

Smart Cities: Asia Leads the IoT Patent Land Grab



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Executive Summary

With the advancements in information and communications technology, the world is becoming more interconnected and we can see this reflected in the intellectual property domain as well. The number of patent publications pertaining to smart cities have been rising since 2010 with a total number of ~3849 published patents/applications. In the current year (2020), 45 patent applications had been published to April 2020. The majority of the patent filings are made in Asian countries such as China, Korea, India, Japan, etc. The US has the second-highest number of patent filings followed by China. Further, Samsung owns the maximum number of patents in the smart cities domain, followed by its Chinese rival Huawei.



Background History

The concept of smart cities emerged in the mid-1990s when the internet and digital communications infrastructure began to become widespread. America Online (AOL) was first to suggest the concept of municipal services provided through a network. This concept attracted more attention when a series of smart city plans were formulated for mega cities, including the Amsterdam Digital City in 1993, Helsinki Arena 2000 in 1996, and Tokyo Smart City in 1998. The smart city plans formulated for Amsterdam and Helsinki were primarily directed towards providing internet and internet-based services, such as web platform services for users, however due to a lack of technological advancements and the cooperation of municipal authorities, the plans didn't turn out to be very successful.

During the 2000s, various technological advancements were made in the field of internet and communication services, and these made the concept of the smart city more realistic. Also, the smart city concept began to spread as the commercial benefits were recognized during this period. As a result, various projects were planned in Europe and the US. IBM entered the arena by launching its cooperative initiative, 'Smarter Planet'. Gradually, various conglomerates including Cisco and Siemens too developed their own ideas. At a country level, South Korea introduced the concept of Ubiquitous City (U-City) in 2003. Here the Ubiquitous Cities Act was legislated in 2008 and applied to several new cities, including Hwasung and Dongtan. The Act suggests how a ubiquitous planning system would be formed, from central government down to the local city authorities.

Post-2010, Asian countries, including China and India, have released hundreds of smart city plans, and global smart city projects have gained momentum. Additionally, the development of new age technologies such as AI, IoT, and Big Data added further possibilities to the evolution of the smart city concept.

Early Stage (1990s)	Growth Stage (2000s)	Expansion Stage (2010s)	Implementation Stage (2020s)
<ul style="list-style-type: none"> The term 'digital city' coined with the rise of Internet Digital city plans released by telecommunication and online service providers including AOL Smart city plans formulated for big cities, including Amsterdam and Helsinki 	<ul style="list-style-type: none"> Business potential acknowledged with the spread of high-speed Internet Following announcement of IBM's Smarter Planet strategy, global companies including Cisco and Siemens entered the smart city field The U-City Act enacted in Korea and applied to several new cities 	<ul style="list-style-type: none"> Asian cities, including some in India and China, announced smart city plans A variety of innovation service models and experimental city plans were released by Gooch and Alibaba 	<ul style="list-style-type: none"> Companies, such as Google, Alibaba, Huawei, etc. are planning to implement smart city projects on a large scale

Source: <https://newsroom.posco.com/en/the-evolution-of-smart-cities-and-opportunities-for-steel-industry/>

Definition

Various authors and standardization bodies have provided the definition of the smart city. For instance, the International Telecommunications Union (ITU) (ITU, 2014) which is focused on ICT, published its definition as “a smart sustainable city as an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects”. Similarly, the International Standards Organization (ISO) (ISO, 2014b) defines a smart city as “a new concept and a new model, which applies the new generation of information technologies, such as the internet of things, cloud computing, big data and space/geographical information integration, to facilitate the planning, construction, management and smart services of cities”. Moreover, it defines the smart city objectives to strive for: “convenience of the public services; delicacy of city management; livability of living environment; smartness of infrastructures; long-term effectiveness of network security” whereas British Standards (BSI, 2014) defines smart city as “the effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens”.

For simplicity, a smart city can be defined as an urban area surrounded by smart sensors and devices. These proactively provide information which can be utilized by the governing organizations to manage city operations and services efficiently and effectively. IoT acts as a backbone infrastructure for the smart city concept. IoT may be defined as a network of devices and sensors that communicate with each other to perform assigned tasks, with no, or minimal, human intervention. This is where IoT comes into play in constructing the smart city. The smart city concept provides a platform that integrates IoT and communication technology to optimize efficiency of city operations and services, to share information with the public, and to ensure the welfare of citizens.

Technology Overview

To achieve the concept of IoT-based smart cities, various sensor and physical devices are deployed throughout the metropolitan area to collect the relevant information. The sensors and the physical devices are connected via a communication network to collect data related to citizens, devices, and assets. This is processed and analyzed to efficiently manage the city's assets, resources, and services as the basis for optimizing the efficiency of the city's operations and to connect citizens to the governance system. For instance, monitoring and managing traffic and transportation systems, power plants, utilities, water supply networks, waste management, crime detection, information systems, schools, libraries, hospitals, and other community services.

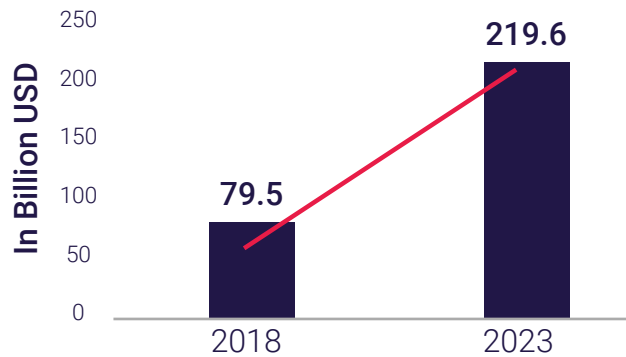
The essential components of the IoT-based Smart City value chain are:

- (a) Data Collection
- (b) Enabling Technologies (for Data Storage and Analytics)
- (c) Communication Infrastructure
- (d) Smart City Applications.

Data Collection	Enabling Technologies	Communication Infrastructure	Smart City Applications
Data collection is performed by sensors/monitoring units deployed throughout the city to collect data related to people, vehicles, weather conditions and city infrastructures, such as hospitals, roads, schools, etc.	Data collected by the sensors/monitoring units infrastructure is stored in a data storage, which may be located locally or remotely. Further, the stored data is fed to a data analytics module, which may utilize various data tools to analyze the stored data and draw outcomes.	Communication infrastructure facilitates wired and/or wireless communication between various components, such as sensors, storage modules, data analytics module, etc.	Information gathered from the data analytics module is utilized to offer various smart city applications or solutions. such as waste management, environment management, water supply management, etc.

Market Forecast

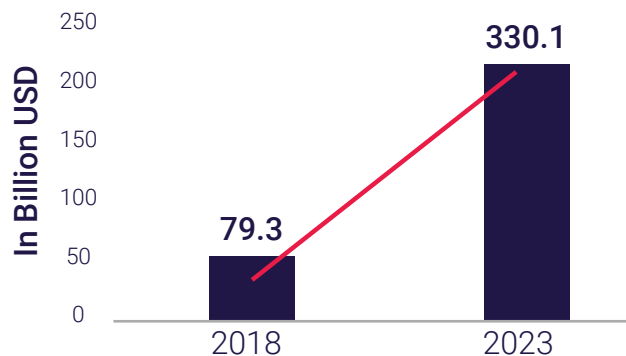
Projected 'IoT in Smart City Market' Revenue
(Source: MARKETSANDMARKETS)



According to a report published by [MarketsandMarkets](#) in 2019, "The Internet of Things (IoT) in the smart cities market is projected to grow from USD 79.5 billion to USD 219.6 billion, at a Compound Annual Growth Rate (CAGR) of 22.5% from 2018 to 2023."





According to a report published by [Zion Market Research](#) in 2019, "the global IoT in smart cities market was valued at around USD 79.3 billion and is expected to reach approximately USD 330.1 billion, at a CAGR of over 22% between 2019 and 2025."

Projected 'IoT in Smart City Market' Revenue
(Source: Zion Market Research)



Patent Trends

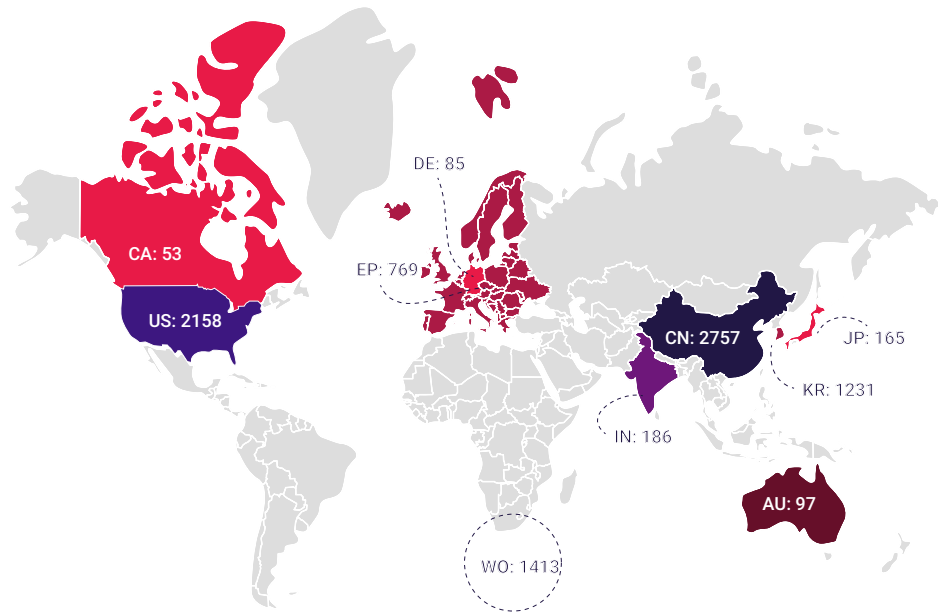
Top Patent/Published Application Holders - Filing Trend

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SAMSUNG 934											
 HUAWEI 164						67	72	212	281	289	13
 LG 56			1				8	21	78	55	1
 QINCHUAN 44							4	7	8	37	
ZTE 29				1	1		24		17	1	
 intel 25	1				1	5	15	5	1	1	
							2	9	8	6	

Source: Charts prepared by UnitedLex IP Team

- Most of the patents/published applications assigned to Samsung (934) primarily relate to Information and Communications Technology (ICT) infrastructure and broadly disclose application of ICT infrastructure in the smart city domain.
- Huawei (164) ranks second in terms of patent filings. Most of the patents/published applications assigned to Huawei relate to Information and Communications Technology (ICT). Huawei also offers an [Intelligent Operation Center Solution](#), which is cloud-based Information and Communications Technology (ICT) infrastructure for the development of solutions and applications for smart cities.
- The patents/published applications assigned to LG (56) primarily relate to 5G communication technologies and its implementation in transportation and the road safety domain. Most of these disclose the application of artificial intelligence/machine learning.
- The patents/published applications assigned to Qinchuan IoT Technology (44) relate to IoT-based solutions for transportation, gas and water supply management, and energy management.
- The bulk of the patents/published applications assigned to ZTE (29) and Intel (25) disclose LTE (4G) and 3G communication technologies and their implementation in Vehicle-to-Vehicle (V2V) communication for road safety. Intel has also partnered with GE to deploy Intel's IoT technology in a smart city platform, called CityIQ. This collects valuable information about the city to improve public safety, enhance convenience and offer new services to improve livability. (Source)

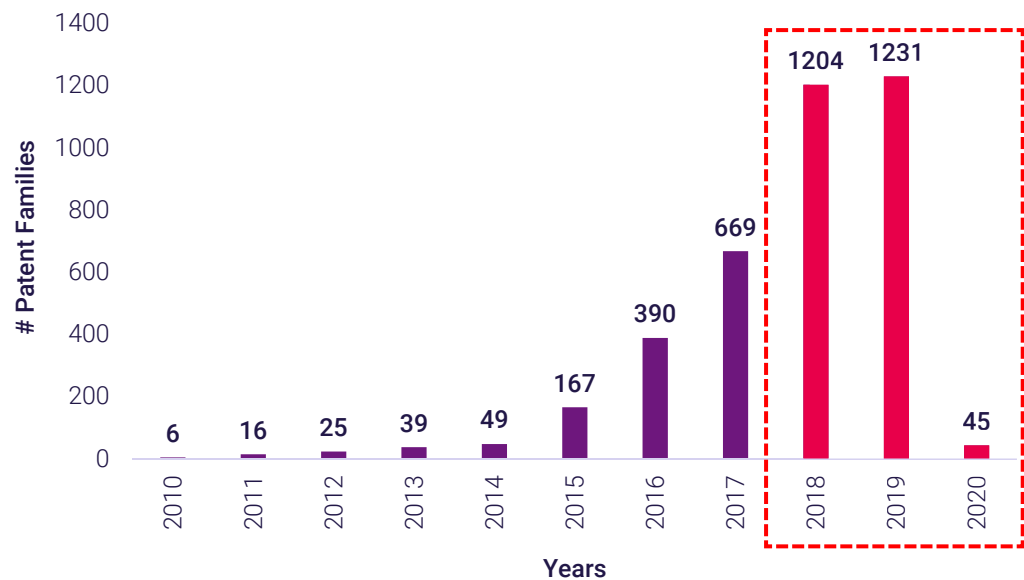
Overall Geographical Footprint - Top 10 Jurisdictions



Source Charts prepared by UnitedLex IP Team

- Most of the patents/published applications were filed in China, followed by the United States, WIPO (WIPO-PCT publications), Korea, Europe (EP), India, Japan, Australia, Germany, and Canada.
- 2757 (~30%) of 9123 expanded family members are filed in China alone.
- China has strong presence in the LTE, 5G and IoT technology domains, thereby, resulting in aggressive patent filings. Additionally, Chinese universities, such as Wuhan University, Anhui Technical College Mechanical & Electrical Engineering, etc. are also actively researching and filing in the LPWAN- and LTE-enabled transportation and energy management domains. Chinese companies, including Huawei and ZTE, are also investing in developing 5G-enabled smart city applications. As a result, ~14% of patent applications filed in China are assigned to Chinese universities.
- Samsung owns more than 50% of the patent applications filed in the US.

Filing Trend



Source: Charts prepared by UnitedLex IP Team

Patent filing activity in 'IoT based Smart Cities' began in the early 21st century; however, the domain started witnessing a significant rise from 2015 and the peak in filings (1231) occurred in 2019. We have extracted a unique patent set of 3849 patents/publications, which translated to an expanded set of 9123 patents/publications.

- Primarily, aggressive patenting activity from Samsung and Huawei resulted in uptick in patent filing from 2015 onwards.
- The domain has witnessed high patenting activity in recent years due to the activity of major IoT platform/service providers, e.g., Huawei, Qualcomm, Intel, etc. in the implementation of IoT in the public domain. Examples are transportation, energy management, etc. Further, the increasing interests of national/state governments towards transforming cities into smart cities for effective governance in the recent years has resulted in aggressive patent filing.

Note:

1. The number of patent applications filed in 2018, 2019 and 2020 may increase as some of the patent applications filed during this period may not have been published.
2. We have shown a Patent filing trend starting from 2010 up to 2020. However, we have analyzed a unique patent set of 3849 patents/publications and an expanded set of 9123 patents/publications.

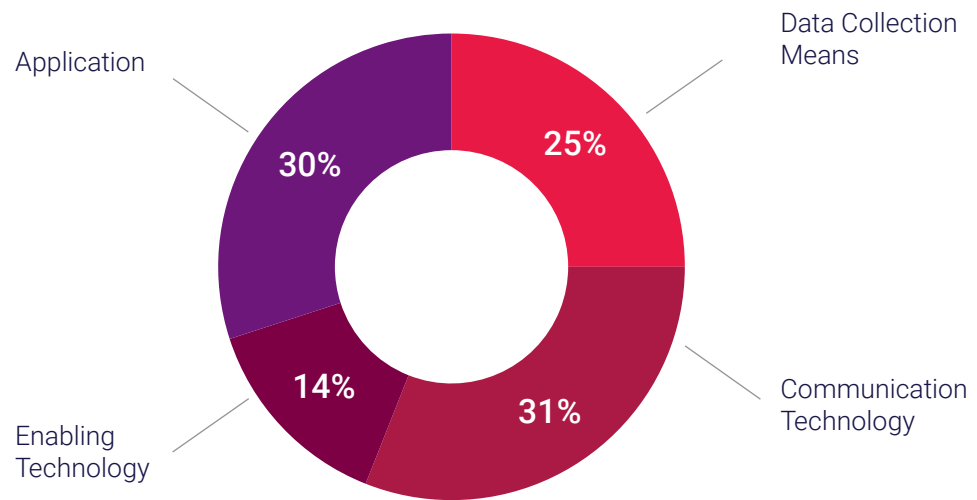
Overall Geographical Footprint - Top 10 Jurisdictions

1		1	1		8	1	1	9	13	12	4		CA
1	2	1					4	9	10	18	17	13	DE
1		1		1	1	1	6	10	32	25	7	2	AU
		1	1	9	1	1	16	43	40	24	91	1	JP
		1	1	20	34			5	32	34	77	35	IN
1	1	3	4	62	20	9	82	132	218	220	15		EP
		1	3	42	20	74	134	194	417	224	98		KR
		13		51	27	11	102	197	325	410	278		WO
				43	31	70	147	178	366	557	727	17	US
1	6	6	21	65	54	36	151	333	474	904	704	7	CN
2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	

Source: Charts prepared by UnitedLex IP Team

- Chinese companies, such as Huawei, ZTE, Qinchuan IOT Technology Co., Shanghai Inesa Group, Terminus Tech Co Ltd, Fangda ITES Technology Co Ltd., and universities including Wuhan University, Anhui Technical College Mechanical & Electrical Engineering, etc., are responsible for the significant number of patent filings in China.
- Primarily, aggressive patenting activity from Samsung, Intel, Ford, GM, and LG has resulted in incremental patent filings in the United States from 2015 onwards.
- Samsung is the major patent filer in Korea (KR), followed by LG, and Hyundai. Samsung offers a product, [Nexshop](#), a solution for targeted advertisements based on customer behavior. Further, the solution monitors customer flow based on machine learning and perspective video-based analytics.
- Samsung, Intel, and Cisco are the major patent filers in Europe (EU). Cisco offers various products, such as [Kinetic for Cities Parking](#) and [Kinetic for Cities Waste Management](#), which offer intelligent parking services and solutions to track waste bins to avoid health hazards respectively.

Technology Taxonomy Charts



Source: Charts prepared by UnitedLex IP Team

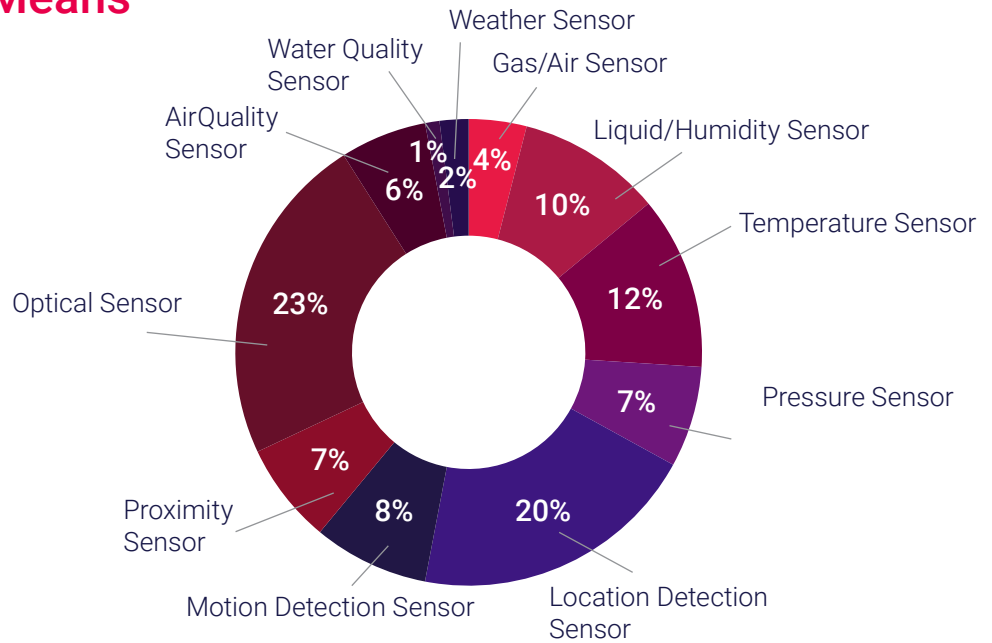
Insights

- Most of the patents/published applications (~97%) tagged under data collection means were filed post-2014.
- In the taxonomy node “Enabling Technologies”, Samsung is the top assignee, followed by Huawei and LG.
- More than 55% of the patents/published applications tagged under “Communication Technology” relate to wireless communication.

Category Definitions

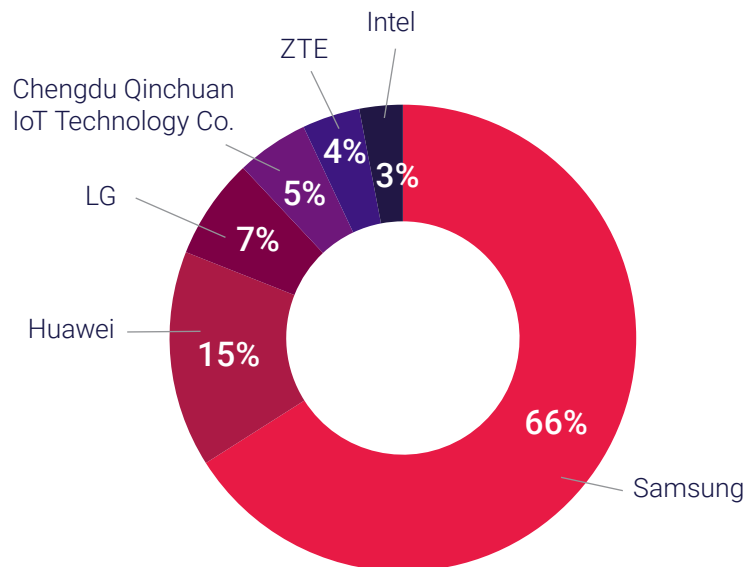
- **Data Collection Means:** Includes patents/published applications disclosing the type of sensors used for collecting data from various resources, e.g., air quality sensors, gas leakage sensors, etc.
- **Communication Technology:** Includes patents/published applications disclosing the use of different wireless and wired communication technologies to communicate between various resources/devices.
- **Enabling Technologies:** Includes patents/published applications disclosing the deployment of new age technologies, such as cloud computing, blockchain, AI/ML, etc. in the smart city domain.
- **Application:** Includes patents/published applications disclosing smart city application areas, e.g., real-time traffic monitoring and management, waste management, energy management, etc.

Technology Taxonomy Charts - Data Collection Means



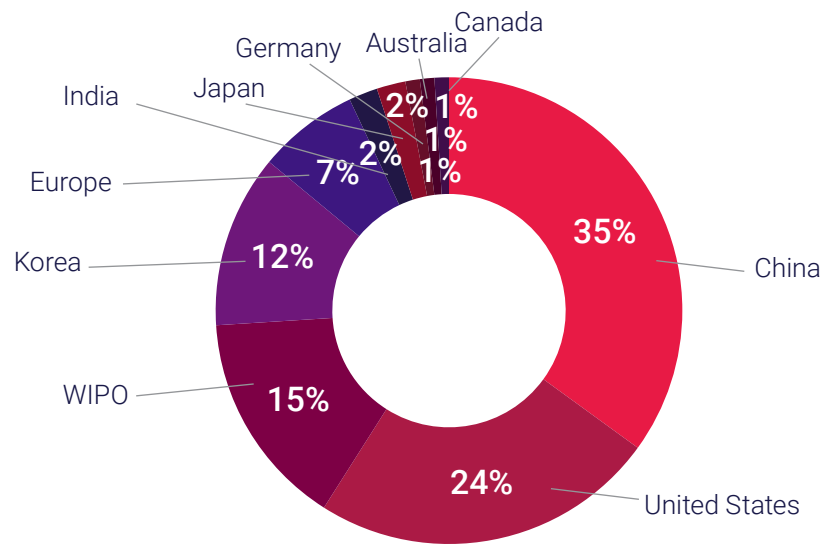
Source: Charts prepared by UnitedLex IP Team

Top Assignees in Data Collection Category



Source: Charts prepared by UnitedLex IP Team

Top Geographies in Data Collection Category



Source: Charts prepared by UnitedLex IP Team

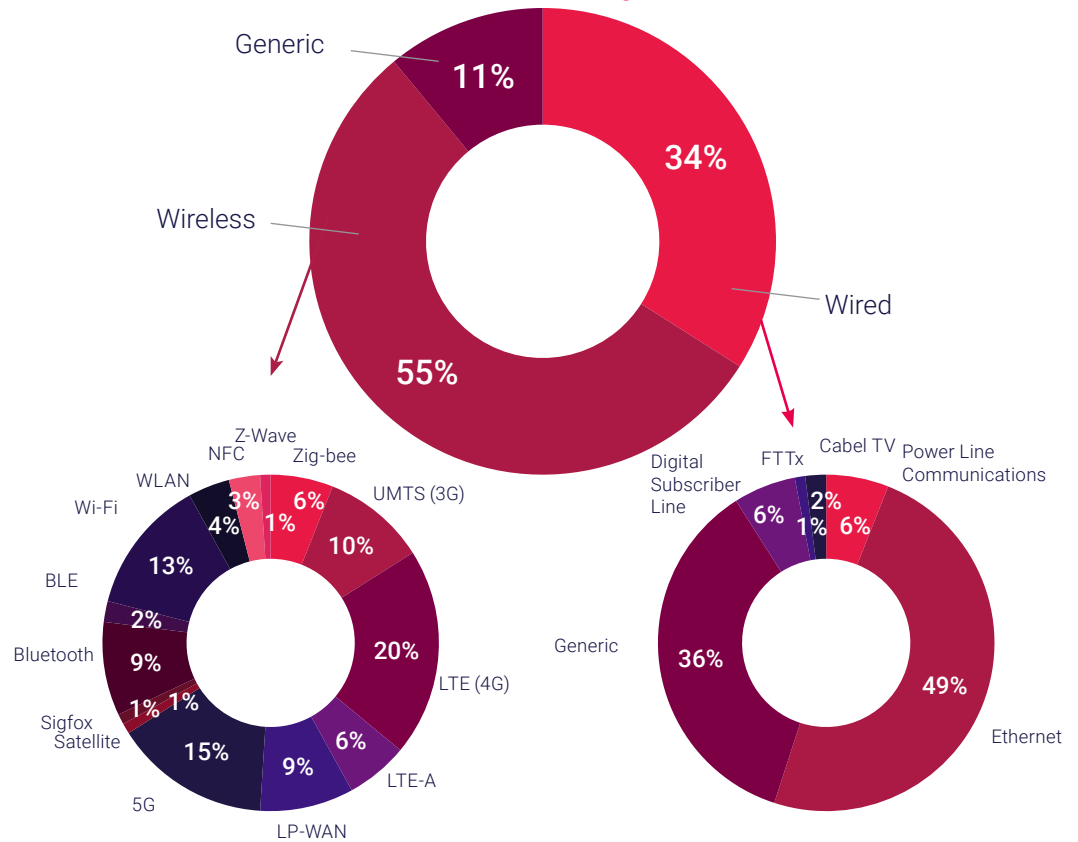
Insights

- In the taxonomy node “Gas/Air Sensor”, Samsung (16) is the top assignee, followed by Chengdu Qinchuan IoT Technology Co. (11). Further, Chengdu Qinchuan IoT Technology Co. has a product which offers an [IoT based smart gas meter](#).
- In the taxonomy node “Optical Sensor”, Samsung (127) is the top assignee, followed by Huawei (84) and LG (45).
- LG is the top third assignee based on the number of patents/publications in the Data Collection category. LG also offers a data-driven platform, [Cityhub](#), that collects and analyzes city data for services in the field of healthcare, education, shopping, etc.
- Intel has just two patents/publications related to “Air Quality Sensor”. Further, to strengthen the Market of Smart Cities, Intel has partnered with Bosch to provide an air quality management and tracking systems for smart cities. ([Source](#))

Category Definitions

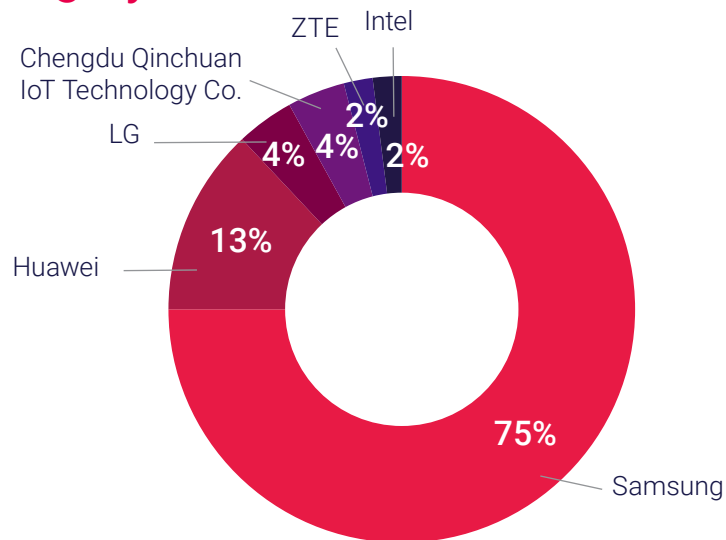
- **Gas Sensor:** Includes patents/published applications disclosing the use of gas sensors for detection and identification of gas leaks and measurements of gas pressure, gas flow, gas level, etc.
- **Humidity/Liquid Sensor:** Includes patents/published applications disclosing the use of humidity/liquid sensors for detection and identification of humidity of air, moisture in soil, water pressure, water level, water leak, water usage, etc.
- **Temperature Sensor:** Includes patents/published applications disclosing the use of temperature sensors for measurement of the environment and other smart city resources.
- **Pressure Sensor:** Includes patents/published applications disclosing the use of pressure sensors for detection/monitoring and measurement of air/atmospheric pressure, pressure gauges, pressure regulators, etc.
- **GPS/GIS:** Includes patents/published applications disclosing the use of GPS/GIS sensors for identification of the location of various smart city resources.
- **Motion Detection Sensor:** Includes patents/published applications disclosing the use of motion detection sensors for the detection and identification of motion or activity of various smart city resources, e.g. detecting vehicle speed.
- **Proximity Sensor:** Includes patents/published applications disclosing the use of proximity sensors for detection and identification of the location of various smart city resources to be implemented in resource management, e.g. fleet management, waste collection.
- **Optical Sensor:** Includes patents/published applications disclosing the use of optical sensors for detecting light and converting it into electrical signals, e.g. cameras, photoconductive sensors, photovoltaic sensors, etc.
- **Air Quality Sensors:** Includes patents/published applications disclosing the use of air quality sensors for detecting the air quality of the environment and other smart city resources like HVAC systems implemented in smart homes and buildings.
- **Water Quality Sensors:** Includes patents/published applications disclosing the use of water quality sensors for detecting the water quality of supply water and analyzing the various pollutants present in the water.
- **Weather Sensors:** Includes patents/published applications disclosing the use of weather sensors for detecting the weather conditions of the city, e.g., snow sensors to detect the amount of snow fall.

Technology Taxonomy Charts - Communication Technology



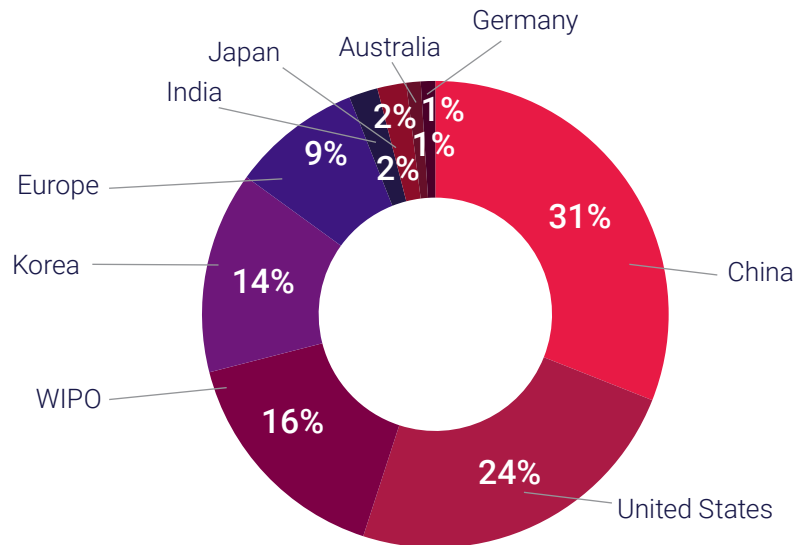
Source: Charts prepared by UnitedLex IP Team

Top Assignees in Communication Technology Category



Source: Charts prepared by UnitedLex IP Team

Top Geographies in Communication Technology Category



Source: Charts prepared by UnitedLex IP Team

Insights

- Most of the patents/published applications are tagged under “Wireless” because of the increasing trend in R&D activities pertaining to wireless technologies.
- Samsung has the maximum contribution of patents in Wireless field, followed by Huawei. Further, based on information from a third-party [source](#), Huawei announced the launch of eLTE Multimedia Critical Communications System (eLTE MCCS), which provides "ultra-reliable" communications solutions for public safety organizations.
- In the taxonomy node “Power Line Communication”, Samsung (8) is the top assignee, followed by Terminus Tech (5), and Huawei (3).

Category Definitions

- **Wired Communication:** Includes patents/published applications disclosing the use of wired communication for transmitting/receiving data from various city resources.
- **Wireless Communication:** Includes patents/published applications disclosing the use of wireless communication for transmitting/receiving data from various city resources.
- **Generic:** Includes patents/published applications that broadly mention the communication means, e.g. IoT, but do not specify the type of communication means/method used.

Wired Communication

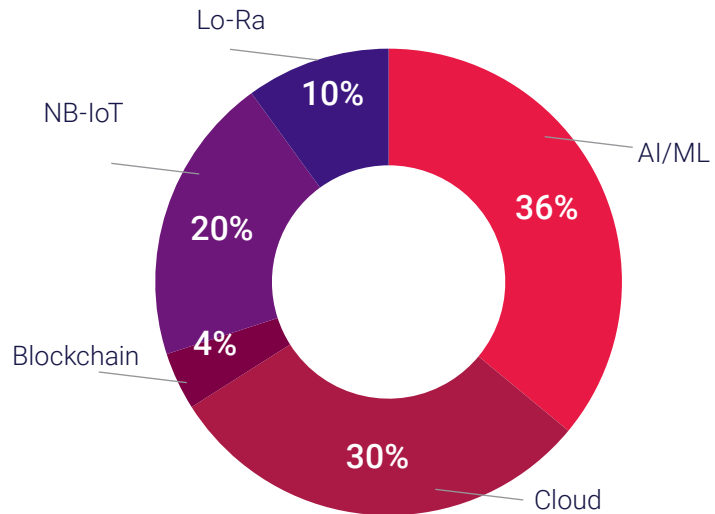
- **Fiber to the x (FTTX):** Includes patents/published applications disclosing technologies that provide broadband network architecture using optical fiber to deliver all or part of the local loop used for last mile telecommunications. FTTX includes fiber-to-the-home (FTTH), fiber-to-the-premise (FTTP), fiber-to-the-curb (FTTC), etc.
- **Digital Subscriber Line (DSL):** Includes patents/published applications disclosing technologies that are used to transmit digital data over telephone lines.
- **Cable TV (CATV):** Includes patents/published applications disclosing technologies that are used to deliver television programming to consumers through coaxial cables.
- **Power Line Communications (PLCs):** Includes patents/published applications disclosing technologies that enable sending data over existing power cables.
- **Ethernet:** Includes patents/published applications disclosing technologies for connecting wired local area networks (LANs), enabling devices to communicate with each other via a protocol.
- **Generic:** Includes patents/published applications disclosing the use of wired communication as a mean of communication between two or more resources. These do not fall under the above categories or identify any specific wired means for communication.

Wireless Communication

- **Universal Mobile Telecommunications System, UMTS (3G):** Includes patents/published applications disclosing a 3G technology-based communication means for sharing data.
- **LTE (4G):** Includes patents/published applications disclosing a 4G technology-based communication means for sharing data.
- **LTE Advanced (LTE-A):** Includes patents/published applications disclosing an LTE-A technology-based communication means for sharing data.
- **Low-Power Wide-Area Network (LPWAN):** Includes patents/published applications disclosing technologies for wireless telecommunication designed to allow long range communications at a low bit rate. LPWAN includes Ultra-narrow Band modulation and telegram splitting standardization. LPWAN includes Sigfox, Lora, NB-IOT, LTE-M, etc.
- **5G:** Includes patents/published applications disclosing a 5G technology-based communication means for sharing data.
- **Satellite:** Includes patents/published applications disclosing technologies for relaying and amplifying radio telecommunications signals via a transponder, creating a communication channel between a source transmitter and a receiver at different locations on Earth.

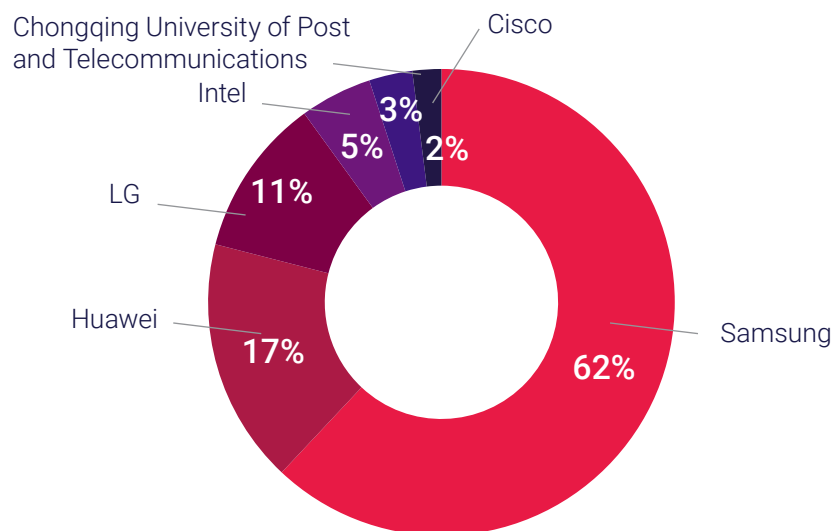
- **Bluetooth:** Includes patents/published applications disclosing technologies for the wireless exchange of data between fixed and mobile devices over short distances using Bluetooth.
- **Wi-Fi:** Includes patents/published applications disclosing technologies for wireless networking that use radio waves to provide wireless high speed internet and network connections.
- **WLAN:** Includes patents/published applications disclosing technologies that allow devices to connect and communicate wirelessly, thereby allowing users to move around the coverage area while maintaining a network connection.
- **Bluetooth Low Energy (BLE):** Includes patents/published applications disclosing technologies intended to provide considerably reduced power consumption and cost, while maintaining a similar communication range as compared to traditional Bluetooth.
- **Near-field communication (NFC):** Includes patents/published applications disclosing technologies that enable two electronic devices to establish communication by bringing them within 4cm (1 1/2 in) of each other. NFC-enabled devices act as electronic identity documents, payment, and keycards.
- **Z-Wave:** Includes patents/published applications disclosing technologies that provide wireless communications protocol used primarily for home automation. It is a mesh network using low-energy radio waves to communicate between appliances, allowing wireless control of residential appliances and other devices.
- **Zigbee:** Includes patents/published applications disclosing technologies that provides high-level communication protocols used to create personal area networks with small, low power digital radios, designed for small scale projects that need wireless connection. ZigBee is a low power, low data rate and proximity wireless ad hoc network.
- **Generic:** Includes patents/published applications disclosing use of wireless communication as a mean of communication between two or more resources that do not fall under the above categories or identify any specific wireless technology.

Technology Taxonomy Charts - Enabling Technology



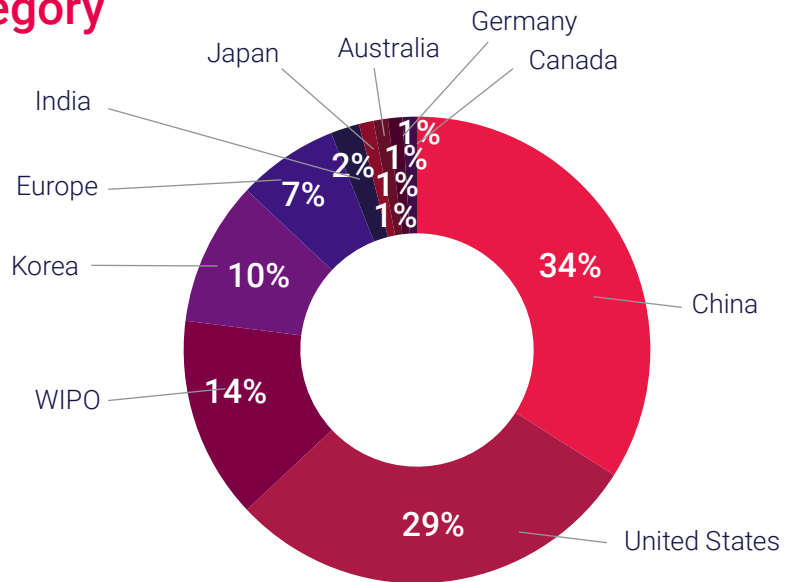
Source: Charts prepared by UnitedLex IP Team

Top Assignees in Enabling Technology Category



Source: Charts prepared by UnitedLex IP Team

Top Geographies in Enabling Technology Category



Source: Charts prepared by UnitedLex IP Team

Insights

- All the patents/published applications tagged under “NB-IoT” were filed after the year 2015. In the current taxonomy node, Huawei (64) is the top assignee, followed by Samsung (43).
- All the patents/published applications tagged under “Lo-Ra” were filed after 2014. In the current taxonomy node, Cisco and Intel are among the top assignees with five patents/published applications each.
- In the taxonomy node “Cloud”, Samsung (154) is the top assignee. Based on the information from a third-party [source](#), Samsung SDS partnered with Telensa on an Urban Data Project based on a cloud platform that builds a trust infrastructure for urban data that allows cities to gather, protect, and use the data for the welfare of the public.

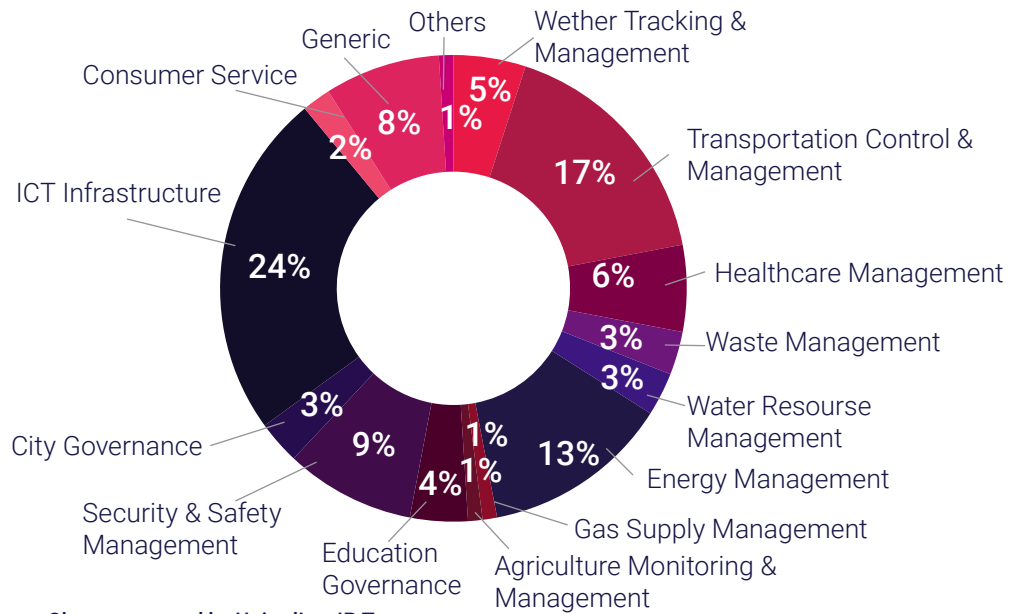
Category Definitions

- **Artificial intelligence/Machine learning (AI/ML):** Includes patents/published applications disclosing technologies that encompass several techniques such as algorithms and heuristics to solve various problems. Artificial intelligence/machine learning includes neural networking, deep learning, prediction models, learning models, decision trees, etc.
- **Cloud:** Includes patents/published applications disclosing technologies that provide on-demand computer system resources, especially data storage and computing power, without active management by the user.
- **Blockchain:** Includes patents/published applications disclosing technologies

that provide a distributed ledger that can record transactions between two parties efficiently, and in a verifiable and permanent way.

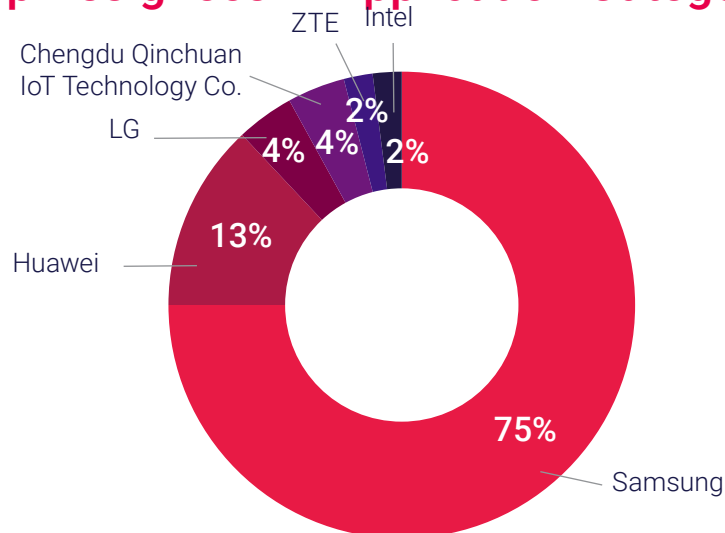
- **Narrowband Internet of Things (NB-IoT):** Includes patents/published applications disclosing technologies that provide a Low Power Wide Area Network (LPWAN) radio technology standard to enable a wide range of cellular devices and services. NB-IoT limits the bandwidth to a single narrow-band of 200kHz.
- **Long Range (LoRa):** Includes patents/published applications disclosing technologies that provide low power wide area network (LPWAN) connectivity for long range, low power IoT solutions.

Technology Taxonomy Charts - Application



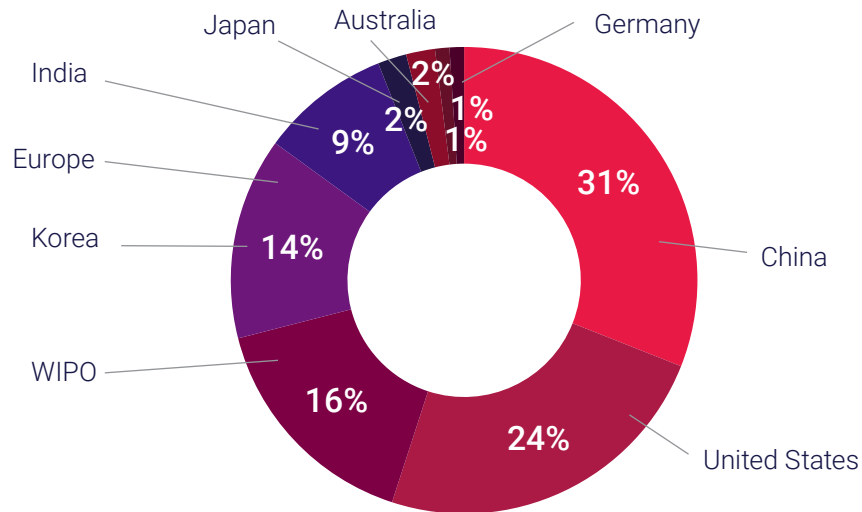
Source: Charts prepared by UnitedLex IP Team

Top Assignees in Application Category



Source: Charts prepared by UnitedLex IP Team

Top Geographies in Application Category



Source: Charts prepared by UnitedLex IP Team

Insights

- Most of the patents/published applications (~90%) tagged under the taxonomy node “Environment/Weather Tracking & Management” were filed after 2015. In the current node, Chengdu Qinchuan IoT Technology Co. and Terminus Tech Co. are the top assignees with five patents/published applications assigned to each.
- In the taxonomy node “ICT Infrastructure”, Samsung (885) is the top assignee, followed by Huawei (147).
- In the taxonomy node “Energy Management”, Samsung (12) is the top assignee.
- For patents/published applications related to “Healthcare”, Samsung (203) is the top assignee followed by LG (11). Based on the information from a third party [source](#), Samsung and SK Telecom have teamed up to build a nationwide IoT network which will provide renewable energy solutions, cloud platforms and big data analytics for needs such as healthcare and medical services, and for autonomous and electric vehicles.
- Intel has 14 patents/publications related to “Transportation & Control Management”. Further, Intel offers [Vision Accelerator](#), a product that facilitates computer vision-based solutions for tracking and managing city traffic.

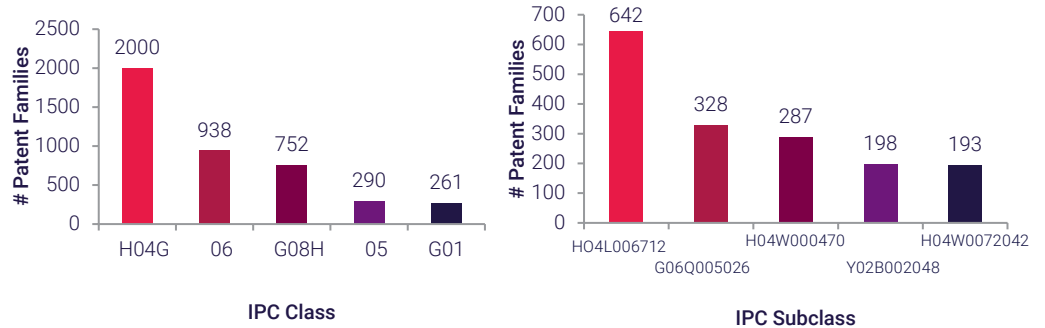
Category Definitions

- **Environment/Weather Tracking & Management:** Includes patents/published applications disclosing technologies for real-time environmental tracking/monitoring/predicting weather conditions.
- **Transportation/Traffic Control & Management:** Includes patents/published applications disclosing technologies for traffic monitoring/regulating, fleet management, vehicle, and pedestrian safety, V2X communication for safety and accident avoidance, public transport management, etc.

- **Healthcare:** Includes patents/published applications disclosing technologies for healthcare service monitoring, first responder management, public health monitoring, online healthcare services, elderly support services, etc.
- **Waste Management:** Includes patents/published applications disclosing technologies for garbage and waste management, garbage bin monitoring, waste resource management, waste bin collection scheduling etc.
- **Water Resource Management:** Includes patents/published applications disclosing technologies for smart water meters, water leaks, water billing/usage monitoring, sewage treatment, etc.
- **Energy Management:** Includes patents/published applications disclosing technologies for smart streetlights, energy management solutions, smart electricity meters, smart HVAC controlling, autonomous light controlling/switching, building energy management, etc.
- **Gas Supply Management:** Includes patents/published applications disclosing technologies for gas pipeline monitoring, gas leakage detection, gas usage detection, gas leak safety, etc.
- **Agriculture Monitoring & Management:** Includes patents/published applications disclosing technologies for agricultural services, smart irrigation services, soil fertility management, plant trimming apparatus etc.
- **Education Governance:** Includes patents/published applications disclosing technologies for library management, smart book lending, school/college student access management, e-learning services, etc.
- **Security/Safety/Crime Monitoring & Management:** Includes patents/published applications disclosing technologies for public safety, security, disaster management, crime monitoring/recording, law/emergency management services, etc.
- **City Governance:** Includes patents/published applications disclosing technologies for city management, community management, city resource allocation, municipality resource management, etc.
- **ICT Infrastructure:** Includes patents/published applications disclosing technologies that include software, middleware, storage, and audiovisual systems, communication devices, software/hardware for IoT based communication, telecommunication services, etc.
- **Consumer Service:** Includes patents/published applications disclosing technologies for consumer services like retail, commodity exchange, hotel services, advertisements, food quality services, smart contracts, etc.
- **Generic:** Includes patents/published applications broadly specifying smart city application.
- **Others:** Includes patents/published applications disclosing technologies for supply chain, chatbots, kiosks, construction, anomaly detection, logistics, etc.

Top Classes

IPC Classes and Subclasses



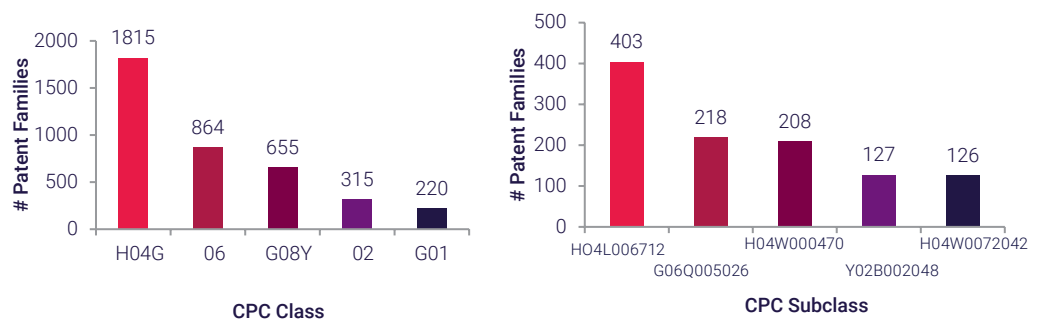
Source: Charts prepared by UnitedLex IP Team

Note: Please refer WIPO IP Portal for the definitions of classes.

Insights

- Top assignees filing under IPC Class H04: Samsung and Huawei.
- IPC Subclasses H04L002908 and H04L00500 under IPC Class H04 pertain to “Transmission of Digital Information”.
- Top assignees filing under IPC Class G06 and G08: Samsung, Chengdu Qinchuan IoT Technology Co. and LG.

CPC Classes and Sub-classes



Source: Charts prepared by UnitedLex IP Team

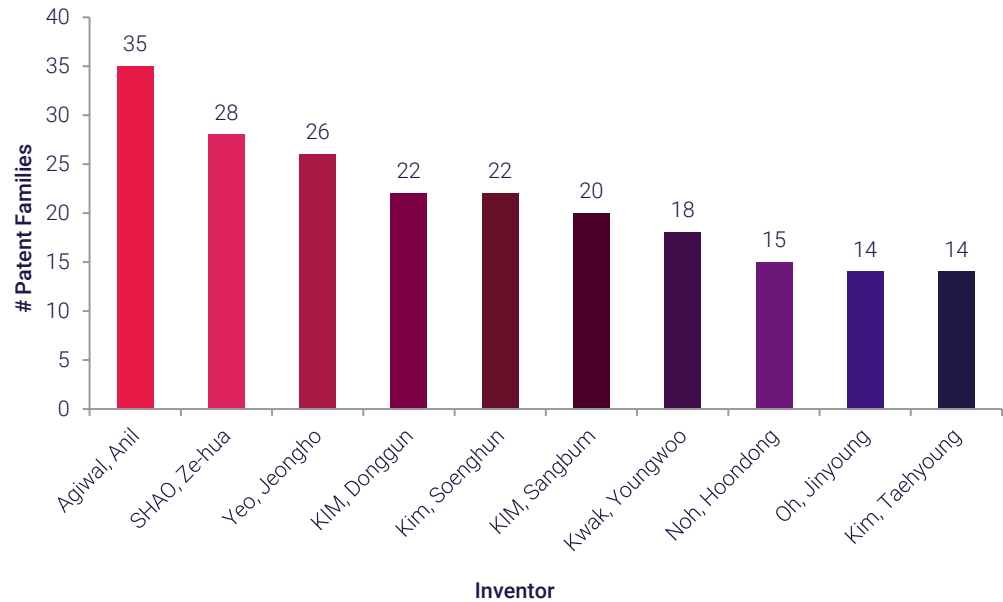
Note: Please refer Espacenet for the definitions of classes.

Insights

- Top assignees filing under CPC Class G01: Samsung and Chengdu Qinchuan IoT Technology Co.

- CPC Subclasses H04W000470 and H04W0072042 under CPC Class H04 pertain to “Wireless Communication Networks”.

Top Inventors



Source: Charts prepared by UnitedLex IP Team

Note: Please refer Espacenet for the definitions of classes.

Inventor	Assignee
Agiwal, Anil	Samsung
Shao, Ze-hua	Chengdu Qinchuan IoT Technology Co.
Yeo, Jeongho	Samsung
Kim, Donggun	Samsung
Kim, Soenghun	Samsung
Kim, Sangbum	Samsung
Kwak, Youngwoo	Samsung
Noh, Hoondong	Samsung
Oh, Jinyoung	Samsung
Kim, Taehyoung	Samsung

Comparing Key Players in Patent Technologies

Samsung

Samsung is the leading player in the smart city domain with a large difference of ~770 unique patent count compared to LG. We have analyzed the sub-categories of four technology categories i.e., data collection means, communication technology, enabling technologies, and application. Samsung has maximum patent filings related to the following sensors for data collection: location detection sensor, optical sensor, temperature sensor, motion detection sensor, gas/air sensor, and air quality sensor. For wired communication, most of the Samsung patents relate to Ethernet and Power Line Communication (PLC). In the case of wireless communication, Samsung owns the maximum number of patents in the following technology categories: 3G, 4G, LTE-A, 5G, Bluetooth, Bluetooth low energy (BLE), Wi-Fi, WLAN, NFC, Z-Wave, and Zigbee. In enabling technologies, Samsung patents mostly refer to the use of Cloud and AI/ML technology. For applications in smart cities, most of the Samsung patents refer to Information and Communication technology (ICT), healthcare, digital education, energy, safety, and consumer services.

Huawei

Huawei is the second-leading player in the smart city domain. In the data collection category, the majority of the Huawei's patents are related to optical sensors. For wired communication, Huawei has maximum patents related to Digital Subscriber Line (DSL). For wireless communication, Huawei owns the maximum number of patents in Low power wide area network (LPWAN). Huawei's patents refer to the use of narrowband IoT as an enabling technology. In addition, most of Huawei's patents are also related to the ICT domain.

LG

LG is the third-leading player in the smart city domain. In the data collection category, the majority of the LG's patents are related to proximity and pressure sensors. For wired communication, LG has maximum patents related to Fiber to the x (FTTX) and Cable TV (CATV). In the case of wireless communication, 5G is where LG owns a good number of patents. LG's patents refer to the use of AI/ML enabling technologies. Further, most of LG's patents describe an application of smart city-related patents in transportation/traffic management.

Chengdu Qinchuan IoT Technology Co.

Chengdu Qinchuan IoT Technology Co. is the fourth-leading player in the smart city domain. In the data collection category, the majority of Qinchuan's patents are related to location and liquid/humidity sensors. In communication technology, Qinchuan's patent filings are related to Ethernet and Satellite communication. Qinchuan's patents refer to the use of AI/ML enabling technologies. Further, most of Qinchuan's patents describe the application of smart city-related patents in gas supply management, transportation/traffic management, city governance, and environment/weather tracking and management.





ZTE

ZTE is the fifth-leading player in the smart city domain. In the data collection category, the majority of ZTE's patents are related to temperature sensors. In communication technology, ZTE's patent filings are related to 4G. ZTE's patents refer to the use of AI/ML enabling technologies. Further, most of ZTE's patents describe the application of smart city-related patents in ICT and transportation/traffic management.

Intel

Intel is the sixth-leading player in the smart city domain. In the data collection category, most of Intel's patents are related to optical and motion detection sensors. For wired communication, Intel has maximum patents related to Ethernet technology. In wireless communication, 4G and Wi-Fi are the technological areas where Intel owns a good number of patents. Intel's patents refer to the use of cloud as an enabling technology. Further, most of Intel's patents describe an application of smart city-related patents in transportation/traffic management.

R&D Activities of Key Players

Company	Activities
1. 	Working towards the concept smart cities that will utilize AI, IoT and 5G. (Source)
2. 	Participated in the formulation of IEEE P2413 (the architectural framework standard of the IoT). In addition, Huawei-proposed Smart City reference architecture standard project P2413.1 which will include Smart City IOC, IoT, descriptions of different vertical applications, and the commonality among them. The architecture will describe the Smart City cloud infrastructure, the edge computing and Big Data analytics technologies, and unified security and management. (Source)
3. 	Proposes the concept of “Smart City 2.0”, which emphasizes the collaboration and governance among the overall eco-system. (Source)
4. 	Provides 5G technology, environmental monitoring solutions, smart lighting solutions, mobility, and public kiosk for smart cities. (Source)

Case Study

The future of IoT is unlimited. It provides solutions in all sectors; cities across the globe are planning and working towards developing IoT-based smart cities. For the implementation of this concept, cities must create the conditions for continuous development; digital technologies are becoming increasingly important, government and technology innovators must collaborate and develop urban infrastructures to solve challenges faced in metropolitan cities such as traffic, pollution, energy management, etc.

Smart Parking in Patras, Greece:

Deutsche Telekom's local affiliate Cosmote implemented Narrow Band IoT (NB-IoT) in Patras with their partners to create a smart parking solution. To date, this has been installed along Patreos Street, a long street that runs through the city center which offers on-street parking. Sensors embedded into the street under the parking spaces sense when a space is vacant or occupied. The detected status is then communicated through Cosmote's NB-IoT radio access network, which was upgraded for this pilot by Huawei, and linked to Deutsche Telekom's core network. The parking data are then collected by a Cosmote's local partner and published on a parking app where residents can view the available parking spaces. The app navigates the driver to the exact parking spot.

The launch of this scheme comes as no surprise as both Deutsche Telekom and Huawei filed patent applications disclosing use of NB-IoT. Deutsche Telekom has 33 NB-IoT related patents/published applications. Their most prolific inventors are Dominik Schnieders, Stephan Spitz and Thomas Gehrsitz. Most of the NB-IoT related patent applications assigned to Deutsche Telekom do not explicitly disclose application of NB-IoT in smart city domain. In comparison, the NB-IoT related patent/published applications, assigned to Huawei broadly disclose application of NB-IoT in smart city domain. Huawei has 64 patents/published applications disclosing NB-IoT based solutions for smart city domain. Their prolific inventors are Zhu Jun and Jia Qiong.

Smart Lighting in Patras, Greece:

The smart lighting solution was installed on Othonos kai Amalias street, which runs along the seafront at Patras. The lighting system is controlled by NB-IoT, which can be adjusted to different light levels at different times of day, thus reducing electricity consumption and improving safety in the local area. The system uses Cosmote's NB IoT radio access network, linked to Deutsche Telekom's core network. The lighting system uses LED technology and Flashnet smart lighting controllers, which is accessed throughout the day by the apps run by its partners.

Deutsche Telekom has additional patent/published applications disclosing the use of NB-IoT, however majority of these relate to the facilitation of communication infrastructure between various devices.

Weather Tracking on Mount Fuji, Japan:

KDDI, a Japanese telecommunications operator is working in collaboration with the municipalities in Gotemba City and Oyama Town to help climbers tackle Mount Fuji by providing weather information. To facilitate weather tracking, KDDI has installed IoT sensors at each of the starting points for an ascent of Mount Fuji to track the temperature, humidity and the number of people passing that point. Thereafter, KDDI provides information to help climbers plan their schedule, clothing, and equipment. At launch in 2017 KDDI used LoRa connectivity to enable the service. In 2018, it switched to LTE-M to reduce costs and to extend coverage.

Waste Management in Singapore:

M1, a Singapore-based telecom service provider, has collaborated with OTTO Waste Systems Singapore to provide a waste management system. IoT sensors are installed in the litter bins to track how full they are so that cleaning crews can be notified. M1 deployed its NB-IoT network technology to develop sensor embedded litter bins.

On similar lines, cities such as Amsterdam, Atlanta, London, Melbourne, and Philadelphia are also testing smart bins. They include sensors to monitor how full the bins are and once the bins are full, cleaning crews are notified. These smart bins are solar-powered.

M1 has also collaborated with Gabkotech, an IoT-based smart building facility management solutions provider, to develop a smart toilet monitoring system. This uses human counter, density, and gas sensors to optimize cleaning schedules for building managers and owners. M1 is using its NB-IoT connectivity to facilitate the smart toilet monitoring system.

Agriculture Management in Malaysia:

Maxis, a communications service provider in Malaysia, is running a trial of Mobile IoT technologies to connect environmental sensors in a plantation. The sensors capture humidity, temperature, and rainfall data, which is relayed to the plantation managers via NB-IoT. Data can be accessed from a PC or smartphone app to ascertain the environmental conditions, predict yield, and identify the parameters that drive productivity.

Future Proofing

The IoT-based smart city domain is booming as players are actively collaborating to facilitate solutions for smart city applications. Technology giants and service providers are acquiring tech start-ups and niche players to strengthen their own portfolio and performance.

Today, China leads the global patent landscape in the smart city domain. Both private organizations and universities are registering patents for an enormous range of activities. And other Asian countries, including Korea, India and Japan, are among the top 10 preferred jurisdictions for patenting activity. In the US, Asian companies, like Samsung and Huawei are driving the patenting activity.

Now this domain has reached its implementation stage and major global companies, including Google, Alibaba and Huawei, are planning to implement smart cities on a global scale. As they do so, we expect patent applications to continue to grow and the landscape to change.

Scope and Methodology

The whitepaper study was focused on identifying and analyzing the relevant patent assets in the smart city domain. Further, the study included various trends in the domain, for example, filing trend, top assignees, top geographies, etc. For the patent mining, we have restricted our search to a larger area/community such as a city, where IoT is implemented. We did not consider home automation and/or smart home appliance related patents for the analysis. Please find below the methodology:

Step I

- Understanding and High-Level Taxonomy Preparation
- UnitedLex developed an extensive understanding of the given domain via publicly available literature, websites, articles, products, etc.
- UnitedLex prepared a very high-level taxonomy having one or more categories against which relevant patent families need to be categorized.

Note: Identification of patent families relevant to the technology in question is typically done using databases such as Derwent Innovation to ensure coverage of main jurisdictions. Please note that we use "Collapse by INPADOC" family feature of Derwent Innovation to retrieve the relevant patent families for further analysis.

Step II

- Data Set Preparation & Sanitization
- UnitedLex identified various keywords, classes (like IPC, US Classes, etc.), assignees and inventors and executed various search strategies on Derwent Innovation patent database to identify the patent dataset for the jurisdictions covered by the database. For exhaustive coverage of jurisdictions, UnitedLex also used Orbit database for dataset identification.
- UnitedLex grouped the identified dataset in patent families.

Note: Only one representative patent publication from a patent family is typically considered for analysis; however, all family members (particularly for Jurisdiction analysis) are considered in analyzing trends/charts.

- Detailed analysis and Categorization of the identified patent dataset
- 1. UnitedLex performed a first-level analysis based on Title/Abstract related to the given domain to shortlist potentially relevant patent families.
- 2. UnitedLex then studied the shortlisted patent families in detail (Title, Abstract, Claims, and Detailed Description), and categorized those families into the taxonomy.

Step III

Note1: For some patent publications, where only Title and Abstract is available, such patent publications are analyzed based on Title, and Abstract (or information available). Further, such publications are analyzed based on broadest possible interpretation and categorized accordingly.

Note2: Foreign patent publications are analyzed based on the available machine translation (Title, Abstract, Claims) and categorized accordingly.

Step IV

- Trend Identification and Observations
- UnitedLex conducted a statistical and graphical analysis of the categorized patent families to identify patent filing trends, most important patent assignees/inventors, technology nodes witnessing maximum and minimum patent activity, etc.

Step V

- Non-Patent and Market Study
- Correlated findings from Whitepaper with Market/Non-Patent Literature data.
- UnitedLex also performed NPL search in finding R&D activities of top assignees.



About UnitedLex

With more than 3,000 legal, engineering, and technology professionals globally, UnitedLex enables legal organizations to thrive in the Digital Age.

Over the past 15 years, we have successfully delivered eDiscovery, Source Code and Document Review, IP Monetization, and Contract Management Improvement services to over 25% of the Global 500, 30% of the Fortune 50, and 50% of the Am Law 100.

Contact UnitedLex to learn more about transforming your Intellectual Property function and our broader programs for Digital Legal Transformation.

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