power consumption by 20 times.

In addition, a single chip embedded in an autonomous vehicle is powerful enough for the vehicle to process all the camera images to identify pedestrians, traffic lanes, and traffic lights and perform perfectly in terms of both self-driving and safety controls.

The ETRI is planning to load the chip onto a board in various forms and expand its use to various AI-related service servers such as data centers. The chip is also expected to be used in AI speakers, autonomous vehicles, high-performance servers, telemedicine, financial services, and facial/behavior recognition. It is also expected to greatly contribute to localizing parts and creating value added in the area of deep learning.

Currently, AI that we tap in our daily lives has a simple reasoning ability required to answer simple questions like what the weather is like. The ETRI will continue to strive to develop new chips that would enable humans to engage in in-depth discussions about weather patterns and climate issues among others with a machine as they become capable of both reasoning and learning at the same time.







## Do You still Get an Endoscopy? Capsule Endoscopy is Far More Convenient!

### A HBC-based Capsule Endoscopy

Stomach cancer is the most common cancer in men (792 persons) and the 4th most common cancer in women (385 persons) according to a survey conducted among 100,000 men and women, respectively in Korea. The 2012 WHO report says that Korea ranks first in stomach cancer in the world and that Asia including China accounts for 60% of the global stomach cancer outbreaks. As such, the need is growing to commercialize the capsule endoscopy that lets doctors examine not only the small intestine but also the esophagus and the stomach. The development of capsule endoscopy based on HBC (human body communication) is expected to open the era of early cancer diagnosis.

We can now go through the esophagus and stomach endoscopies easily without fearing the pain associated with the procedures while agreeing to their necessity. It is thanks to a capsule developed by the ETRI's researchers. They use the HBC technology to transmit data using the human body as the medium.

The existing gastrointestinal endoscopic examination for upper gastrointestinal tract has disadvantages such as cross infection caused by reuse, foreign body sensation, abdominal discomfort due to air injection, and examinees' nausea or belching. Capsule endoscopy can eliminate such shortcomings.

Although there was a capsule endoscopy in the past, precise observation was difficult due to its slow shooting and image transmission speed. The ETRI's researchers developed a human body communication technology capable of transmitting 24 shots per second, which is 4 times faster than the previous one. Through the transfer of the cutting-edge technology, it has become possible to precisely observe sections like the esophagus which the capsule has to pass quickly. The checkup has become similar to watching a video.

To increase the speed required to transmit large-capacity image data created through high-speed shooting, ETRI scientists ▲ utilized the unique signal modulation method and ▲ the analog circuit technology tailored to human body channel characteristics.

They say that the system consists of ▲ the capsule endoscopy for upper gastrointestinal tract, ▲ the image analysis system for disease reading, and ▲ the terminal receiver for upper gastrointestinal tract.

The capsule is as small as 1x 3.1 centimeters. It functions as a transmitter equipped with an LED lamp, two front and rear cameras, a coin-type battery, and a magnet.

The image captured by the capsule is transmitted and stored in an external cell phone-sized receiver through an electrode or a belt type receiver attached to the body. The resolution is 320x320Pixel. The battery can last two hours.

Thanks to the system, doctors can control the capsule with a built-in magnet using a magnetic controller while viewing received images. Doctors can change the position and posture of the capsule. They can keep it on the stomach wall as long as they want to observe it as closely as possible.

The capsule endoscopy is expected to replace the wired endoscopy and help doctors improve their diagnostic accuracy. The ETRI's researchers are also planning to introduce the upper gastrointestinal tract capsule endoscopy in foreign countries like China and Arab countries with the highest incidence of gastrointestinal diseases and European countries including the United Kingdom with a high incidence of esophageal diseases.

They meanwhile plan to further develop the technology so that they can come up with technologies and products that can screen the entire digestive system, including the esophagus, stomach, duodenum, small intestine, and large intestine, through a single capsule endoscopy. The ETRI is opening the way for more accurate and comfortable examination of the human body.





# Telecommunications & Media Research Laboratory

The Telecommunications & Media Research Laboratory conducts research in three major fields: communication, media and contents, and radio-satellite, including 5G and Post 5G(5G +, 6G) mobile communication, which is an essential infrastructure of national growth, as well as hyper-realistic virtual broadcasting/digital contents for realizing everyday digitalization, and radio-satellite fields that are invisible but essential to the hyper-connectivity era.

In the communication sector there are the Future Mobile Communication Research Division and the Network Research Division. The former develops social issue solving technology with 5G, 5G convergence technology for other industries, and original technology for Post 5G, whereas the latter is developing an information/knowledge-based networking technology and an ultra-high-speed, ultra-wide band, ultra-low delay optical network technology.

In the media/contents sector there are the Media Research Division and the Creative Content Research Division. The former develops a hyper-realistic service technology that breaks the boundaries between virtuality-reality and the next-generation broadcasting media original-standard technologies. Meanwhile, the Creative Content Research Division develops digital contents technology for realizing human-centered digital life and next-generation content original technology for digital arts/technology.

In the radio-satellite sector, there are the Radio & Satellite Research Division and the Meteorological Satellite Ground Segment Development Department. The Radio & Satellite Research Division supports Korea's telecommunications policy through research on frequency, propagation environment analysis, and satellite communication and brasting. The Meteorological Satellite Ground Segment Development Department is developing a ground system that consists of an ensemble of facilities responsible for the acquisition, processing, and distribution, which is essential to enhancing the performance of meteorological satellites.

In the future, the Telecommunications & Media Research Laboratory will become a 「Global Technology Leader」 with world-beating competitiveness in the fields of communication, media-contents, and radio-satellite.



# Creation of a Hyper-connected Society Whose Impacts Citizens Can Feel

## MN(Moving Network) System

Wi-Fi is a short-range communication technology enabling people to use the wireless Internet using radio waves within a certain distance from where a wireless access device (AP) is installed. Korea has a particularly well-established public Wi-Fi infrastructure. It is easy to find Wi-Fi signals even on the street as well as in coffee shops, airports, schools, and public transportation. Recently Korea has succeeded in the test run of a Wi-Fi communication system for vehicles enabling city/express bus passengers to enjoy the internet 120 times faster than now, making significant progress in the country's public telecommunications infrastructure.

The better the public Wi-Fi infrastructure is established, the lower telecommunications prices become. The reason is that smartphone users can reduce their dependence on mobile carriers' expensive data plans when using their devices outside of their workplaces or homes.

If the Wi-Fi zone expands, consumers are more likely to connect to Wi-Fi, rather than going through carriers' LTE wireless networks, in public places such as parks, welfare facilities, cultural and tourism facilities, public institutions, traditional markets, bus stops, and plazas, as well as major streets.

As an ICT powerhouse, Korea boasts high quality of its existing public Wi-Fi service. As of the end of 2018, its public Wi-Fi download and upload speed was 354.07Mbps and 360.90 Mbps, respectively, ahead of the country's commercial Wi-Fi speeds.

Recently the ETRI's researchers have developed a vehicular communication system that is 120 times faster than the Wi-Fi system installed on public buses. LTE technology is being used for the country's public Wi-Fi service available on buses. However, since only a part of the LTE communication frequency is used for public Wi-Fi service, the Wi-Fi speed in the bus is rather slow, around 20 Mbps. The actual speed further decreases when there are a lot of passengers or you want to enjoy large-capacity contents there.

To address the issue, the ETRI's researchers have developed a backhaul

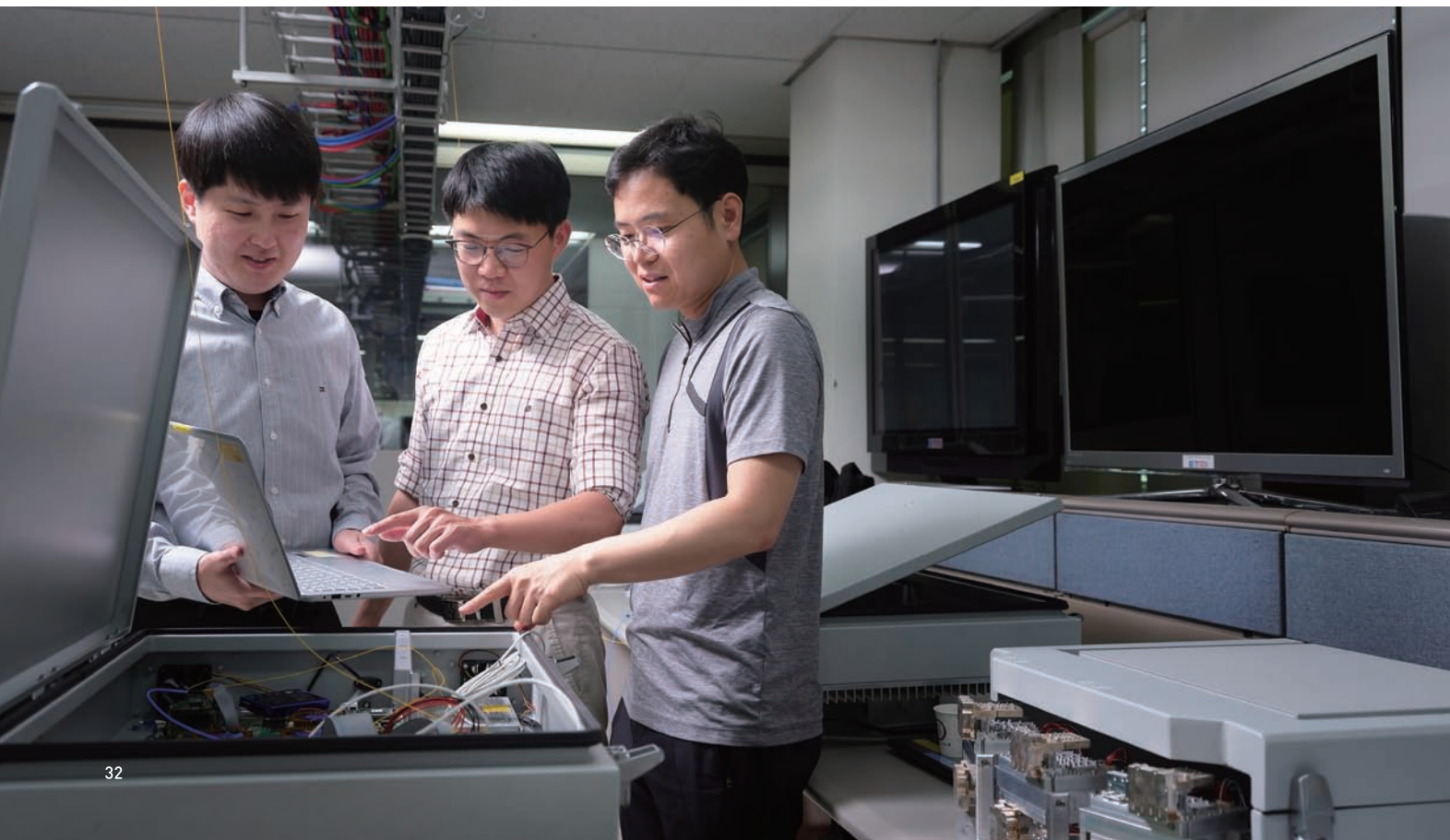
network technology that connects buses and terrestrial base stations by utilizing millimeter wave frequencies in the 22 GHz band. The researchers have named the technology the Moving Network (MN) system as it is optimized for an moving environment.

The 5G technology that is currently commercialized in Korea uses only low frequencies in the 3.5 GHz band, so its speed does not feel fast enough. High-band millimeter waves should be used to improve the service quality. However, tapping the millimeter wave in an outdoor environment was challenging because its signal distance was short, and diffraction did not easily occur.

ETRI's MN system has overcome those difficulties and achieved desired results through the institute's proprietary technologies such as the beamforming technology that efficiently sends signals where necessary and the beam switching technology that can control and manage multiple beams at a time. The demonstration was critical not only in terms of the speed but also in the sense that the 22GHz frequency was used in a real road environment.

The researchers will work even harder to realize the true 5G commercialization using millimeter waves in a bid to help citizens adapt to a hyper-connected society moving forward.

In the short term, they are focusing on research aimed at improving the prototype quality and making 1Gbps Wi-Fi service available on all buses in the country by 2022.





Since satellite communication statically allocates satellite resources (beams) to a specific area, the same signal is sent to the sea and airspace, for instance, where there is no communication demand. Conversely, additional beam cannot be allocated to an area where communication traffic is high. Its communication efficiency is yet to be improved. In response, the ETRI's researchers have succeeded in developing the technology required to send satellite resources variably according to demand for satellite signals.

## Satellite Signals Wherever You Want! Use the Internet as Much as You Want on Airplanes!

### 'Beam Hopping' Technology

Satellite communication means communication services made available through satellites. Satellite communication is huge in that it provides communication services to all over the world. It is extremely burdensome since a satellite that requires huge funds and high-level technology must be manufactured and launched.

Satellite communication however has a great advantage: it is useful in areas where off-the-shelf wireless communication cannot be used, say, at sea or on a plane. Thus it can be used for a variety of special purposes including marine communication on the ocean. Most notably, it can provide wireless communication services such as mobile communication features anywhere in the world since a communication network can be quickly established irrespective of natural disasters or geographical obstacles on the ground.

Its downsides include the high cost because fewer people subscribe to the service than general wireless communication and a long delay time associated with the fact that satellites are located 36,000km above the ground. It was also difficult to use the resources flexibly over the relatively long lifespan of a satellite.

The ETRI's researchers have successfully developed a new technology enabling users to utilize satellite resources (beams) efficiently according to their needs while adding flexibility to the satellite services overall. What they have developed is a satellite communication modem tapping the 'beam hopping' technology that can allocate satellite resources variably according to consumers' needs.

This new technology can actively transmit satellite signals wherever necessary. Therefore it can send signals only to desired ships and airplanes in vast areas, increasing the communication speed and reducing the cost incurred with the expensive satellite communication

frequency band. The situation can be compared with a satellite chasing a particular plane to supply it with signals.

According to the researchers, the core technology is the 'network synchronization' technology that synchronizes the signals between satellite signals and satellite ground stations that change over time and the 'variable data transmission technology' required users' terminals. The ETRI has not only secured the core technologies through its own research. It has also established standards Set by the International Organization for Standardization(DVB-S2x). It has developed a communication modem meeting these standards for the first time in the world. The researchers also called the technological breakthrough quite significant in that the ETRI has preempted the technology faster than its competing institutions and therefore can prevent foreign equipment makers from dominating the domestic market in areas such as the military and transportation industries where satellite communication technology is widely used in Korea. Most notably, the ETRI's satellite communication transmission/reception model will be applied to the beam hopping satellite communication developed by Eutelsat in France for the first time

in the world. For four days in October 2019, the ETRI's researchers successfully conducted a technology verification test using a satellite emulator provided by the Fraunhofer Institute in Germany, which simulated the same environment as a beam hopping satellite, at the Rambouillet teleport in France.

The test results have shown the communication data capacity and distribution efficiency increasing by up to 15% and 20%, respectively, from the service point of view, and the communication speed producing a maximum of 400 Mbps per beam. Given that the maximum current speed in the same frequency band is 150 Mbps, the new technology is expected to enable more than 100 passengers to simultaneously access HD video streaming on a plane.

The ETRI's researchers are planning to transfer the technology to overseas and domestic satellite communication equipment manufacturers. In addition, they are carrying out research to further develop the network synchronization technology and the modem technology with the goal of commercializing the beam hopping satellite scheduled to be launched in 2020. The ETRI's research and development continues to open a more efficient communication era.







## Beyond the Evolution of Communications Technology, Turn Imagination into reality!

### Ultra-low Latency & Lossless Network Technology

5G is not just the evolution of simple communication technologies. It is the beginning of a new world that realizes imaginations. In the full-fledged 5G era, hologram meetings will be possible as in the movies <Kingsman> and <Avengers>. Rescuers wearing AR glasses may rescue people from disasters. This is just a small part, and there will be many changes in our everyday life that can only be imagined in movies. However, there is a technical issue that needs to be tackled to realize a 'real 5G' era: the construction of ultra-low latency network infrastructures.

We need to know the three characteristics of 5G in order to understand what changes 5G brings to people's everyday life: 'super-high speed,' 'ultra-low latency,' and 'hyper-connectivity.' While the peak data rate of LTE is up to 1Gbps, that of 5G has been improved up to 20Gbps. However, the speed is not the only benefit of 5G; its true advantage is ultra-low latency.

Ultra-low latency means that the delay time for data sent from the smartphone terminal to return to the terminal through the base station, mobile networks and server is extremely short. This is the reason that 'real-time' service has now become possible.

Yet there is a problem to be solved in order to realize the real-time service. Even in heavy traffic conditions, latency should not increase and data loss should not occur. Currently, the packet network devices constituting the Internet have a limitation: it is not possible to predict the delay in the process of transmitting traffic once congestion occurs. In addition, information in transmission gets lost in the recovery process if a network fails. Even after recovery, the quality of service can be degraded because additional jobs are required, such as retransmission of information. In order to solve the problem, the ETRI's researchers have developed the 'Deterministic Networking(DetNet) core technology' and succeeded in interworking test with the Korea Advanced Research Network(KOREN).

As the technology prevents data loss and minimizes data transfer time between devices connected remotely over the network, while making it predictable, it is possible to control devices precisely through the network. The technology is expected to be applied to a wide variety of industrial areas such as remote control, telemedicine, smart factory, and drone control as well as a number of hyper-immersive services such as remote virtual reality(VR) and hologram communication.

Together with the National Information Society Agency (NIA), the ETRI has succeeded in demonstrating the ultra-low latency transmission of 1Gbps data by connecting the DetNet system prototypes through

430km (round trip) optical transmission networks between Daejeon and Seoul for two weeks from the end of October. With the technology developed by the ETRI, delays do not exceed the given threshold even when the network is in the traffic congestion condition. As a result, data can be transmitted within a latency of less than 10 microseconds per node (one hundred thousandth of a second) under any circumstance.

Besides, even if a network fails during transmission, data never get lost; additional delays caused by retransmission or loss of important information are fundamentally prevented.

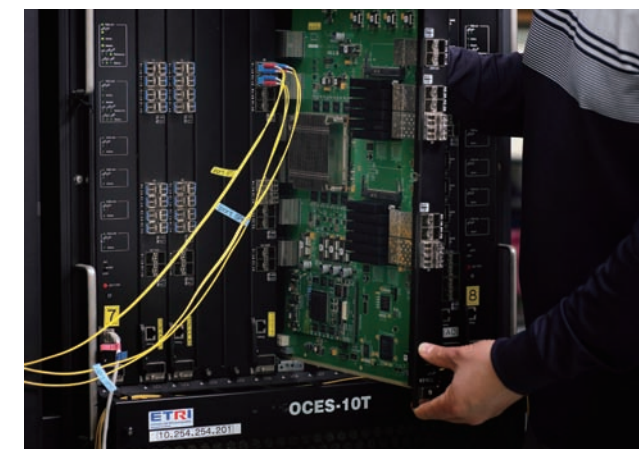
The ETRI's researchers have developed the technology to be applicable to nation-wide enterprise networks by enhancing existing technologies that are limited to the local area network(LAN).

The ETRI has demonstrated that it is leading the world's best technology by developing the DetNet technology, which is being standardized in the Internet Engineering Task Force(IETF), in the form that can be applied to high-capacity transport network systems for the first time in the world and succeeding in trial demonstration.

By proactively securing core next-generation networking technologies required for ultra-low latency and lossless packet delivery, the ETRI has paved the way for not only economic benefits but also shared growth among convergence industries.

In February 2020, the ETRI transferred the technology to Korean domestic transport network equipment vendors, Coweaver and Woorinet.

The ETRI's researchers are planning to boost the capacity of the technology to 100 Gbps. They have also begun R&D with an aim to commercialize the packet-optical integrated network system, equipped with the enhanced feature, by 2022. The ETRI's efforts continue to create a new world where imaginations become real in telecommunications, rather than pursuing mere evolution of the telecommunications technology.





# Hyper-Realistic Video Service Beyond the Continent in Real Time!

## Realistic UHD Live Broadcasting Technology

‘Vision’ is a sense that humans rely on most when they judge objects. Through it, humans determine the size and shape of various objects as well as light and its brightness in addition to the location and the movement. Recently a new era of videos has dawned where we can see stuff far more realistically. That is thanks to the Ultra-Wide Vision (UWV) technology. The ETRI’s researchers are opening a new era of broadcasting with wide viewing angle and ultra-high definition technologies.

UWV is a sensory imaging technology that maximizes the sense of realism and immersion through panoramic images that provide a viewing angle of 120 degrees or more while maintaining ultra-high definition of UHD (Ultra High Definition).

Recently, the ETRI has developed a technology that creates UWV images similar to humans’ maximum viewing angles while maintaining UHD-class ultra-high definition. Based on the technology, the ETRI’s researchers have succeeded in a test that relayed a soccer game in the Netherlands and a TV debate in Belgium across continents, ushering in an era of providing hyper-realistic video service beyond the continent in real time. The ETRI’s researchers have developed the technology with an aim to provide a differentiated media experience: the new technology creates images optimized for a human-perceived viewing angle of 100-110°.

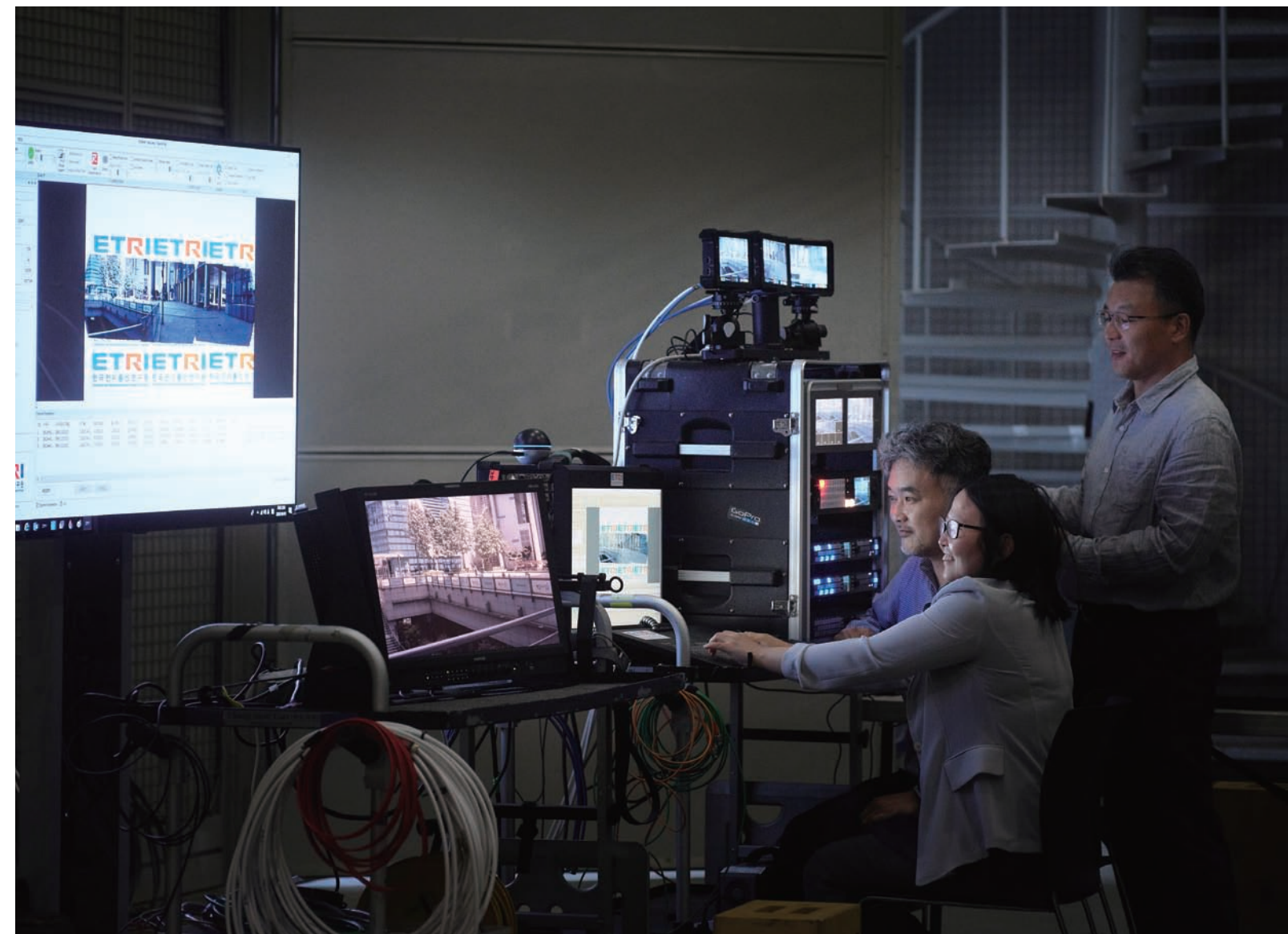
Previously, when large-capacity video information was combined into one, images looked unnatural or there was a problem in transmission. The ETRI’s researchers have put together images from multiple ultra-high-definition cameras into one through the ‘real-time monitoring generation technology.’ Consequently we can broadcast super-realistic images that look natural as if they were shot with a single camera with a very wide angle.

An image created through the new technology is composed of a 12Kx2k UWV image, which is 3 times UHD resolution (4Kx2K), and an 8Kx4K image, which is 4 times UHD resolution, based on the horizontal width conversion, with the vertical width remaining the same. Through the technology, we can feel the same immersion and realism that we feel at the venue of a sporting event or a concert while watching TV in our living room.

The ETRI has also developed VR video contents that allow us to view a desired screen with 8K resolution from any angle we choose. Users can put on a terminal such as a head-wearing display (HMD) or use

a large screen to maximize the sense of presence and immersion. Based on the technology, the ETRI’s researchers applied a 360° VR service to a TV debate held in Brussels, Belgium in April 2019. TV viewers could enjoy a 360° view of the panelists. Furthermore, the researchers drew keen interest by introducing convergence technology that tapped AI to automatically convert dialogues into subtitles and analyzed the panel’s emotions and illustrated them in emojis. This achievement was particularly significant in that the ETRI’s researchers not only introduced new features recognizing human voice and emotions in the European market but also built trust in Korea’s broadcasting and networking technologies through international joint

research with the Dutch and Belgian scientists. Subsequently, the new technology was selected as a new broadcasting technology at Eurovision Song Contest 2020, the largest music competition in Europe. Discussions are underway about technology transfer with a number of broadcasting stations and service providers. The new technology is also expected to be used in various contents fields such as AI-based broadcasting and hyper-realistic untact(contactless) meetings. The ETRI is planning to continue to develop new technologies that can pioneer next-generation media services in a bid to secure stronger competitiveness in broadcasting technologies.





# Intelligent Convergence Research Laboratory

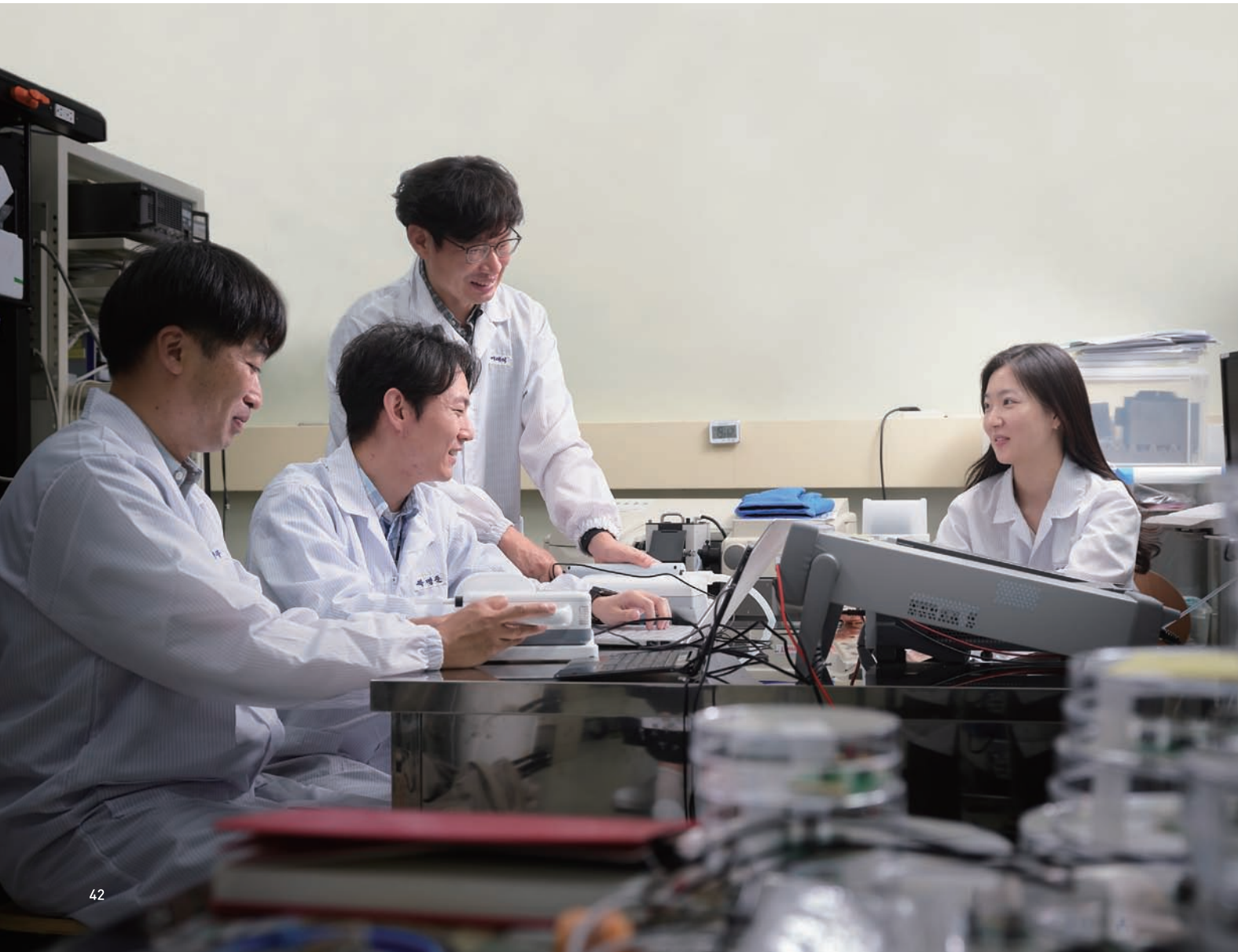
The Intelligent Convergence Research Laboratory is carrying out major research and development as part of efforts to promote ICT Convergence and Intellectual Informatization of the Nation and Society(city, traffic, welfare, environment, defense, safety, etc). It is researching and developing key technologies to come up with intelligent ICT solutions to the problems of people's lives with the establishment of direction and standardization of intelligent ICT policy. In particular, the laboratory is playing a leading role in improving the safety and quality of people's life by performing R&D aimed at realizing consumer-oriented new manufacturing and energy industry ecosystem, creating a smart city as well as intelligent transport · logistics ICT infrastructure, realizing next-generation medical intelligence for enabling 100 years of health, and accomplishing intelligence of the defense ICT and public industrial safety. It is also focusing on intelligent cyber-security core technologies that block sophisticated and automated hacking.



# Spot Lung Cancer through Breath Trust

## Development of 'Electronic Nose' to Detect Lung Cancer from Breathing

Lung cancer is the deadliest cancer in Korea. It ranks second in the five-year survival rate among the country's major cancers. That makes its early detection all the more important. X-ray and CT tests widely used to diagnose lung cancer have a radiation risk in addition to the fact that they are costly. Amid the urgent need to diagnose and prevent lung cancer that threatens public health in the country, the ETRI's researchers have found a solution in ICT.



Recently the ETRI's researchers have developed a machine learning algorithm technology that identifies lung cancer patients through sensors in array that detects volatile organic compounds produced by cancer cells in the lung through exhalation and data obtained therefrom. They published the findings in 'Sensors & Actuators B,' a famed international journal.

The breakthrough was conceived from the awareness that the human nose smells things through nerve cells. The technology makes it possible for an electronic sensor to smell things as the human nose does when respiratory gas enters it and convert the smell into an electrical signal to determine the presence of a disease. Thus the invention is dubbed the 'electronic nose.'

The 'electronic nose' system developed by the ETRI is as big as a desktop computer composed of three parts such as an exhalation sampling unit, a metal oxide chemical sensor module, and a data signal processing unit. The technology requires just human breathing to produce test results. First, the examinee's breath is taken into in a vinyl kit.

Gas components emitted during breathing are collected in the kit through a sampling module based on carbon adsorbents. Then the module gets inserted into the electronic nose system. When the system is driven, the built-in sensor produces different electrical resistance signals depending on the level of gas adhesion.

By carrying out an algorithm analysis of the component data of the exhaled breaths and comparing the results with the patient's exhalation information, the examiner can get help in trying to determine the presence or absence of lung cancer in the patient's body. With the support of Seoul National University Bundang Hospital, the ETRI's researchers collected the exhaled breaths of 37 lung cancer patients and 48 healthy people, conducted the relevant analysis more than 200 times to develop a machine learning model, and proceeded with the database creation.

Researchers at the Department of Thoracic and Cardiovascular Surgery of the hospital checked the clinical significance of the system. The findings have indicated approximately 75% accuracy. The system is therefore expected to perform the role of a supplement for the diagnosis of lung cancer quite well.

Most notably, the ETRI's technology is cheaper and simpler than the existing diagnostic equipment in sensor manufacturing costs while it boasts high precision compared to its price. Its convenience is also outstanding. It can be used not just for the prognosis of lung cancer patients but also for the self-health management of the general public.

Through subsequent studies, the researchers are planning to acquire additional expansions of patient cohorts, build big data, and apply deep learning algorithms to the system. They aim to further improve the system accuracy in the process while looking into the possibility of early diagnosis of various other cancers such as stomach cancer and colorectal cancer. Besides, the ETRI's researchers are working to develop a 'wearable electronic nose system' which can measure in real time the amount of acetone concentrated in the exhaled breath as fat breaks down when obese patients exercise. It is still difficult to accurately quantify one's exercise volume except for exercise hours. The new system could address the issue once and for all. Currently, the ETRI is working with a private company that has shown interest in the technology for technology transfer and commercialization through a startup company.

When it is commercialized, the technology can demonstrate strong competitiveness in the medical device market related to lung cancer diagnosis while greatly reducing the government's health insurance related payments. Moving forward, the ETRI's researchers plan to upgrade the system through accuracy improvement and big data application with an aim to actively contribute to the promotion of public health based on their research outcomes in biotechnology and ICT over the past 20 years.



# Apply Intelligence to CCTV and Predict Crimes!

## Proprietary Technology for Predictive Video Surveillance Systems

Currently, intelligent CCTV is used as a supplementary means for security guards, but it will not be long before CCTV can be used as a completely independent tool. The Distributed Antenna Systems (DAS) of the United States provides real-time information on the escape route of criminals through CCTV big data. The development of an integrated CCTV that combines big data and artificial intelligence is getting closer. How will intelligent CCTV upgrade public safety systems? The ETRI's researchers provide the answer.

Recently, there has been a report of a man attempting to follow a woman into her house where she lives alone, generating a great social reverberation. If we look closely at crimes like this, we can see that intruders search for their targets for some time before they finally commit a crime. If we look back from a particular crime, therefore, we can see that there were advance indications invoking a strong sense of déjà vu. A paradigm shift is underway in fight against crime, from crime response to crime prevention. Technologies are being developed that draw on AI to analyze CCTV screens in real time to detect signs of violent crimes and alert relevant parties in advance based on the calculated probability.

If the technology is developed, crime occurrence can be predicted including the place and the time. To develop more advanced predictive security technology, the ETRI has added an intelligent CCTV video analysis technology to the statistical crime prediction method used in advanced countries. For example, one can calculate the crime occurrence rate by comparing the current situation seen through CCTV in a specific location with the precursors of crimes identified in crime statistics. AI collects information on the precursors of past crimes along with their surrounding circumstances. When it detects a similar situation, AI sounds a warning to the CCTV Control Center before a crime occurs. Most notably, AI analyzes both visual and audio information to immediately identify dangerous situations where suspects tail victims in the wee hours. AI also figures out the characteristics of the suspects on the screen right away to support police probes.

Suppose that there is a man who keeps tailing a woman in an alley about ten meters behind her.

If the area is crime-prone and the situation looks dangerous, AI sends off a warning signal to the monitors of police that either rush to the location or broadcast a warning remotely to prevent a crime from

occurring. If the suspect covers his mouth with a face mask or hides his face with a hat, the probability of crime occurrences increases.

However, if the same situation happens at the same location at 2:00 in the afternoon, the probability drops significantly. Thanks to the technological advance, unlike the existing crime prediction system that depends only on crime statistics, the new system increases the accuracy of probabilistic prediction considering the environment alike.

Furthermore, the ETRI has also announced that it plans to develop a technique required to manage sexual offenders. The ETRI's researchers are planning to develop the 'Path Re-ID' technology that analyzes and compares the characteristics of candidates on the move using the 'Person Re-ID' technology that it has developed on its own in order

for authorities to pinpoint a specific person among many people immediately.

So far, the institute has analyzed more than 20,000 court decisions and a large amount of visual crime datasets. After further raising prediction accuracy about various types of crimes, the ETRI is planning to launch a pilot project for Seocho District in Seoul at the end of 2020 with the goal of completing the development of the new system by 2022.

The ETRI will continue to work hard to ensure that CCTV will be able to not only witness the occurrence of crimes but also predict the possibility of crime occurrence up to 80% as a cutting-edge high-tech social safety system critical for citizens' safety.



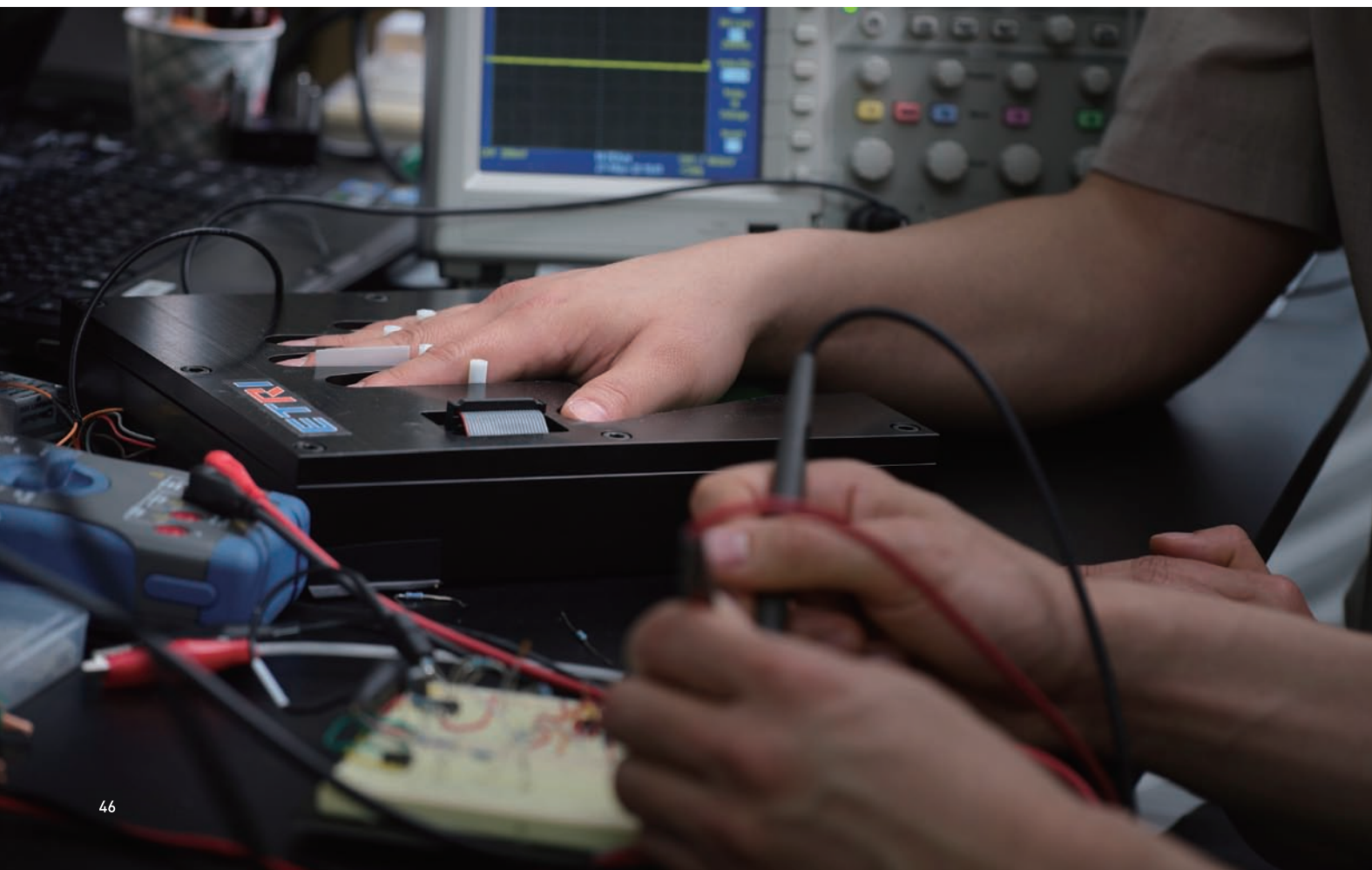




## Show Your Palm for Authentication!

### Non-Replicable 'Biometrics' Technology

As interest in information security is on the rise, personal authentication using biometrics such as fingerprints is gaining traction instead of accredited certificates of authentication. However, personal authentication based on fingerprints, irises, veins, etc., is not entirely dependable since all those two-dimensional images are easy to replicate. The ETRI's researchers have succeeded in the development of a new biometric recognition technology that synthesizes and authenticates the bones, muscles, fats, blood vessels, blood, and body fluids of human fingers.



All the commercialized biometric authentication technologies rely on the images of fingerprints, irises, and faces. Their shortfall is that the images are easily reproducible. To solve the problem, the ETRI's researchers have developed a biometrics technology that cannot be copied, which will be a turning point for the development of next-generation security technologies.

While the existing technologies depend on human physical appearance like fingerprints or irises, the new study concentrates on the structural characteristics of human bodies. Each individual sharply differs in bones, muscles, fat, blood vessels, blood, and body fluid. The researchers have developed a signal system tapping such individuals' complex structural differences and applied the deep learning technology to it. It is similar to measuring body fat percentages or taking ultrasound scans during a physical examination.

The technology that has been developed by the ETRI's researchers so far requires people to place their hands on palm frames and register their structural physical characteristics for far more precise personal authentication. The results have been published in international academic journals such as 'Scientific Reports' and 'the IEEE Transactions on Cybernetics.'

The researchers have obtained approval from the Institutional Review Board (IRB), conducted clinical trials on 54 patients, and secured more than 7,000 clinical data. They verified the clinical data through machine learning and deep learning models and raised the biometric

accuracy to over 99%. Of course, fingers were chosen for the test for the sake of convenience. Any part of the human body can be used. The researchers are planning to reduce the system weight to a sensor or chip moving forward.

The researchers have pointed the following as core technologies involved in the latest development: ▲ the bio-tissue modeling technology, ▲ the deep learning technology for biomedical signal analysis, and ▲ the vibration and electrode element technology. The ETRI technology is more convenient to use than conventional biometric technology, too: authentication can be made using any part of the human body. People no longer have to place their fingers or faces closer to a sensor installed in a machine. They can attach the sensor to their body, or they can complete the process through a mobile device without any physical contact with the sensor.

Therefore, holding a smartphone could be enough if a chip were installed in the part phone users usually touch. Authentication can also be made when an individual grips things like a mouse, keyboard, or steering wheel. The new technology can be applied to financial transactions, access control, and watches, among others.

The researchers are planning to collaborate with world-class security technology companies to commercialize the technology in the near future. New creative ideas make the world more convenient and safer. The new ETRI proprietary technology is expected to serve as a driving force for the development of the biometric industry.





## Top 7 AI Trends for 2020

7 AI-driven trends in 2020  
- "Beyond Perception"

AI is undeniably the hottest thing these days. Chairperson Masayoshi Son of SoftBank, who visited Korea last July, emphasized the importance of AI, saying that "What Korea should focus on is first, second, and third – AI." According to Son, AI will pave the way toward the biggest revolution that humankind has ever witnessed. The Korean government published "National AI Strategy," and ETRI also released "Top 7 AI trends for 2020," a report that analyzed the wave of the fourth industrial revolution from a political, economic and technological perspective.

In the past, people found that AI was just imitating the "perception" of humans. According to ETRI's "Top 7 AI trends for 2020," however, AI is functioning as the new driver for the shift in global supremacy by leading business analysis and R&D innovation that humans are incapable of while creating added economic values with creative activities that were generally considered to be the exclusive domain of humans. The 7 trends identified in "Top 7 AI trends for 2020" are as follows:

First is the Chinese AI. The US has been leading a lot of industries and technologies, but the Chinese government led efforts to pave the new way with the proprietary AI flavor by creating a rich "data value chain." In other words, the AI strategies of global powerhouses are triggering the competition for supremacy, the report says. Second is "AI Nationalism." A new kind of nationalism is emerging - protecting a country's own AI-related data and services while minimizing influences from other countries. Leading countries and services in AI face difficulties in crossing the border due to trade restriction measures, tariffs, and personal data protection laws. The

ETRI report points out the possibility of weaponizing AI technologies as well as the widening scientific and technical gaps among countries as they work alongside political orders.

Third, "Augmented analytics" and "Dark Data." AI is eliminating the barriers to the scope of data and limitations of analysis that could not be accessed, even though companies owned them, through unprecedented analysis methodology. AI is helping in the decision making of humans while providing insight and new values.

Fourth is R&D innovation intelligence. AI clearly showed that it is dramatically revolutionizing industries with deliverables such as autonomous vehicles and Watson the machine doctor. As the bigger value that can be had from AI, however, it can transform how human researchers think to improve R&D productivity.

Fifth, the evolution of creative intelligence. AI is found to be capable of drawing pictures, writing novels, and shooting movies from scratch instead of merely copying. There is potential in design and strategy development beyond human capacity.

Sixth, "AI Homunculus." The human brain becomes most active when

sensory organs are acting. Human intelligence has evolved in proportion to the development of the body and functions of organs. The evolution of AI means that research on the interactions of physical entities such as vehicles, drones, and robot arms with the external environment will be more important in order for AI to become more advanced and independent.

Seventh is the new computing form factor required in the era of AI. Just as the chipset from Intel defined the form factor known as the "standard PC," there is a need to pay attention to how and whether AI's deep relations with GPU and ASIC mean that new proprietary computational devices will work in the creation of new market by playing certain roles.

New IBM CEO Arvind Krishna warned during the annual conference in May that "All companies will be forced to be an AI company after the COVID-19 crisis." Hopefully these 7 trends covered in the report will be helpful in finding core capacity for survival, beyond merely complementing corporate and national capabilities.





# ICT Creative Research Laboratory

The ICT Creative Research Laboratory has the vision and goal of 'leading the future ICT technology through disruptive creative research', and it is carrying out challenging research and development of new future ICT technologies in order to contribute to the realization of the 4th industrial revolution and Beyond-5G hyper-connection society.

To achieve such vision and goal, the ICT Creative Research Laboratory is researching and developing cutting-edge future technologies such as human enhancement devices, cloud intelligence enhancement devices, neuromorphic devices, quantum computing SW · HW, quantum communication, tera-bps photonic · RF convergence components, wearable super-sensory communication, holographic space interaction devices, ultra-light AR · VR devices, etc. In addition, the ICT Creative Research Laboratory is exploring and researching more basic underlying technologies such as terahertz devices, synapse-based emotion cognition devices, nano-electron source, 2D · nano semiconductors, meta materials, quantum devices, etc.

By creating synergy from the collaboration with industries and research institutes in Korea and abroad, the ICT Creative Research Laboratory will also do its best to help domestic component companies take the lead in new markets and become global enterprises, making Korea a strong nation in the field of ICT devices and semiconductors.





## Detect Green Algae with Drone and Prevent it through AI Analysis!

### The hyperspectral technology

Every summer, we hear news about green algae and begin to worry about our drinking water - a sign of the so-called 'green algae anxiety.' In the past, we spread ocher or used waterwheels to remove green algae. Recently, we sometimes open up sluices as a way of improving the water quality in dams. However, once introduced into the water, nutrients remain in the aquatic ecosystem unless they are completely removed, and green algae recur. As such, it is best to predict and prevent the occurrence of green algae in the first place. The ETRI has succeeded in developing technology required to detect green algae through hyperspectral technology in the hope that the country's beautiful rivers and lakes will no longer suffer from 'the green algae latte' that locals christen after a popular green-tea drink.

In the summer, when the water temperature rises above 25 degrees Celsius and the amount of sunshine increases, nutrients are excessively supplied to the country's water systems, letting green algae and plankton proliferate resulting in algal blooms there.

Green algae occur in slow or stagnant bodies of water. They disturb the aquatic ecosystem and eventually affect water quality. Most notably, when the threshold is exceeded, the algae increase exponentially, making it difficult to take actions then. Desperately needed was the technology with which we could accurately predict the probability of the algae occurrence.

The ETRI's researchers have succeeded in developing a new technology enabling a drone equipped with a hyperspectral camera to remotely analyze water quality and predict the level of green algae occurrence with artificial intelligence, reducing people's anxiety and greatly contributing to the management of drinking water safety.

Using drones, the ETRI's technology can observe the entire water body and measure the degree of algal blooms most efficiently. With the technology, we can easily grasp the overall status of algal blooms including the movement, diffusion, and distribution of green algae in rivers and rivers. Compared to satellites or aircraft, drone-based monitoring costs less while producing higher resolution images.

AI quickly conducts big data analysis on the acquired data. Once it is launched, the new technology can also predict

where an algal bloom will occur in 7 days, leading to more effective response to the relevant body of water.

Previously, samples had to be collected from rivers and streams. Access to necessary spots was strenuous at best. Thus collecting and analyzing samples took a long time, making it hard to respond before algal blooms spread more often than not. The new technology can complete the entire task much faster without hassle.

The core is the hyperspectral technology which has been developed in a non-defense sector for the first time in Korea. The ETRI's researchers were able to secure the proprietary hyperspectral imaging technology based on the high-precision optical system technology that it developed while carrying out a defense project in the LIDAR sector.

Compared to ordinary images that are divided into red, green, and blue (RGB) lights, hyperspectral imaging technology can divide visible light and near-infrared light into more than 200 subregions. Even when the water quality looks normal to the naked eye, a drone with a hyperspectral camera can classify the level of algal blooms in Daecheongho Lake or the Geum River, for instance, into 'warning,' 'alert' or 'outbreak' right away. From the light spectrum of harmful algal blooms, the technology can digitize their exact status in real time.

The hyperspectral technology is expected to be used in various other fields such as the analysis of red ties in the sea, the prediction of agricultural production depending on the impact of pests, food freshness assessment, and skin aging estimation.

Meanwhile, the ETRI's researchers are planning to develop their analysis capacity further to surpass the 90% mark in the algal bloom prediction. In addition, they will be working to make it possible to track the spread of toxic algae in diverse situations, leading to early suppression of the growth of green algae. The ETRI will be proceeding with research designed to localize expensive hyperspectral sensors while reducing their weight and size by 2022.

The ETRI is hopeful that with its green algae detection technology will eliminate the anxiety that is repeated every summer and create an environment in which people can drink water without any concern.





# Active Sound Field Sensor for Sound-Based Intrusion/Fire Detection

## Smart Safety Sensor based on Sound Field Changes

In the 21<sup>st</sup> century, single-person households along with ‘loners’ who do not seek out human interaction or relationships are becoming an increasingly common type of households in a modern society. The phenomenon has both positive and negative sides. The biggest among the negative aspects is ‘safety’: In addition to break-in risks, fire risks get bigger in single-person households. Home security systems are available. Yet their installation and maintenance costs are high. Many choose to take risks instead of utilizing the systems. The ETRI’s researchers have developed a sensor that uses sound to detect intrusion and fires with sound, making the world not only more convenient but also safer.



Crimes targeting women living alone are on the rise these days. Digital door locks are extremely popular in Korea. Criminals have figured out that they can open the locks with a master key without entering any password, raising residents’ anxiety.

The ETRI’s researchers have developed a sensor that can detect an intrusion or a fire through sound, paving the way for the prevention of crimes and fires at the same time. Together with SecuWorks Inc., the ETRI has developed the world’s first smart safety sensor that detects intrusions and fires through not only sight but also sound on the basis of changes in sound fields.

The sound field refers to the dispersion of sound energy within given boundaries. Then an active sound field sensor generates sound through a speaker and analyzes changes in the sound field formed within a given space. Human movement or temperature changes also affect the sound field. The sound field sensor detects the situation by receiving altered sound waves through a microphone. The active sound field sensor developed by the researchers consists of three parts such as a microphone, a speaker, and a signal processing unit. Its size is 8cm x 5cm. It can be attached to the ceiling.

The biggest advantage is that the new system has no blind spot unlike existing image sensors or infrared sensors that fail to detect intrusion or excessive heat in a blind spot or occasionally make false alarms. The active sound field sensor uses sound reflection and diffraction (a phenomenon in which sound or radio waves propagate to the back side when they pass through an obstacle), and so it can detect any movement beyond obstacles completely.

The sensor can also capture sound as well as movements, and so it can be used for a number of purposes. For example, if you set a security mode in the AI speaker feature, the system produces a sound similar to a cricket cry for 0.5 seconds every 2-3 seconds. By sending out sound waves periodically, the system analyzes sound fields created in the space. You can set the system so that you can receive texts or notifications when changes occur in the sound field due to movements or temperature changes.

You can find out that a fire has broken out almost immediately. Existing sensors detected temperature changes after a fire has spread extensively. An active sound field sensor can detect a fire within 50 seconds wherever the fire has started within the given space, raising the possibility of fast fire suppression.

The researchers also regard the marketability of the technology as high: one can install the system in a CCTV and an AI speaker through software update. Its expandability to the IoT, among others, is excellent, too. The system is also outstanding in price competitiveness: it is about 30% cheaper than existing systems. Since it has no blind spot, the new system requires fewer sensors for the same space. The maintenance cost is also lower: the new system saves all the expenses



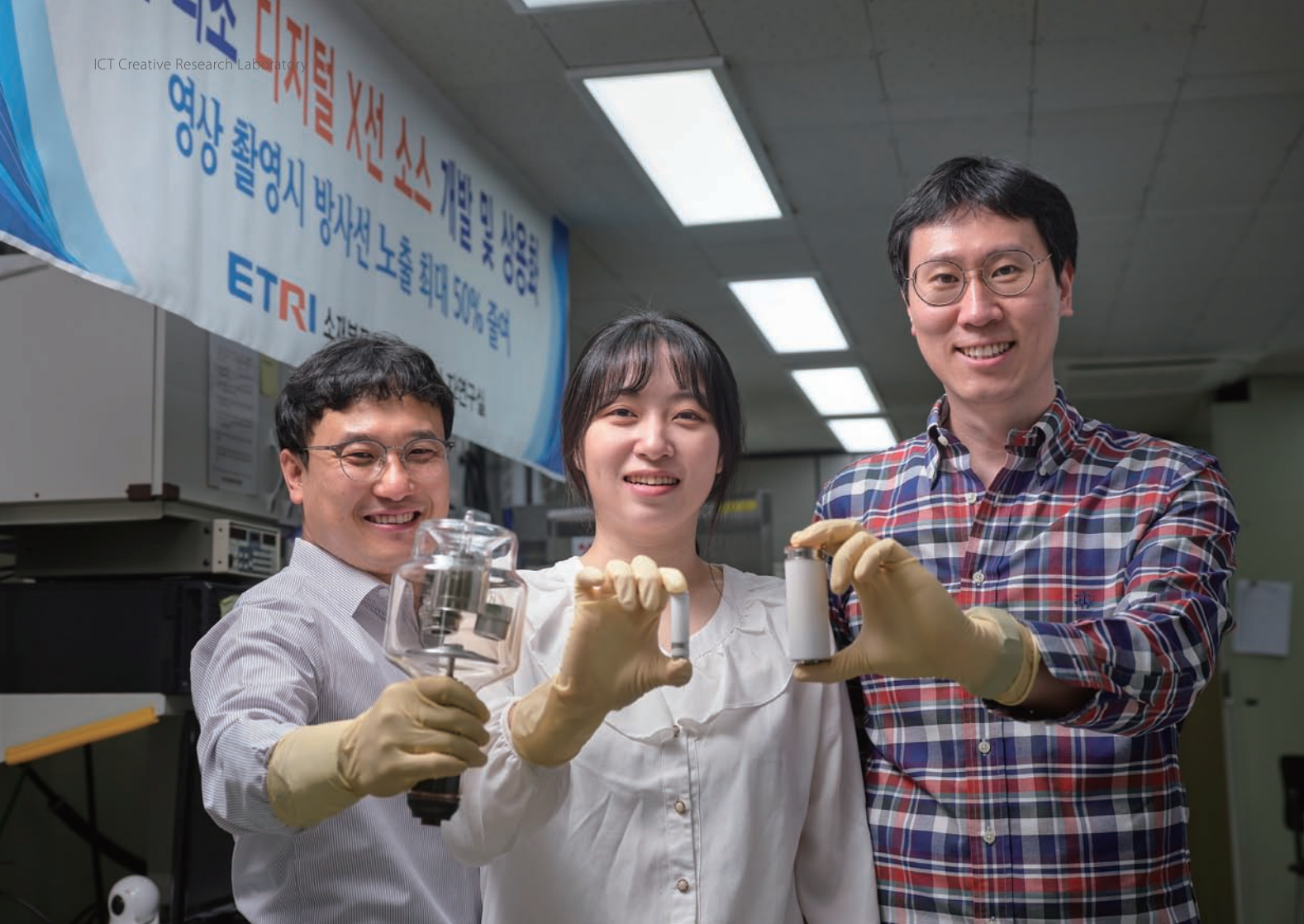
involved with false alarms.

The new active sound field sensor is likely to be particularly popular among rapidly growing single-person households and public institutions with relatively higher risks of crimes and fires. The sensor is also expected to be widely used in welfare facilities including nursing homes that want to detect seniors’ extraordinary movements and take actions quickly.

Moving forward, the researchers are planning to conduct research on the development of sensors that draw on sounds inaudible to humans and those that can identify the nature of changes in movements and temperatures more accurately through deep learning. Recently, the sensor has been installed at Nakwon Instrument Arcade, Seoul to prevent intrusion and fire in its famous musical instrument shops. Meanwhile, the ETRI will join forces with Korea Electric Power Corporation to commercialize the technology incorporated into the latter’s substations and switchboards to detect fires or signs of fires in advance. The ETRI is also planning to expand its active sound field sensor market into the areas of smart home appliances, smart cities, and port containers and ships.

Currently, Japan dominates more than half of the global sensor market. The ETRI is looking forward to the successful commercialization of the sensor and hopeful that along with the import substitution effect, the new technology will effectively address the issue of safety blind spots in single-person households including the elderly.





## The World's First digitalization of 120-Year-Old Analog X-ray Source

### CNT-Based Digital X-Ray Source

X-ray, a kind of electromagnetic wave, can inspect the inside of the objects without destruction. So, the X-ray inspection are widely used in diverse areas such as medical diagnosis, industrial inspections, process, material analysis and security screening. However, there is always the risk of exposure to unnecessary radiation when we use X-rays classified as one of radiation. Fortunately, we may not need to worry about unnecessary radiation exposure anymore. The digital X-ray sources developed by the ETRI dramatically reduce the risk of radiation exposure and greatly improve diagnostic performance and accuracy of inspection.

X-rays are electromagnetic waves used for medical diagnosis and industrial inspections. To acquire X-ray images, the system requires an X-ray source, an object, and a detector. Up to now, the development of X-ray technology has been mainly limited to the detector parts. Many research groups in the United States, Japan, and Europe have been continuing research on development of advanced X-ray sources, but they have not achieved any worthwhile results. That is the reason why conventional analog X-ray sources have been used for 120 years since the discovery of X-ray. However, the ETRI's researchers have recently made a new history for X-ray sources through development of digital X-ray sources for the first time.

In conventional analog X-ray sources, electrons were generated by heating a filament at a high temperature of 2000°C, in such a way as that of an incandescent lamp. There were still big problems. It is impossible to turn X-rays on and off quickly because quantitative heat-control is difficult. It means that people could be exposed to radiation unnecessarily. In addition, image quality of X-rays is limited along with long exposure time.

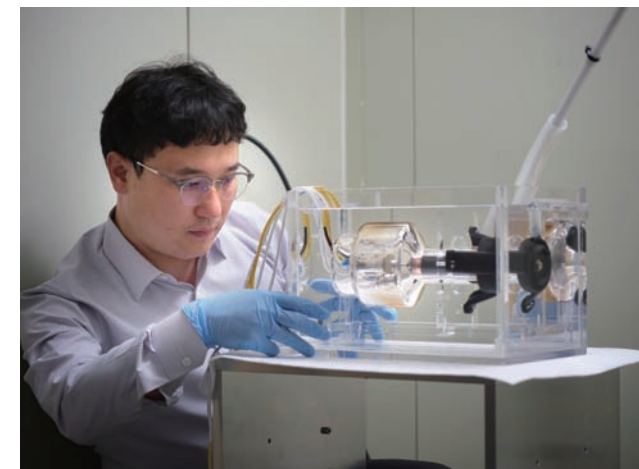
The ETRI has focused on these problems. The ETRI's researchers have solved the issue by using the high-temperature vacuum sealing and field emission technologies. They have noted that electrons can be extracted from the cathode consisting of dense carbon nanotubes when the electric field applied to the cathode. The researchers adopted this physical phenomenon, called field emission, to the X-ray sources. By help of the fast and exact control of electron emission through electric signals, we can digitally modulate X-rays. As a result, the radiation exposure level could be reduced by about 50% compared to the previous one. The ETRI's researchers estimates that the radiation exposure may be further reduced down if the electric signal could be controlled by predicting object's movement.

One of the advantages of the digital X-ray source is that it makes

possible to take fast and precise X-rays acquisitions with the current control of short time of below a microsecond. Compared to the analog operation of conventional X-ray sources in the range of a few milliseconds at most, the digital one can precisely control X-rays up to 10,000 times faster. The exposure time can be adjusted properly according to the movement of the object in the digital X-ray system. So, we can get clear X-ray images with little motion blur. Moreover, since heating module becomes unnecessary, the number of accessories is reduced, which leads to the weight reduction and relatively easier commercialization of the equipment.

Based on these advantages, the technology has been transferred to seven related companies, including two midsize companies. The technology can be used in a variety of areas such as an industrial inspection, customs inspection, portable dental X-ray diagnosis, and ionizer. Its usage is expected to expand in areas including cancer diagnosis that involves physical risks from radiation exposure. Most notably, the technology will substitute the key component for conventional X-ray sources made in Japan that have dominated the domestic market completely, and offer opportunities for local companies to advance abroad.

The ETRI takes pride in the fact that it has broken the 120-year old frameworks of perception and made a technological innovation. The ETRI has overcome the limitations that even advanced countries in the field of precision diagnosis considered impossible, and presented a new paradigm of the X-ray technology. The ETRI finds the upside in any circumstance, takes up the challenge, and comes up with solutions in a bid to create values that could change the lives of mankind. Song Yoon-Ho, Assistant Vice President of Materials and Components Research Division, was honored with 'the ETRI Researcher of the Year Award 2020' for his leadership in the development of the new technology.





# Secret to 100K Concurrent Connections: Pioneer in Localizing Telecom Equipment

## ETRI Powers Korea’s 400G Optical Transmission/Reception Engine

Analog is gradually being replaced by digital. The era of the machinery industry depending on mass production processes has passed. Now is the era of data being driven by the Fourth Industrial Revolution. As a result, many mechanical devices are being replaced with electronic devices equipped with the Internet of Things (IoT). New values like hyper-intelligence, hyper-connectivity, and hyper-convergence are emerging as the key components of a new paradigm. The ETRI has proved that it has grasped what the Fourth Industrial Revolution era is all about and is responding to its key changes properly by launching super high-speed, low-power, and high-density transmission and reception equipment.

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In the era of ICT convergence, information is all transmitted and received as data before being stored and managed in a data center called a ‘hotel of computer servers.’ As the Fourth Industrial Revolution accelerates, however, data usage has spiked in line with expanding related services such as virtual reality (VR) and augmented reality (AR). A kind of data saturation has already occurred. Naturally, desperate need has arisen for the development of optical telecommunications technologies suited for data centers with higher data transmission speed and stronger data processing capacity.

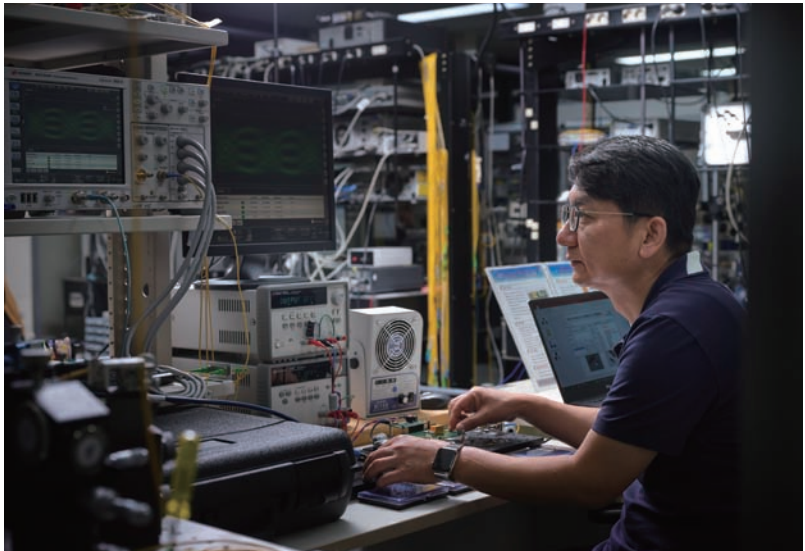
It is expected that an increasing amount of data will be linked and converged together moving forward. Fully aware of the importance of data, the ETRI has developed an optical transmission/reception engine for 400 Gbps signal transmission that can store and manage

vast amounts of information most efficiently. The achievement is all the more significant in that all the work, from design to manufacture, to roll out a 400G optical transmission/reception engine and optical devices optimized for a hyper-scale data center was done with local technologies.

The optical transmission/reception engine for 400Gbps signal transmission is about 3.5 centimeters long, approximately the size of an adult finger. Yet it enables 100,000 users to enjoy HD live streaming on YouTube simultaneously. Compared to existing products, transmission and processing has become 4 times and 8 times faster, respectively.

Data centers largely depended on 100Gbps optical transceivers, consisting of four 25-Gbps channels based on four EML (Electro-absorption Modulated Laser) devices. The ETRI’s researchers have improved the performance of the EML devices to 100 Gbps, four times higher than the previous transmission rate. For the first time in the world, the ETRI’s researchers have realize the 400G-class speed while meeting standards using a 100Gbps-based optical transmission/reception engine per channel.

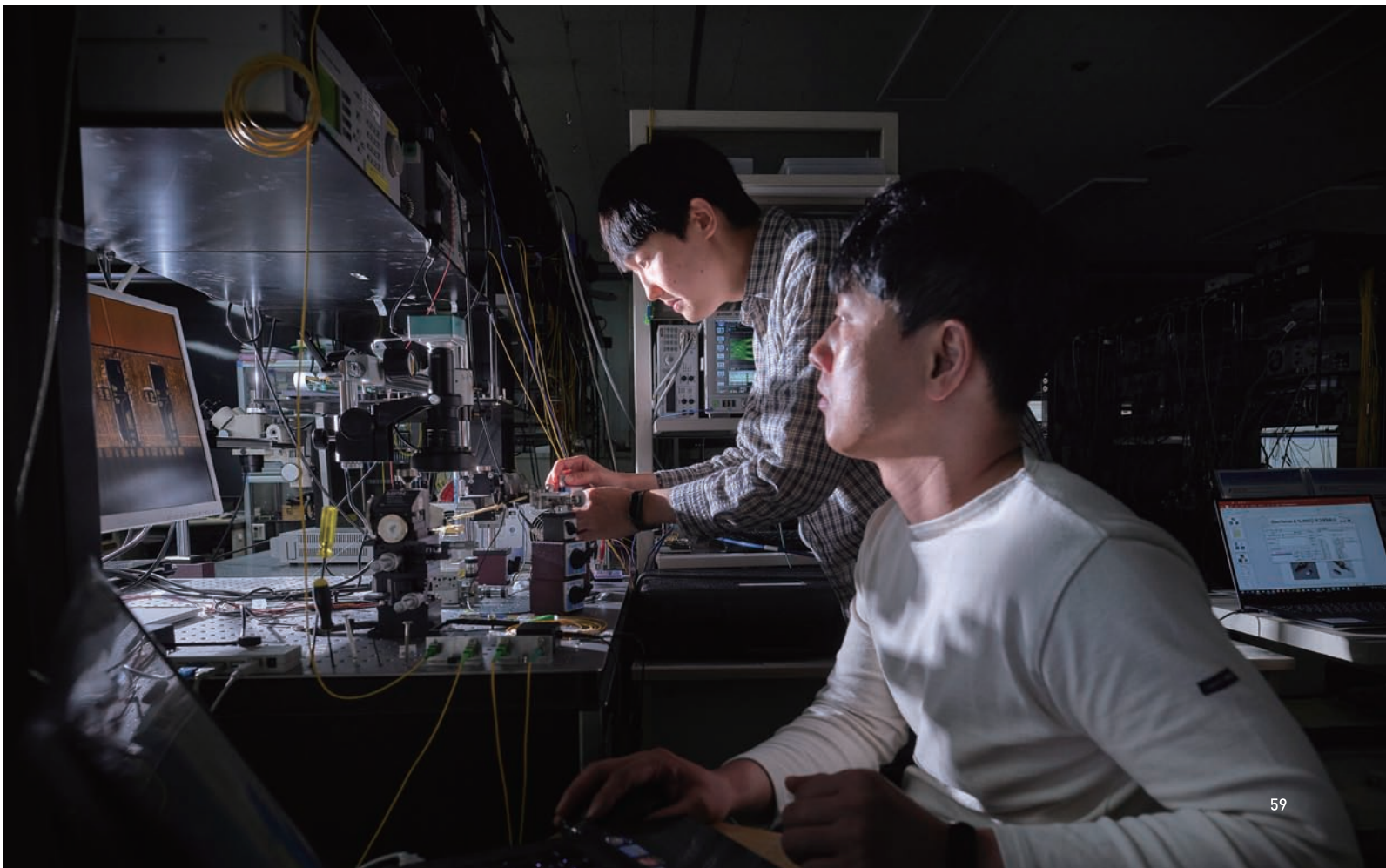
Of course, there was a case in the past where EMLs with lower transmission performance were connected with one another to roll out an optical transceiver with 400 Gbps performance. However, as the number of channels increases, costs to purchase parts rise, and the system is hard to downsize.



By increasing the transmission rate per channel, the ETRI’s researchers have solved both the problems. The device developed by the researchers is outstanding in compatibility as well: it can be as a built-in piece in the optical transceiver as before or used as an attachment on the top of the line card in the communication equipment.

Following the development and the patent application, the ETRI will transfer the technology to domestic optical parts companies. The technological breakthrough is good news for the local industry having to prepare for Japan’s export restrictions. It has also laid the foundation for local companies to compete with world-class corporations in the optical transceiver market anticipated to continue to grow in line with an increasing number of data centers. At the commercialization stage, an optical engine is expected to be equipped with 64 optical engines per line card which can process the data at the rate 25.6Tbps.

The ETRI will never stop at the 400Gbps level. It will do everything it can to secure the 1Tbps technology. In the increasingly accelerating data age, the ETRI will continue building on its technological powers in the area. The ETRI will be always working hard for a better future so that everyone can lead a more comfortable life.





## Superconnected society. Self-learning AI service to boost the competitiveness of humans

### BeeAI - KSB AI Platform

are quickly sweeping the world as one of the core technologies to lead the future economy. The emergence of IoT devices means the connection of everything including people, things, spaces, and data, and they serve as the source of enormous amounts of big data. The convergence of IoT, AI, and big data is leading us to the era of the 4th industrial revolution, which will completely overhaul our lives not to mention industries and economy.

**KSB**  
Convergence  
Research  
Department

※ KSB : Knowledge-converged Super Brain



Convergence Research Group of ETRI has been leading convergence research along with 4 other government-funded agencies including the Korea Institute of Energy Research, Korea Atomic Energy Research Institute, and Korea Research Institute of Standards and Science for the past 5 years, with the social and national goal of “Securing technologies for a human-oriented superconnected society to deal with the era of Internet of Everything(IoE).

The team aims to develop the KSB AI platform to provide common infrastructure technologies needed for creating intelligence for the public sector and industries and applying it to the field.

The KSB AI platform technology is for developing “Superconnected self-learning knowledge convergence AI” capable of analysis, inference, and prediction by refining a large amount of data collected from superconnected IoT devices, learning from it independently, and combining it with professional knowledge from diverse domains.

This will be the source technology for resolving social, national, and industrial issues such as optimizing energy consumption, ensuring the safety of plants, and predicting the diseases of senior citizens and will be applied to the establishment of the superconnected intelligence information industry ecosystem for the era of the 4th industrial revolution.

The KSB team released the framework SW for beta service in July 2018, followed by the full-on “BeeAI” platform with versions 1.0 for general use and 19.06 for edge servers. The team is also working on improving and expanding it to a cloud-type platform (v20.06) that can be operated with rich resources on the cloud.

Especially AI services such as senior citizen health (apoplexy) monitoring technology, intelligent distributed building energy management technology, plant leak diagnosis technology, and intelligent

IoE Edge computing technology -- all based on this platform -- will be made available to the public.

For commercializing these, ETRI selected the Korea Research Institute of Standards and Science as the primary partner to develop the technology for monitoring disease-related information such as apoplexy. The research team will work with general hospitals to analyze data based on the biometrics of patients to develop algorithms and find out the influences on the specific disease through data sensing such as heartbeat and food pressure. They plan to make an early diagnosis of diseases from the signals sent from wearables.

In addition, ETRI will cooperate with the Korea Institute of Energy Research to develop the technology of controlling the energy in different sectors of a building, which will be far more efficient than traditional energy controls for the whole building. This will enable optimal energy controls of small and medium-sized buildings while analyzing energy consumption patterns based on temperature, humidity, and energy consumption information of each sector considering the comfort of the user when present in the sectors.

Meanwhile, the Korea Atomic Energy Research Institute will be the partner in applying this technology to power plants for the early detection of gas leak from piping so that quick decisions can be made after monitoring related signals.

They are also working on the “Edge” computing technology for on-site data analysis and intelligent processing to help cloud systems deal with the explosive increase of data.

The KSB Convergence Research Group is running on-site testbeds for verification tests by working with companies based on core technologies and platform software developed from the Phase 2 project. The KSB team will provide technical support to companies in their solution development, verification, and commercialization.



## ICT for effective response of livestock diseases from infection precaution to spread protection

### Integrated management system for FMD(Foot and Mouth Disease)

Even after months of worldwide pandemic crisis of COVID-19, it seems to be showing no signs of becoming dormant. It sure did one thing - realize the fear of an infectious disease by making the world feel phobia and suffer massive difficulties in running a normal society. Viruses infecting human are not the only issue at present, however. Animals are also suffering unprecedented contagions at a lightning speed, and the war to overcome their negative impact is ongoing.



SDF Convergence  
Research Department

※ SDF : Smart Defense for  
Foot and Mouth Disease

There was one infectious disease that preceded COVID-19 in terms of popularity in Korea - it is African Swine Fever Virus(ASF) transmitted from wild boars. ASF does not affect humans but is fatal to pigs, with almost 100% mortality. It shook the foundation of livelihood of a lot of livestock farms directly hit by the death of animals. Its social and economic ramifications are also quite significant due to the raise of the meat price and consumer sentiment shrink.

Today, the SDF Convergence Research Department of ETRI is drawing attention for having succeeded in the attraction experiment to control the number of wild boars, the main culprit of the spread of ASF. SDF utilized ICT technology-based know-hows on controlling animal epidemic using such as CCTVs and detection sensors alongside traditional trap and fodder to monitor the appearances of wild boars in real time and to come up with the attraction method to catch them easily.

The team ran tests on whether using the urine and secretion of a female farm-bred pig shows different results in attracting wild boars. The results of 4 repeated experiments for 2 months in an area with few appearances of wild boars showed that they appear only when there was secretion placed in the area. The experiment provided clues as to an easy way to catch wild boars in low hills or even planes without having to search around for wild boars in rough and mountainous areas.

Widespread since the 2000s, FMD has caused relatively significant social and economic damages. The SDF team of ETRI, set up in response to the need for research for an ICT-based platform for effectively responding to infections, has been conducting research on an integrated management system utilizing AI.

The team developed AI technology for finding out whether a new infection has erupted based on ICT sensors that capture the vocal data and behavioral videos of animals while conducting research for the development of an integrated disease control platform, such as building of welfare-oriented farms to suppress animal diseases, minimization of stress on animals and related analysis, AI-based early analysis of symptoms, and high-sensitive on-site diagnosis of infections, preventing the spread of infections through effective control of vehicles and people.

It was in the midst of these efforts that the occurrence of ASF was confirmed; thus, the SDF team conducted the experiment in a bid to broaden activities for expanding its response system. The SDF Convergence Research Department believes that the analyzed results of smell and sounds that attracted wild boars can be applied to other animals such as wild cats and water deer.

"We are more than glad to be of practical help in resolving the issue facing the livestock industry with AI-based animal disease monitoring and know-how from response research. This experiment will be the trigger for utilizing AI to address animal infections, beyond FMD and ASF," said Yu Han-young, the chief of the SDF team.

The SDF team plans to build a testbed farm in the form of a living lab and an integrated platform to advance the results for utilization by farmers. The team will also work with the Ministry of Agriculture, Food and Rural Affairs, Animal and Plant Quarantine Agency, and Veterinary Service Laboratory on utilizing ICT technologies while collaborating with the Ministry of Environment to address issues of wildlife animals.



# DMC Convergence Research Department

※ DMC: Defense Materials and Components

## National Self-Defense Realized through ICT: We Take Matters into Our Own Hands!

Localization of Core Semiconductor Components for Defense Weapons Systems and Platform Development

While the convergence industry using ICT has been regarded as a key industry for securing the future growth engine of the country, one of the new areas of attention is defense. In the future battlefield, which is expanding not only on land, but also in the air, sea, and space, the application of advanced ICT is expected to become more important in various fields such as weapons, combat, and defense operations. ETRI is striving to apply the world's leading ICT to national defense and to realize national self-defense.

The development of independent high-tech weapons systems has been progressed for the purpose of strengthening military forces and securing economic development by exporting weapons. However, Korea still depends on imports for many of the core parts of advanced weapon systems.

In this situation, the export license (E/L) of advanced countries is being strengthened, so it is necessary to independently develop core weapon systems and components and secure localization-based technologies. In particular, in the field of military semiconductors, the United States, Europe, China, and Japan have invested enormous budgets to complete the government-led core infrastructure and conduct R&D. As there is no specialized military laboratory for military use in Korea, it is urgent to expand the domestic infrastructure and build a platform for the development of military semiconductor devices. In response, ETRI began to localize defense materials and components and secure original technology. This is expected to be of great help in securing core power technology and realizing self-defense to respond to the situation of neighboring countries.

The DMC Convergence Research Department is an organization that is supported and supported by the National Institute of Science and Technology (NST) Convergence Research Project to develop the core semiconductor components for defense weapon systems and develop platforms by utilizing excellent technologies possessed by

government-funded researchers and civilians.

ETRI hosting DMC Convergence Research Department builds a core component platform for compound semiconductors and silicon-based logistics. Currently, the researchers are developing gallium nitride (GaN)-based high-frequency power devices and monolithic microwave integrated circuits (MMICs), which are core components for surveillance reconnaissance weapon system radar. Silicon-based high-voltage switches and non-cooled infrared image sensors, which are core components for semiconductors for firearm weapons system detonators, are also major targets for development. In addition to developing components, the researchers plan to develop reliability technology for core components for military use and to build a core parts platform and foundry service for military use.

The DMC Convergence Research Department plans to devote itself to securing core technology for defense and establishing a foundation for self-sufficiency with organizations with know-how beyond the conventional customs that had been immersed in the competition for simply winning defense projects. The project is expected to proceed by the end of 2022, and researchers are working to retain the competitiveness of related industries by localizing defense components and self-sufficiency of military components technology in general.





# IoT Services Growing Smarter through Edge AI Service Technologies

## edge AI technologies

Things that were possible only in movies now come true: intelligent CCTV identifies and tracks criminals with a single photo and homes save energy by predicting weather fluctuations. The rapidly developing IoT and AI are permeating our daily lives in a variety of ways. Most notably, edge computing-based AI technologies have expanded their impacts on IoT devices so as to provide smarter performance by collaborating with the cloud-based AI technologies. Today, edge computing-based AI technology is being evolved continuously beyond anybody's guess.

A hyper-connected society has arrived where people, devices, and things are interconnected by the IoT for the establishment of an intelligent network. Smart home devices remind people of their schedules. People can control the temperature at home and turn gas on and off while they are outside. Smart refrigerators read the shelf life of food and automatically place orders for necessary goods. All such things have become possible thanks to the blending of AI to the IoT technologies.

Cisco predicts that approximately 29.3 billion devices will be connected through the Internet by 2023. However, there exists a problem that should be resolved in order to provide AI services to such a large number of devices. The problem is how to handle an explosively increasing IoT data traffic.

Providing cloud-based AI services cannot avoid facing limitations in terms of network bandwidth and computing resources. To resolve such a problem, edge computing technology has received a considerable attention as a promising solution.

The edge computing technology resolves the shortage of network and computing resources by carrying out networking- and computing-intensive workloads nearby workplaces instead of in the cloud. Most notably, the competitiveness of edge computing technologies has increased due to recent advances in the performance and efficiency of the processors that perform computing tasks along with the development of hardware accelerators dedicated to machine learning such as GPUs, NPUs, and TPUs.

Edge computing technologies are expected to be widely used in environments requiring network cost reduction, real-time response, and data privacy. It can be implemented in various fields such as manufacturing, energy, medical care, transportation, and smart city, where continuous services must be provided even when network resources are limited.

In order to provide a customized site-service to small industries, Honam Research Center has developed the followings : Plug-and-play type edge computing gateway HW platform, EdgeX based edge computing gateway SW platform, FPGA-based data processing engine, and open-source-based lightweight AI inference engine. Furthermore, the center has already developed prototypes of modular edge computing gateways that can flexibly respond to changes in hardware and software according to different service requirements by different industries. The center also completed the development of an edge computer-based AI service optimization technology to offer optimal AI services.

The center has published 8 research papers at home and abroad and filed 12 patents in Korea. In partnership with business, it has set up a test bed for R&D on 'Edge Computing Solutions for Plant and Building Energy Management.' It is expected that the edge computing gateway developed by the center will be implemented across various industries and in everyone's daily life to build not only smart cities and smart factories but also smart homes and smart vehicles.



Honam  
Research Center



## Integrated Smart Farm Solution, All-Round Solver in Agriculture

### Integrated Smart Farm Solution

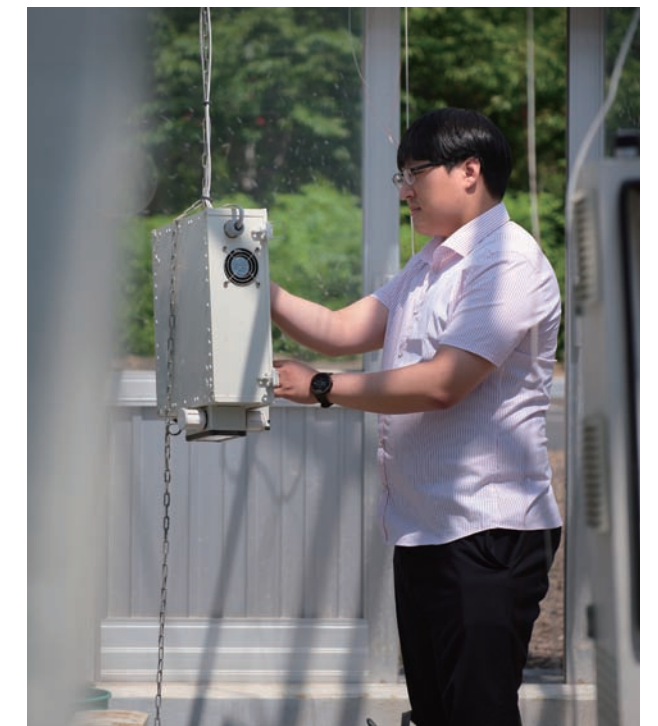


Daegu-Gyeongbuk  
Research Center

The Robot harvests fruits and vegetables in the farm. Now, agricultural drone that only covered the pesticide spraying area, is expanding the field to sowing, yield measurement, and disease prediction. On intelligent farms without people, crops are grown smartly. This unfamiliar farming is approaching reality, not imagination. This is a new smart farm blueprint in progress at ETRI.

Food shortage is now a predictable disaster to anyone. Although the population has increased, the reality is that the agricultural population has decreased by the ageing. There are researchers struggling to find a solution to this problem. They are the ETRI's researchers who are trying to address the difficulties and problems faced by the agricultural industry through a 'smart farm' tapping into scientific and technological advance. The smart farm uses ICT to measure and manage the growth environments 'without time and space restrictions' thanks to science-based agricultural technology involved. In the United States, even nanotechnology and robotics technology are applied to agriculture as well as the IoT. The Netherlands known as a top agricultural producing country in Europe has developed various sensors and control solutions based on data and know-how accumulated over a long time while promoting production management and quality optimization through big data analysis. The smart farm market continues to grow in many countries. Global competition is intensifying, too. The Korean government also considers smart farming as a key growth engine in agriculture and is promoting its dissipation as a critical issue. With the goal of developing 'AlphaGo for Agriculture,' the ETRI's Daegu-Gyeongbuk Research Center has been conducting intensive research since 2013. Most notably, the center has further developed the comprehensive smart farm environmental control technology developed by the Division of Convergence Research of the National Science and Technology Research Association(NST). It has already commercialized the technology for 60 farms in Korea including Pohang Sunrise Farm. In partnership with ISU group, the center has also exported the smart farm solutions to large greenhouses located in Xinjiang Province, China. It was Korea's first establishment of a large-scale smart farm overseas. For the optimal management of the greenhouses, Korea's most advanced and precise comprehensive environmental control solutions were applied. Most notably, the software provided to the farm is not only customized for the diverse types of greenhouse structure. It is also equipped with the duplexing technology and the complex environmental control logic required to guarantee the reliability of the

real-time alarm system, other systems, and the entire software. Currently, the center is also focusing on consulting services by cultivation experts while carrying out research on the development of cloud-based smart farm solutions and element technologies required by autonomous smart farms. In 2021, the center is planning to embark on full-fledged research on AI-based autonomous smart farm technologies that can optimally control the greenhouse environment autonomously through the analysis of big data about the complex environment inside and outside the greenhouse including plenty of visual information. It will soon become a reality to operate a fully autonomous greenhouse where artificial intelligence farms on its own without human intervention - the final goal of the center.





## Communicating AI Technologies

### AI Open API Service

A young man representing a start-up looks around the exhibition hall with a twinkle in his eyes in pursuit of new business opportunities related to AI. Students are also keeping their ears open for the latest research trends in AI-related studies. 'ETRI AI Practice Tech Day' held at the COEX exhibition hall was a meaningful opportunity to communicate with other people through AI technology while helping further strengthen the country's AI industry's competitiveness.

Seoul SW-SoC Convergence  
R&BD Center



In December 2019, the ETRI led by the Seoul SW-SoC Convergence R&BD Center hosted the 'ETRI AI Practice Tech Day' event at the COEX and strengthened networking for the development of the AI industry. Declaring the 'Total Research Institute of National Intellectualization Making a Better Tomorrow' as its vision, the ETRI created an opportunity to share the core AI technologies that it was developing. The Seoul SW-SoC Convergence R&BD Center prepared informative contents and exciting events.

The first session featured four topics such as ETRI language intelligence technology and application, visual intelligence and practical application, complex intelligence R&D and application, and prospects of big data technology developing into AI technology. In addition, the ETRI's AI research was introduced, and discussion was made with those interested in various social issues.

Interest in AI was so great that the exhibition hall was packed. People preparing for business in related fields, those working for AI-related venture companies, and students majoring in AI-related subjects paid keen attention to the ETRI's latest AI research and development status sharing valuable ideas with others at the gathering.

The ETRI opened its API in October 2017 so that domestic SMEs and startups as well as researchers can apply the AI SW results it had developed through the support of the Ministry of Science and ICT to their AI product & service development more easily and efficiently. Most notably, the ETRI has released 28 studies related to the analysis of the Korean language, speech processing, and conversation

processing and more than 27 million accesses have been made by domestic developers in universities and research institutes as well as SMEs and startups at the following access rate: industry (40%), university (36%), individuals (20%) and other (4%). The ETRI is about the release questions and answers on legislation, human attribute detection technology, Vietnamese speech recognition technology, and object detection learning data, among others.

Ahead of the opening of the tech concert, Seoul SW-SoC Center asked for the submission of success stories and presented awards to outstanding cases in the utilization of the platform.

The Kumoh National Institute of Technology team won the grand prize for the development of honor of the target by creating an application 'Puing-Puing' that provides detailed information about food, drug ingredients, and materials, which are difficult to identify using the ETRI's published language analysis API and Wikipedia Q&A API. The other award-winning teams made presentations on their cases in session two, drawing keen interest from officials concerned. The ETRI SW-SoC Convergence R&BD Center, which successfully hosted the tech concert, plans to continuously develop such a communication opportunity in a bid to share with others its AI research achievements and experiences. It also plans to grow into an innovation leader that could lead the development of local industries through the development of artificial intelligence application solutions required by SMEs located in the metropolitan area.



# Part 2

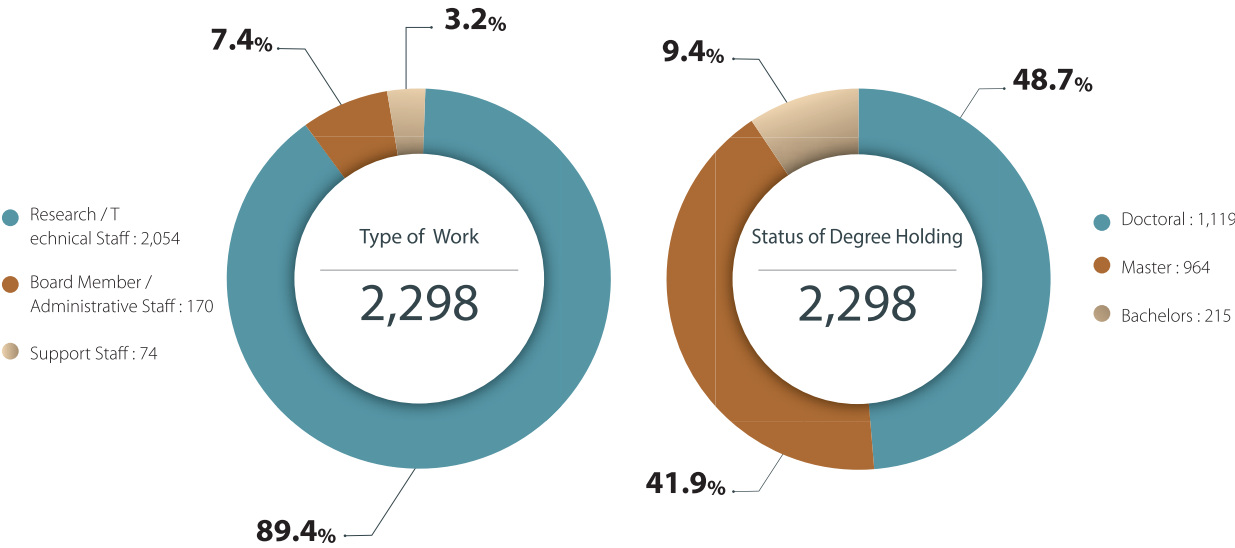
## General Status

74	Personnel & Project Status
75	Patent Application & Technology Transfer
76	Standardization & SCI Papers & SCI Expanded Papers
77	Status and Progress Laboratory Enterprise Status
78	Nationwide Regional Research Center
79	Global R&D Cooperation Network

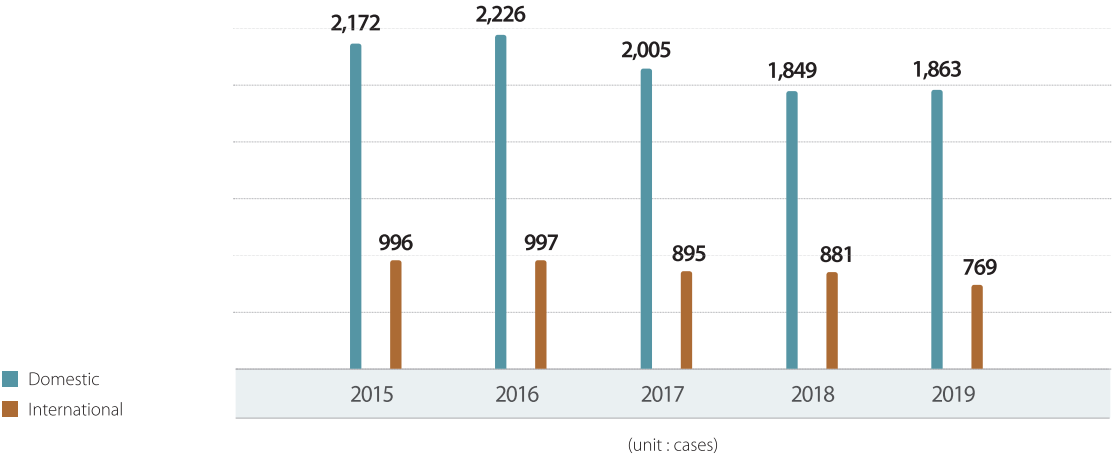


PERSONNEL

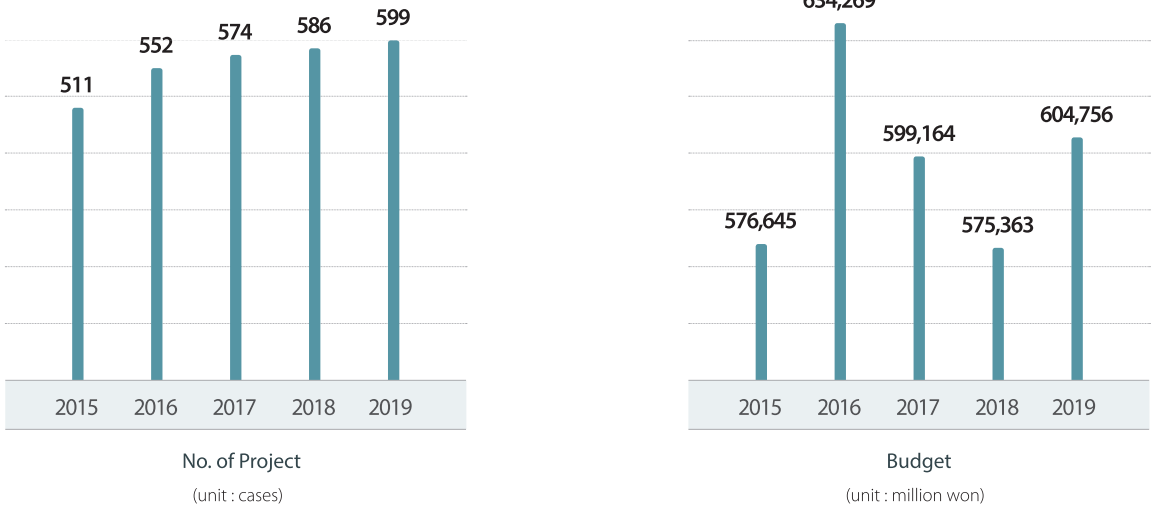
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June, 2020



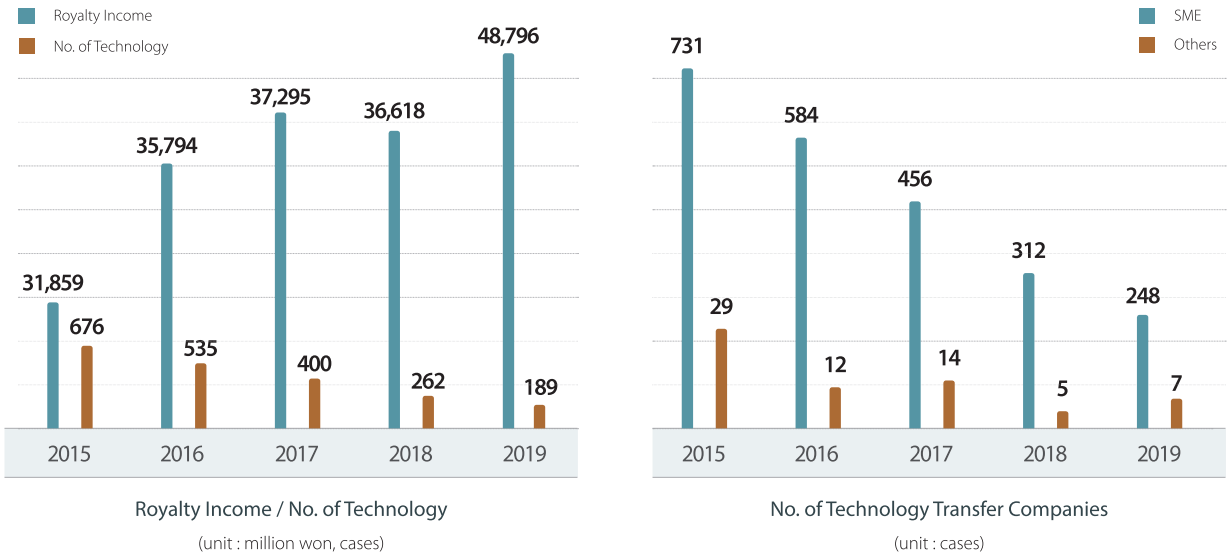
PATENT APPLICATION



PROJECT STATUS

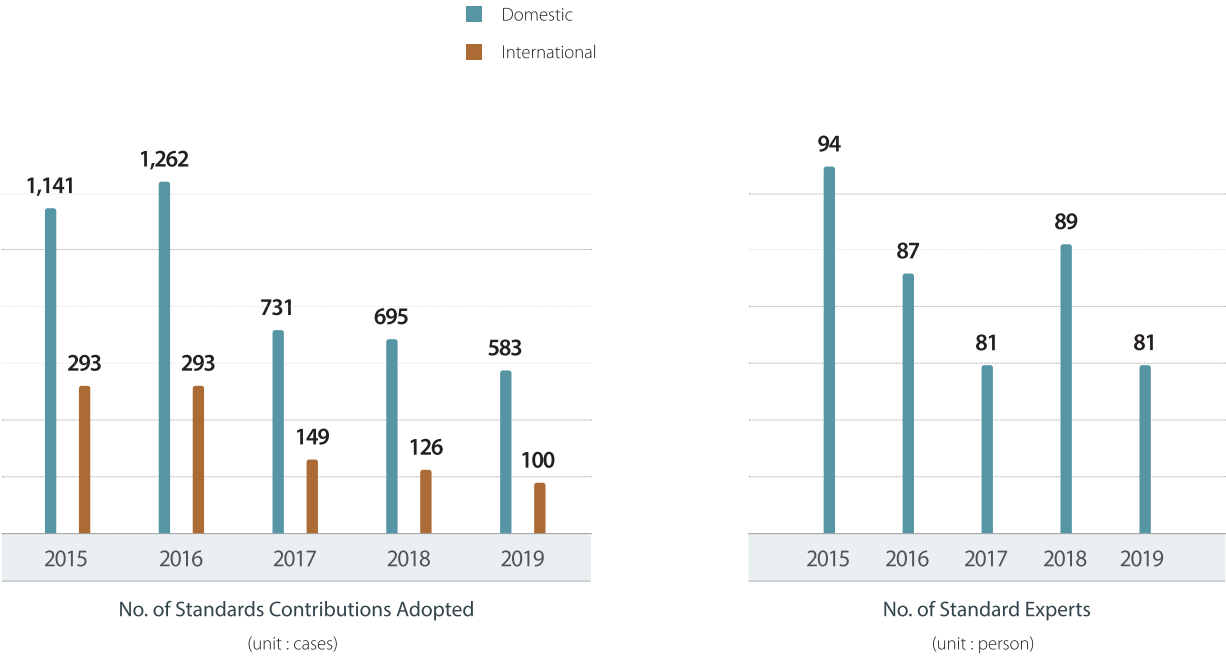


TECHNOLOGY TRANSFER

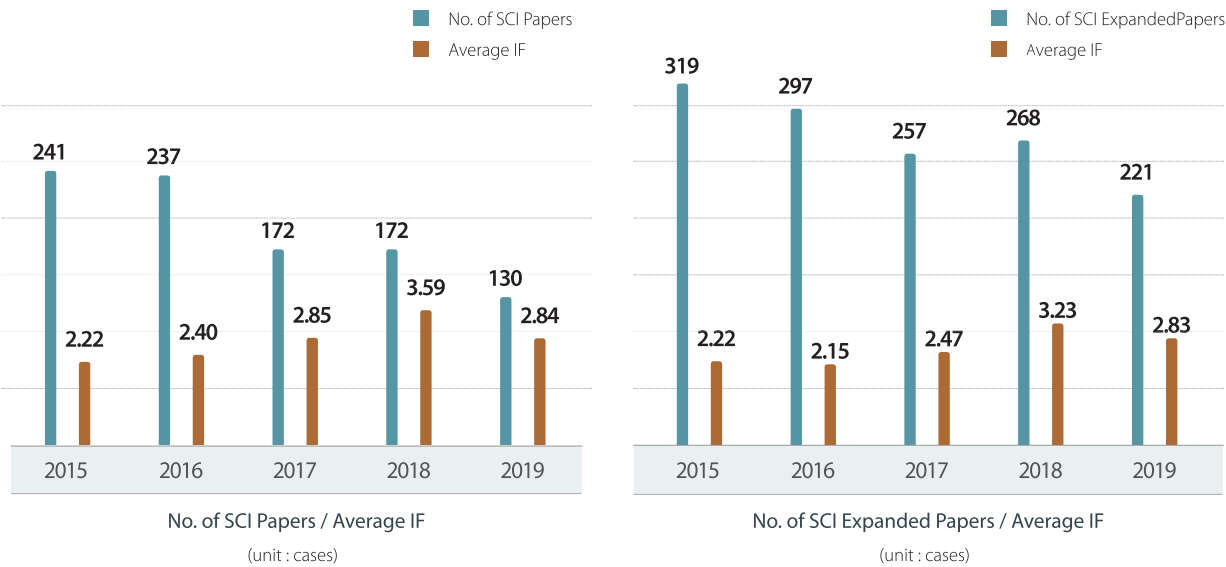




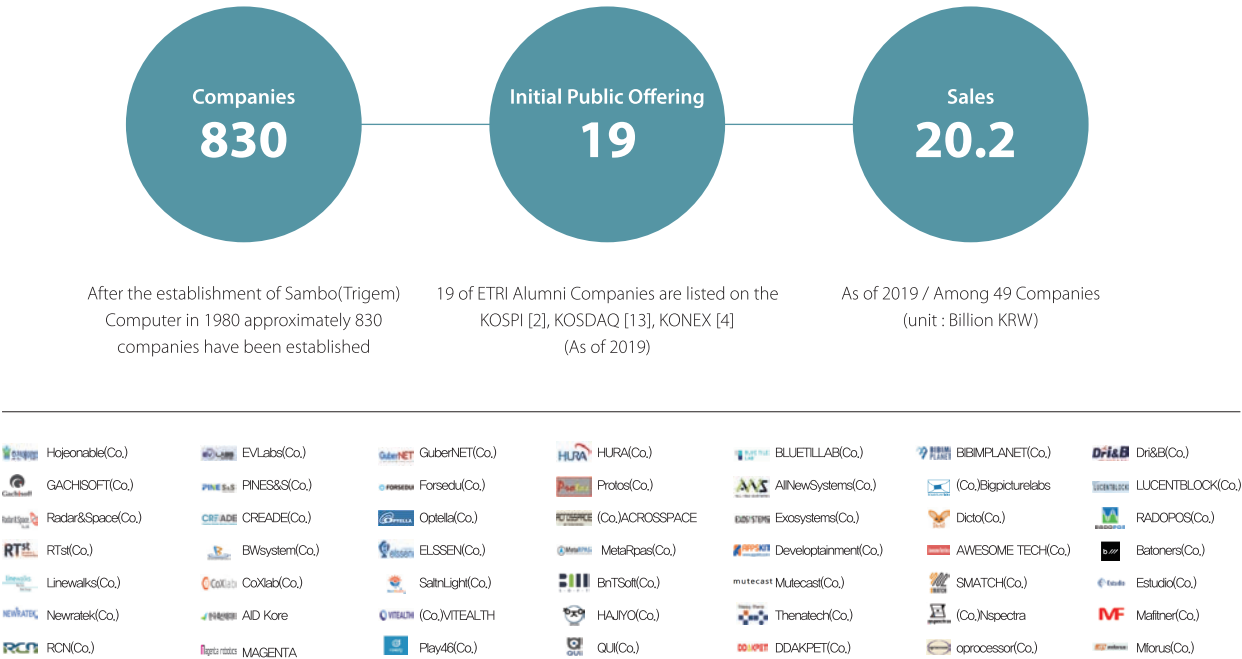
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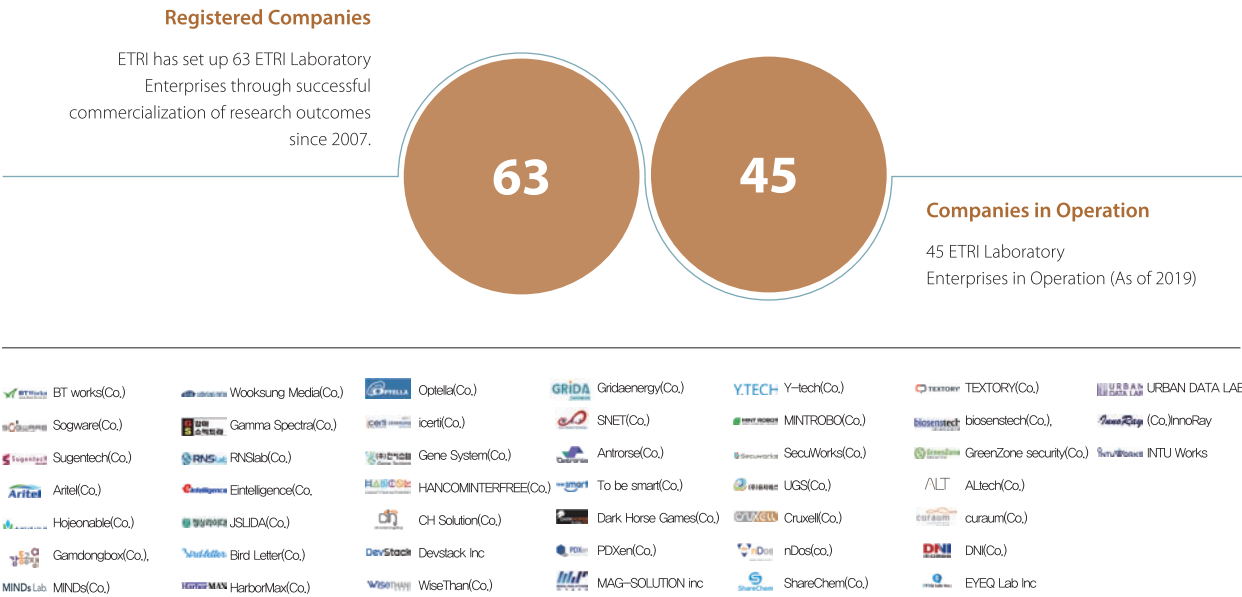
SCI PAPERS & SCI EXPANDED PAPERS



STATUS AND PROGRESS OF ETRI START-UP



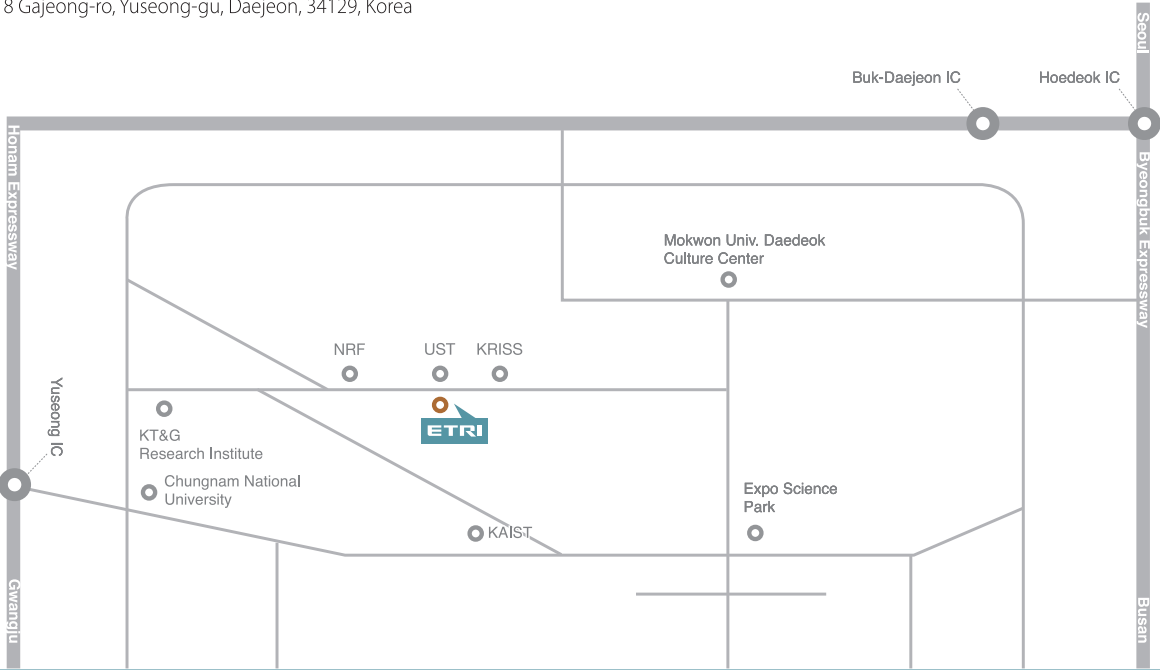
ETRI LABORATORY ENTERPRISE STATUS



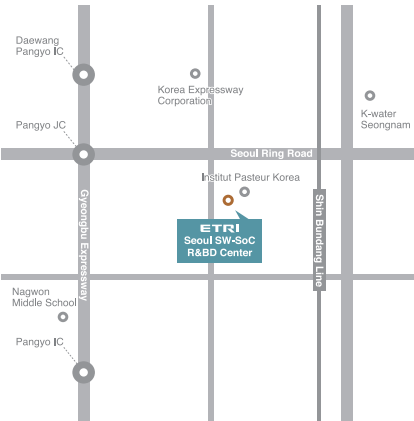


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<b>GERMANY</b> Fraunhofer IAF / Universitat Zu Lubeck / Rohde&Schwarz / X-FAB / MERCK / BOSCH / Fraunhofer Institute for Telecommunications / BMW / Julich / ESCRYPT / BMBF	<b>JAPAN</b> RIKEN / Morita Tech / Zeon / Konica Minolta / NHK / DNPT & DNP / Heartwell / Novatech & Sharp	<b>TAJIKISTAN</b> Technological University of Tajikistan
<b>BELGIUM</b> Solttec Belgium N.V.	<b>CANADA</b> IP Cube Partners / University of Saskatchewan / CRC Canada / UHN / University of Waterloo	<b>JORDAN</b> Ministry of Information & Communication Technology
<b>ISRAEL</b> ARO Volcani Center / Design Art Networks / FINLAND	<b>IRAN</b> Ministry of Science and Technology / Adama Science and Technology University	<b>THAILAND</b> Royal Thai Air Force / Guru Square Co. Ltd.
<b>KAZAKHSTAN</b> Transtelecom / IGITC(International Green Technologies & Invest\-ments Center)	<b>BRAZIL</b> PMCSierra / Cryptography Research Institute / Vanguard Video / AMD / Sedicii Innovations Ltd / Intel / Open Networking Foundation(ONF) / Via Licensing / ICAP / Argonne National Laboratory / Endolynx Inc. / Netlist Inc. / SEMTECH / University of Oklahoma / Veea Inc. / ONRG	<b>REPUBLIC OF SOUTH AFRICA</b> SENTECH SOC LTD / AFRIKO HOLDINGS (PTY) LTD
<b>ITALY</b> SIM2 BV International / ENEA	<b>PALESTINE</b> An-Najah National University	<b>GABON</b> National Agency of Digital Infrastructures and Frequencies
<b>KENYA</b> Postal Corporate of Kenya / Baringo County Government	<b>INDIA</b> CDAC / Sagacious Research Pvt Ltd / Saankhya Labs Private Limited	<b>BOTSWANA</b> DIS Botswana
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