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The 1st Tunisian SMART CITIES Symposium

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Telecommunication Research and Studies Center (CERT)
National IT Industry Promotion Agency (nipa)

Supported by
Tunisia Polytechnic School ( )
Korean Embassy in Tunisia ( )

Welcome message

The Tunisian Government's vision for innovation under the National Strategic Plan "2020-2025" is to promote entrepreneurship, give a decent quality of life to citizens and visitors and promote economic competitiveness to attract industry and talent. These goals can provide the foundation for a smart city and the use of advanced technologies to boost the societal improvement of citizens, across the provision of a range of public sector services, and to foster the economic growth, through the establishment of new industries and fields of business.

A key feature of smart cities is that they create efficiency. Well-designed technology tools can benefit government agencies, the environment and residents. Smart cities can improve the efficiency of city services by eliminating redundancies, finding ways to save money and streamlining workers' responsibilities. The results can provide higher-quality services at lower cost.

CERT, as a public company, has strongly integrated to this project over a bilateral cooperation with the National IT Promotion Agency (NIPA) by conducting the project "Feasibility study of smart city development in TUNISIA" in 2016 and hosted two advisors under the program "Worlds Friends of Korea" in 2019. This cooperation has led to organize the first Tunisian Smart Cities Symposium "TSCS" that invites the national and international universities and companies in the field of ICT to explain their vision for developing the Smart Cities in Tunisia.

I'd like to thank them especially for taking time to let us profit from their experiences and for sharing their knowledge.

I look forward to your comments and hope you enjoy reading the proceedings of the 1st Tunisian Smart Cities Symposium

Sincerely,

Naoufel BEN SAID

CEO CERT

Contribution Chairs

Choen KIM, Technical Program Chair

Born in Busan/Korea in 1953. He has a Diplom-Forstwirt degree as well as a Ph.D. degree in Photogrammertry and Remote Sensing from University of Freiburg i. Br./Germany. Served professor with 29 years since 1989 and is professor emeritus at Kookmin University, Seoul/Korea. He has won many awards (Boon Indrambarya Medal … Chen Shupen Award) in the area of Geospatial Information and Remote Sensing. Since 2019, he as advisor is working for the technical assistance of CERT, Ariana/Tunisia.

Sofiene SGHAIER, International Committee Chair

Holds of an engineering degree in computer science (1996)

Head of the Research and innovation department of CERT, since 2018, Sofiene has over 22 years of professional experience in consulting and expertise in Information Technologies.

At CERT, he works on issues related to IT and telecom infrastructure (billing systems, datacentres design, IT Security system, NOC, etc.), strategy & management, telecom licence attribution. He is also involved in numerous R & D projects in FP7 and H2020 programs.

As a PMO, from 2015 to 2018, in charge of the Infrastructure pillar of the National Strategic Plan “Digital Tunisia 2020” of the Ministry of Communication Technologies and Digital Economy, sofiene led with the Ministry cabinet the concretisation of sever projects such as the universal service, the setup of the National Integrated Network of Administration (RNIA), the national Network Operator Center (NOC), the National Geographic Information Infrastructure (NGIS), etc.

Ahmed GHARBI, Local Organizing Committee Chair

As the head of international cooperation at the Research and studies telecommunications center, Mr. Ahmed GHARBI oversee the operation of promoting the development of collaboration in order to expand customer portfolio and to establish a framework for cooperation in the field of ICT between several partners and international telecom organizations. He holds this position since December 2015.

Over 25 years' experience as a senior expert in telecommunications, with a strong background in radio network planning and radio network optimization, excellent interpersonal skills and the ability to communicate effectively. During this time, he has developed his skills in the following areas :

- Technical acceptance of Telecommunications equipment : Microwave, GSM/RTM, FO
- Coverage and frequency planning of GSM/UMTS networks
- QoS/QoE evaluation for 2G/3G radio networks
- IP QoS evaluation
- Radio networks optimization
- Coverage and frequency planning of radio-relay links
- Radio spectrum management, refarming and on-field measurements
- Evaluation of non-ionizing radiation (NIR) effect on human health
- Technical and economic studies in telecommunication

Mr. Ahmed GHARBI is also a member of the following research projects :

- Management of water resources in Mornag basin, using IoT technologies : Carried out in partnership with the academic entities : Higher school of communication and polytechnic school
- Feasibility study of the communication techno park smart city : Carried out in partnership with National IT Promotion Agency of South Korea and the KOREA ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY

Program of the 1st TSCS

Date November 19(Tuesday), 2019

Time Table

08:30 - 12:00	Registration
10:00 - 10:15	Opening Ceremony
10:15 - 10:30	Coffee Break
AM Session Session Chair : *Associate Professor* Ines Bousnina	
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10:50 - 11:10	**What can RCNN bring to STEG invoice image?** • Takwa Kazdar, Wided Souidene Mseddi, Marwa Jmal, Rabah Attia *Polytechnic School of Tunisia, Univ. of Carthage, Tunisia*
11:10 - 11:30	**Mesh network for smart car parking** • Ali Benbrahim *Tri TUX Company, Tunis, Tunisia*
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11:50 - 12:10	**User-centric privacy implementation in smart home systems** • Sahar Allegue, Mouna Rhahla, Takoua Abdellatif *Polytechnic School of Tunisia, Univ. of Carthage, Tunisia*
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13:30 - 13:50	**Taoyuan smart city prospects** • Kang-Ying Chen, Shun-Chih Hsu *Information Technology Department, Taoyuan City Goverment, Taiwan*
13:50 - 14:10	**5G data-based smart city application beyond infrastructure** • Minkyung Chung, Yongil Kim, Kangjoon Choi, Choen Kim, Minho Kim *Dept. of Civil and Environmental Engineering, Seoul National Univ., Korea*
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14:40 - 15:00	**Analysis of geospatial technology for smart city development: case study of South Korea** • Ahram Song, Choen Kim, Minho Kim, Yongil Kim *Dept. of Civil and Environmental Engineering, Seoul National Univ., Korea*
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Contents

SCIS: Secure Critical Infrastructure Surveillance

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***Abstract*—A secure surveillance of critical infrastructures supposes two things: (1) detecting events of interest like fire, flood and unauthorized person presence and (2) securing the surveillance systems itself from cyber-attacks and anomalies. Thanks to an IoT system, we build a cartography of the observed infrastructure that provides a global view about detected events and about the state of deployed sensors and gateways. The pulse observation is performed in real time with minimal false alarms and takes into account the trustworthiness of sensors.**

Keywords— Event detection · Anomaly detection · Intrusion detection · Reputation systems.

INTRODUCTION

IoT is nowadays intensively used for surveillance systems and particularly for critical infrastructure protection such as defense industrial base, critical manufacturing and information technology sectors where unauthorized human access and disaster events like fire and flood must be detected as soon as possible. The surveillance system is composed of a set of sensors and gateways that are distributed in the supervised areas to collect different data like temperature, smoke, motion, etc. Data is then aggregated, analyzed and archived to detect and anticipate events of interest. Nevertheless, not only surveillance data is important to analyze and visualize, the safety of the surveillance system itself has to be considered. Indeed, it is important to identify faulty or corrupted sensors and to detect cyber-physical attacks. Data from malicious nodes has to be discarded from analysis in order not to induce wrong decisions. Therefore, supervising critical infrastructures supposes two things: detecting events of interest and also securing surveillance systems from cyber-attacks and anomalies. Recent works propose Intrusion Detection Systems (IDS) [1] handling different kinds of attacks. However, the integration of such IDS in surveillance systems with minimal overhead in terms of engineering or detection delays, is still challenging. In this paper, we extend our previous works on IDS and event detection systems to propose a unified system [7] [8]. We propose SCIS (Secure Critical Infrastructure Surveillance) that builds a cartography combining insights about the events of interest and the nodes trustworthiness. Indeed, the cartography system provides a global system view where not only events are highlighted but also a pulse observation of the surveillance system itself. A reputation system calculates trust values of the different sensors of the surveillance system. We built a cartography for the surveillance of a real factory. The cartography is dynamically updated with detected events. We simulated security attacks and nodes anomalies by injecting faulty data. We show that this update occurs in real time and with minimal false alarms. Compared to existent solutions that separately focus on event detection [2] or IDS [3], we propose an integration of both systems in a single one using IoT architecture. The cartography provides the following features. It is up-to-date reflecting really observed events. It is scalable handling a large amount of events and covering a large supervised area. The rest of the paper is structured as follows. First section presents related work. Section 2 describes the IoT system architecture and the reputation based model used for sensors' trust evaluation. Section 3 presents our prototype that shows the efficiency of our approach. We show the cartography update using three scenarios: an un-authorized person detection, a fire detection and Sensor security attack. Section 4 concludes the paper and presents some perspectives.

I. RALATED WORK

Authors in [4] propose a pattern-sensitive partitioning model for IoT sensors data streams capable of paralyzing data processing in order to achieve a high detection for event pattern in a minimum delay. Authors in [2] extend Sipresk, a big data analytic platform, to detect, classify and report events in Ontario highways in a minimum delay. Authors in [5] propose a novel anomaly detection method, called Fog-Empowered anomaly detection, using an efficient hyperellipsoidal clustering algorithm. They use a fog computing architecture to minimize latency in anomaly detection. A Lightweight distributed IDS in a three-layered IoT architecture including the cloud, fog and edge layers was proposed in [6]. Authors in [3] propose SVELTE, a distributed intrusion detection system for IoT that detects communication attacks in 6lowpan networks using RPL as a routing protocol. The previous mentioned works only consider event or anomaly detection as main objective. In our previous work, we proposed Read [7], a reliable event and anomaly detection system for WSN. Although the proposed system was proven to be reliable ensuring a high detection rate and low energy consumption, it focuses only on WSN and does not consider IoT challenges as security attacks where the gateway is connected to cloud servers and IP protocol is used. In our recent work [8], we proposed an anomaly detection system that consider both WSN and IoT anomalies using an adaptive machine learning usage depending on nodes capabilities. This work presents a unified system for both events and anomalies detection.

II. SCIS IoT ARCHITECTURE FOR EVENT DETECTION AND IDS

As shown in figure 1, SCIS architecture is based on a set of sensors and gateways deployed in the supervised zone. Collected data is sent to an analytic server for event and anomaly detection. The server is connected to an MQTT broker where consumers may subscribe to different kind of topics related to events of interest like fire, flood, etc.. A particular topic is related to sensors reputation. All data related to sensors observation go through this topic. The trust manager is a particular process subscribed to the reputation topic and is a provider of the trust topic where it sends the trust values that it calculates. The cartography is actually a process that is a consumer of all event topics and of the trust topic. Therefore, the cartography is regularly notified about the occurrence of any event of interest and about any value changes of sensors trust. In addition to the event consumer that receives processed data from SCIS system, the cartography process contains two other components: the visualization web service and the history database that stores historical data. The event and anomaly detection are actually based on the aggregation of two types detectors: a rule based detector based on well-defined signature of each sensor behavior and a machine learning component to detect non expected attacks [7, 8]. Two kinds of machine learning algorithms are used (Support vector Machines (SVM) and Deep learning (DL) components) depending on the execution environment. Indeed, in our previous work, we show that this hybrid detection leads to a high detection accuracy and to low false alarm rates. We use a reputation based system to monitor and update sensors trustworthiness using the Beta function. This function is defined based on the total number of unsuccessful (f). A monitor mode is chosen to survey a set of neighborhood nodes based on their node past actions that are categorized as successful (s) or unsuccessful (f). A monitor mode is chosen to survey a set of neighborhood nodes based on their network behaviour within a time interval. The node trust value TNi of the node Ni can be estimated as

$$TNi= (s+1) / (s+f+2) \qquad (1)$$

The reputation based model is applied in a hierarchical manner such that each node is monitored by its higher level node. Sensor nodes are monitored by their respective gateway. Rule based and SVM anomaly detectors are deployed at gateways to detect common WSN attacks such as SFA, BHA and HFA [7]. Gateway nodes are not necessary trusted. Therefore, they can be malicious after IP attacks such as dos, u2r, r2l and probe attacks [8]. Deep learning anomaly detector component is used for anomaly detection at Gateway level. The successful past actions number s for a gateway is incremented whenever a packet originating from it is classified as normal. In contrast, if the packet is classified as malicious f is incremented.

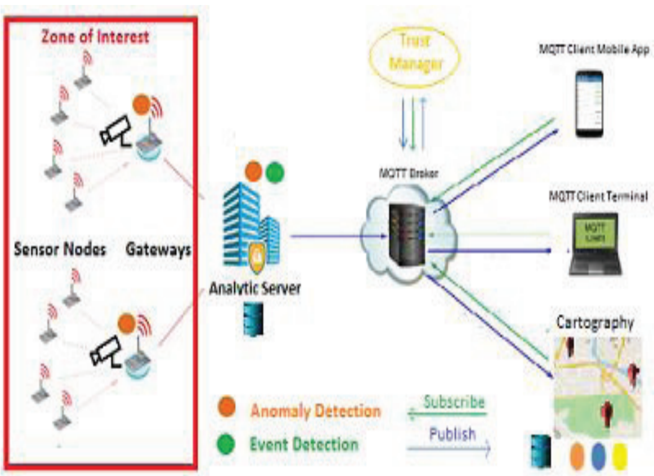

Fig. 1. SCIS Architecture

III. CARTOGRAPHY

As proof of concepts, we set up our own prototype for surveying an important factory infrastructure. We used six sensing nodes, two gateways and one server. The sensing nodes collect temperature, humidity, smoke and motion data. The gateways are equipped with cameras to take picture of unauthorized person access detected by motion sensor. We show in figure 2 a snapshot of the real time cartography update for three scenarios of detected events and anomalies. In the first scenario, an unauthorized person crosses the sensing range of motion detector 1. In scenario 2, a fire is detected by the fire detector 1. Besides that, we simulate in s an attack against the fire detector 1 and the gateway 2 and we show the real time trust value update (44% for the fire detector and 22% for the gateway). To have detailed information about detected events and anomalies, the tab named “Real Time System Monitoring” may be used. In addition to that, historical data are shown and research for specific information may be done on the tab named “Historical Data”.

CONCLUSION AND FUTURE WORK

SCIS integrates in a unified system, an event, and an anomaly detection sub-systems. It provides a rich cartography that provides a global and real view of the observed infrastructure. The user can visualize the occurring events and the surveillance system state. The scalability is ensured thanks to the IoT architecture. As future work, we plan to explore possible anticipation and visualizing future events based on historical data.

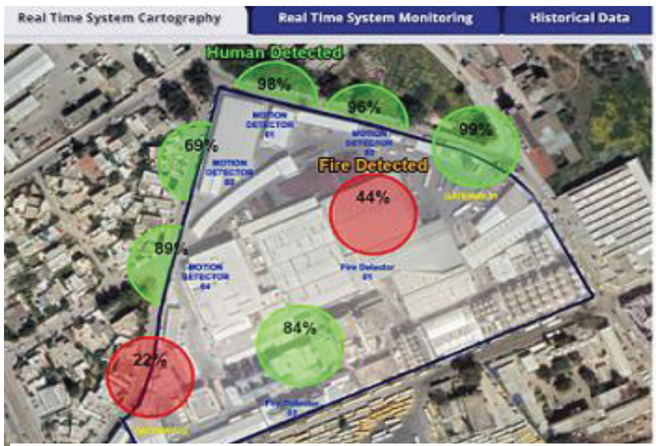

Fig. 2 Real time SCIS cartography

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What can RCNN bring to STEG invoice image?

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Abstract— **Smart capture systems or document image analysis and recognition (DIAR) are designed to reduce human efforts and errors in valuable information extraction and processing from scanned documents. Region based Convolutional Neural Networks (RCNN), as subfamily of the CNN, a very deep structure enabling the human-like brain system simulation, are the-state-of the art models in computer vision domain. However, only few works have used RCNN for the DIAR system. We present in this paper, an overview of an RCNN-based approach for the STEG (Tunisian Comapany of Electricity and Gas) invoice image processing to be part of a smart capture system.**

Keywords— document image, RCNN, FCN, segmentation, invoice

I. Introduction

Traditionally, many organizations across the world, try to capture and process scanned document's content through Document Image Analysis and Recognition (DIAR) systems, namely, the Cheque Truncation System (CTS) which is dedicated for cheques processing [10] used in order to reduce human effort [12] : For each financial transaction, an employee has to verify carefully written information including date, signature, legal and courtesy amount present in each cheque which is which is a time-consuming task, especially when it comes to treat a massive amount of cheques. However, when it comes to use the CTS, the recognition and verification of information becomes a challenging task since the cheque layout depends on handwriting language and the bank adapted template.

Document image processing depends on the application domain and image content. Some document image, indeed, may need to be processed very differently, like cheques and invoices, since they contain specific types of templates e.g straight lines, dash lines and tables which yield to great diversity of document image categorization. A four-class categorization was found in [1], of document images: Online document images, Scene images and video frames, web images, and General Offline document images and are grouped into four sub-classes:

- Class-1: newspapers, journals, magazines, books, etc.
- Class-2: engineering drawings, bank checks and forms.
- Class-3: Advertisement, book/magazine covers, posters, postal envelops, etc.
- Class-4: Unconstrained handwritten documents image

In recent years, the related research increases dramatically with the advent of deep learning, especially, Convolutional Neural Networks (CNN) [22]. Before its emergence, feature extraction and representation were hand-crafted. More recently, some researchers still focused on using shallow models. However, others took advantage from the Region based CNN efficiency and started to design RCNN-based DIAR systems.

Smart capture system is designed to facilitate data extraction, especially when it comes to an invoice with a sophisticated template full with tables and texts (alphabetical and numerical characters). Such data could be used in handling STEG Invoice payment for many companies, for example: Once the invoice is received, the smart capture system extracts the amount and the date, and notify the user. So, the system has to recognize this invoice through its logo and detect price and date. In

Figure 1, we show examples of regions of interest which the system have to detect.

Figure 1. Example of regions of interest (logo, table, text) which must be detected by the Smart Capture System

This paper presents our efforts to identify the necessary artifacts, in terms of processing steps and data, in order to build RCNN-based segmentation module for a Smart Capture system which aims to extract valuable information (price, date, logo, price without VAT, etc) from STEG Invoices.

II. Document Image Analysis

According to[15], a DIAR system includes four principal modules: pre-processing, object segmentation, object recognition and document classification. A DIAR pipeline starts always by an acquisition step [10] where a document image can be produced from a scanner or a fax machine [2].

The preprocessing step, aims to improve the quality of the image. The object segmentation allows identifying the basic objects in the document, depending on the application level considered. For example, the segmentation is referred to a layout analysis task when dealing with regions in the page. Object recognition or classification deals with the objects identified in the previous step. For document image classification module, it can be performed at various stages of document (this step is out of the scope of this work). Furthermore, it can be followed by further document image analysis steps. The desired output of DIAR systems is usually in a suitable symbolic representation that can subsequently be processed by computers.

Our work is aimed at specifically layout analysis and object recognition, especially table detection. In the section, we briefly compare the related works to the layout analysis and table detection.

A. *Layout Analysis*

Layout analysis is the process by which a document page image is decomposed into its structural and logical units, such as images, tables, paragraphs, etc [4]. This process is critical for a variety of document image analysis applications, since it forms the basis for all subsequent analysis and recognition processes. The first who addressed page segmentation using CNN was [2]: Considering the page segmentation problem as a pixel labelling task, they used a one convolutional layer based-CNN for the pixel labelling task. In order to speed up the pixel labelling process, the simple linear iterative clustering (SLIC) algorithm is applied as apre-processing step to generate super pixels for given document images. However, in PageNet system [21], which is a page boundary extractions system. PageNet used an FCN (Fully Convolutional Network) proposed by [14], to classify pixels as page or background. After thresholding the FCN output, the binary image is converted to the coordinates of quadrilateral around the main page region in the image. For both pre-processing and post-processing, image is resized. PageNet achieves 97.4% mean Intersection over union (mIOU) while the human agreement is 98.3% mIOu.

B. *Table detection*

Tables are important document elements. Some works typically regard their detection as separate problems [9]. The table detection problem was defined on the 2013 ICDAR competition [7] as a three task: 1) table localization: locating the regions of a document with tabular content; 2) table structure recognition: reconstructing the cellular structure of a table; 3) table interpretation: recovering the meaning of the tabular structure; Based on this definition, we present and compare, in this subsection, the recent CNN-based table detection works.

In table localization, instances of a table model are segmented. In 2017, [5] used the popular object detector framework Faster-RCNN [16]. Their method consists of two major modules: Image transformation and table detection. They first transform document image to natural image procedure in order to separate document regions. Thus, Faster R-CNN is fine-tuned to perform easily the table detection module. They achieved better result than traditional table detection system (not based on CNN) and improve the accuracy from 44% to 60.5% on the UNLV dataset [19]. In the same context, [18] fine-tuned also Faster R-CNN for table detection, but without any image transformation, using pre-trained weights from training in [16]. Whether, [9] started from a probability map generated from the multi-task, multi-scale deep FCN and CRF. They thresholded the probability mask for table at 0.5 after applying the CRF and then applied connected components analysis (CCA) on it to get possible locations of table. In order to remove false positives, a deep CNN is used to classify whether each region is the table or not.

III. STEG INVOIE IMAGE PROCESSING

In this section, we present an overview of an RCNN-based segmentation module for a smart capture system to process STEG invoice. Based on a set of training data which represent 80% of the whole collected set, the RCNN is trained to label regions of the document and classify them into three main classes: text, table and logo. The system has to detect all text regions in the document, inside and outside table regions. Once the model was trained, we evaluate it against 20% of data set.

A. *Training data collection*

According to [1], most of standard used datasets are not available (specific data set such as academic papers) or restricted available (paid, available by request or unavailable on their websites). As a result, we learned that the most challenging task in designing CNN-based DIAR is collecting the training data. To build our segmentation module, we needed labeled instances of tables and STEG logo. We gathered those invoices, scanned and labeled them.

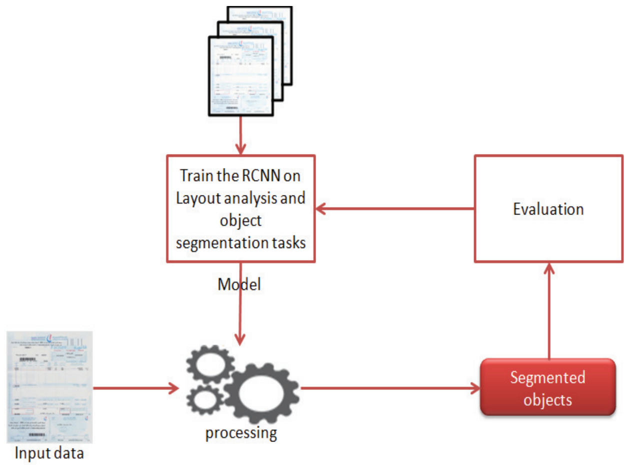

Figure 2. An RCNN based approach for STEG Invoice segmentation

B. *RCNN-based segmentation*

By reviewing CNN-based image document processing, we learned that CNN are able to learn the entire supervised document image processing, from feature extraction to final classification. Despite the emergence of CNN-based region, we observed that only few works of document image processing have applied CNN based region detector. That's could be explained by the fact that naively employing CNN based detectors in digital documents, suitably transformed into images, leads to failures mainly because of the intrinsic appearance difference between digital documents and natural images. However, transforming document image to a natural image could allow for better result. Furthermore, the empirical study of [20], proof that CNNs learn a wide variety of region-specific layout features, as interpreted in [8].

Based on the literature review, we propose to take advantage from the efficiency of CNN-based region for an object segmentation task in invoice scanned Image. Added to that, STEG invoice require a finer segmentation and in this case, researches follow, usually, connected-component analysis-based approach. We notice that some recent works used FCN which provide high accuracy in segmenting object and [9] are the only ones who combine the connected component analysis with CNN. In our case, it is highly probable that we consider the RFCN (Fully convolution Neural Network based Region) [3] in order to make use of RCNN, FCN and connected component in finer segmentation of STEG invoice.

IV. Conclusions

This paper has presented an overview of an RCNN based approach to segment objects in STEG Invoices. This approach relies on ones of the state-of-the art deep learning model which is the Region based CNN and follows a supervised training strategy to learn the segmentation process.

Acknowledgment

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Mesh network for smart car parking

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Abstract— **Deploy a conventional IoT network for smart parking have many constraints such as energy availability, indoor network coverage, cost , and many others. The deployment of IoT oriented networks based of mesh topologies reduces all these constraints.**

Keywords— mesh networking, IEEE 802.15.4, 6LoWPAN, , Thread network protocol, smart city, smart parking.

I. Introduction *1*

The actual solutions for smart parking includes the next features:1.municipality parking subscribtion, 2."search of parking place" near destination, 3.parking reservation, 4.route direction to park place, 5.car detection in park place, 6.car identification or user identification, 7.payment. Points 5 and 6 are IoT related. Actual uses cases shows that certitude that the right car is placed on the reserved parcking place is quite low. Even when using rfid tags or CCTV image recognition.

Known smart car parking IoT networking coverage has two major problems, cost and energy consumption. Using a mesh network will reduce the network architecture and thus reduce the cost. The range of Ipv6 range of devices are very low energy consumption, they can be powered by a small photovoltaic cell and a small rechargable battery.

II. Use of IEEE 802.15.4 Mesh network

A multitude of gateways collecting data won't be necessary with a mesh network. Each device is a node and act as a gateway. a mesh refers to an interlaced structure. In networks, it refers to the many interconnection of nodes that can establish links to connect to others. Since all nodes are connected in a fluctuating web, devices can act as routers and forward traffic to others. This enables the content to hop between them until it reaches a destination.

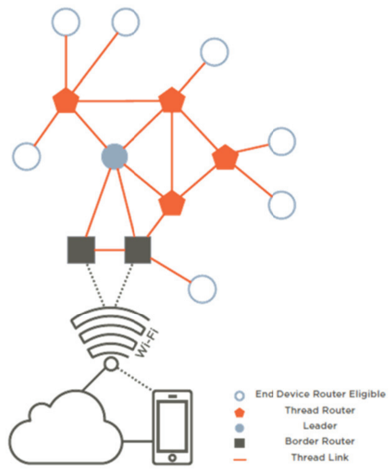

Fig.1 Thread protocol architecture

Advantages of Tread protocol

1. No more problem of single point of failure, which is the issue in star topologies. If one node can no longer operate, the network has the ability to reroute which enables it to still communicate between the remaining nodes.
2. Taking the network down is impossible.
3. The network works with minimal infrastructure and can therefore be deployed faster at a lower cost than traditional infrastructure.
4. Since the devices in a mesh network can retransmit signals further, they have an ability to connect thousands of sensors over a wide area (ex: cities).
5. Other instances include operating in areas with large crowds (ex: concerts, festivals, and so forth) or connecting devices in remote areas (ex: in mountains or in public transport under the ground), and many, many more.

function	WiFi	Zigbee PRO	Zigbee IP-SE 2.0	Z-Wave	Thread
Low Power Consumption	✗	✓	✗	✓	✓
Mesh network support	✗	✓	✓	✗limited	✓
Support for IPv6	✗	✗	✗	✗	✓
interoperability	✓	✗	Not clear	✗limited	✓
Open Standard	✓	✓	✓	✗	✓

Table1: Thread protocol compare to others

Thread is an IPv6-based, low-power mesh networking technology and intended to be secure and future-proof. Several electronic manufacturers sutch as NXP, SAMSUNG, Qualcom integrates the thread protocol in a chipset

Thread uses 6LoWPAN, which in turn uses the IEEE 802.15.4 wireless protocol with mesh communication, as does Zigbee and other systems. Thread however is IP-addressable, with cloud access and AES encryption. A BSD licensed open-source implementation of Thread (called "OpenThread") has also been released.

Many integrated circuits already integrate the Thread protocol in their products.

NXP produduce the the KW41Z witch is an ultra-low-power, highly-integrated single-chip device that enables Bluetooth® Low Energy v4.2 and IEEE 802.15.4 Thread protocol. It is also extremely low-power embedded systems. And integrates an Arm® Cortex®-M0+ CPU, up to 512 KB Flash and up to 128 KB SRAM, 802.15.4 packet processor, hardware security and peripherals optimized. The NXP KW41Z will consume less than 0.5 mA with no radio use and 6.5mA on radio Rx use and 8.2mA on radio Tx use.

SAMSUNG produce the Exynos i T100;it is an IoT connectivity solution for short-range communication through supporting Bluetooth 5 and Thread 1.1.1. The Exynos i T100 is based on an ARM Cortex M4

Just like the NXP KW41Z, the SAMSUNG Exynos i T100 is a Thread Certified Component.

III. The Proposed Solution

A thread network can be deployed in the car parking positions. Nodes are installed inside the street conctrete. Just a small solar cell and a red/greend led light appers in the border of the car park. The photo cell brings energy to the node and chrge a small 400mAh battery. The small red/green light indicate the state of the node. Each node have 3 features

1. Identify the user by the bluetooth mac address
2. Be part of the mesh network as a data transport node.
3. Detect that there is a car in position.

With a municipalty subscrition, the user, from home, can make a reservation of a car parking position , near of his destination his mobile reservtion application will also send the bluetooth Id (can be the mac bluetooth or any generated id).

When the user approach the park car reserved position, the red green led flashes indicating the right place. Once user place his car message is sent to his mobile with all informations needed (price , period of time …) .

Mechanically the node device is inserted in the streets concrete on the side (or in the middle) of the car park place. Only appear a photovoltaic cell and the red/green LED light.

The node circuit is composed of the photovoltaic cell bringing enough energy to charge the battery and microcontroller and its devices, a big enough battery to produce energy during the night, a microcontroller with integrated Bluetooth and Thread transceivers and a magnetic sensor for car detection.

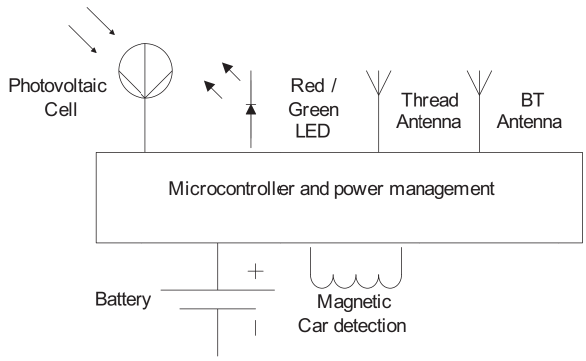

Fig.2 : synoptic of the device/node

The microcontroller is programmed in order to insure all the described features

IV. Energy

The device will produce its own energy needed from photovoltaic cell. The cell should be big enough to collect energy from light in a close space where light should come from windows or other inside light sources.

Energy quantity needed from photovoltaic can be calculated as follow:

Current calculation, Tp is total power drained by the photovoltaic cell during one day :

$$Tp = Pm + Pb + PTxt + PTxb + PRxt + PRxb$$

Where Pm is the microcontroller consumption (ARM CrotexM0 consume less than 0.7mA for normal operations under 3v). Microcontroller should run 7/24, sleep time can be suggested depending on microcontroller sleep modes available by microcontroller manufacturer. This is 12mWh consumption during the day.

Pb is the power needed to complete charge the battery , so 400mWh in case of 2xAAA rechargeable battery

PTxt and PTxc are transmit Thread and bluetooth consumption radio device power. They are estimated at 70mA , power will be 30mWh if a transmission of one second every minute during 8 hours. And same, PRxt and PRxb are receiving Tread and Bluetooth estimated at 10mWh during 10 hours

Total power drain from photovoltaic is then estimated at 400+12+30+10 = 452mWh . A photovoltaic cell of 0.1Wc is more than enough. Dimention is 40mmx40mm.

In order to drain the full power from the photovoltaic cell a DC/DC power supply with MPPT tracking is needed

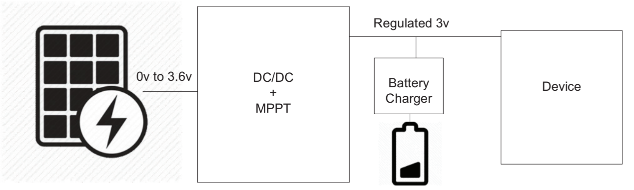

Fig. 3: power supply synoptic

V. Use of the FIWARE platform

FIWARE is an open source initiative defining a universal set of standards for context data management which facilitate the development of Smart Solutions for different domains. The context broker included is its core component. FIWARE gathers, manages and provides access to context information coming from different sources describing what is going on.

Different modules in FIWARE manage :

- The interaction between IoT sensors and other devices, as well as vertical smart solutions and other information systems.
- The processing of current real-time and historical data to extract valuable insights that can aid cities in their smart decisions and planning.
- The creation of dashboards that monitor what is happening across the city, as well as the generation of reports, including KPI monitoring and analysis.

FIware already have an open source car park solution. We intend to adapt our concept in the FIWARE car parking solution as it's already have the real-time data pipeline were the context broker enabled us to collect the id information, As FIWARE collect data of all usage of car parking, it can generate continuous management statistics of car park usage which provides TfWM valuable insight into car park user behaviour which will inform the best end-user solution.

VI. Conclusion

Using the Thread protocol for car park solution can save time of deployment and most important lower the network and installation costs.

Consequently it would be an economic solution for the city to provide smart car park solution for the citizens

Privacy issues in smart cities: Challenges and Approaches

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***Abstract*—With the progression of the Internet of Things IoT, the smart city has become an emerging paradigm, consisting of ubiquitous sensing, heterogeneous network infrastructure and intelligent information processing and control systems. However, security and privacy concerns arise. Indeed, smart city applications not only collect a wide range of privacy-sensitive information from people and their social circles, but also control city facilities and influence people's lives. In this paper, we investigate privacy challenges in smart cities. Recent research efforts are presented to address these privacy challenges and future opportunities for research are highlighted.**

***Index Terms*—Smart city, Privacy challenges, IoT**

I. Introduction

The smart city is based on an assortment of promising techniques, for example the Internet of Things (IoT), cyber-physical systems, big data analysis and real-time control to enable intelligent services and provide comfortable life for citizens. It integrates four main layers as mentioned in figure 1: Sensing layer with ubiquitous sensing components, data collection layer with heterogeneous network infrastructure, data processing layer with powerful computing systems to analyze the physical changes from cities and feed back to the physical world. As a smart city connects the physical world and the information world, many intelligent applications are emerging from sensing to processing.

Smart city applications raise a series of concerns and challenges in terms of security and privacy. When cities become smarter, people may suffer from a series of security and privacy threats due to the vulnerabilities of smart city applications. For example, an attacker may generate false data inducing denial-of-service or disrupt the sensing, transmission, and control to degrade the quality of intelligent services. The smart city should be able to defend the involved information from unauthorized access, disclosure, disruption, modification, inspection, and annihilation. Underlying security and privacy requirements, including confidentiality, integrity, non-repudiation, availability, access control, and privacy, should be satisfied in the communication, and physical worlds. Besides, these general requirements, securing a smart city still faces a set of unique challenges. On one hand, a smart city collects

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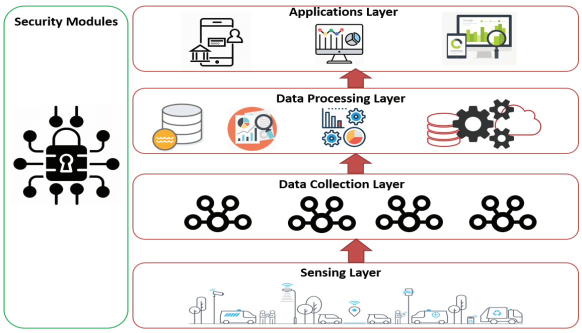

Fig. 1. Classical smart city IoT architecture

granular-scale and privacy-sensitive information from people's lives and environments. On the other hand, it processes this information, manipulates and impacts people's lives. The information system behind is generally heterogeneous and involves several providers and stakeholders. Consequently, security and privacy issues become challenging and prevent the smart city from being tempting enough to encourage more use [2]. With the new way of dealing with information and sensitive data, the General Data Protection Regulation GDPR [6] comes to protect the rights and freedoms of natural persons. Every organization that deals with data has to comply with GDPR, to protect these rights and to be accountable while improving business models [5]. Organization must answer the following questions: what information is processed? why? how and where is data stored? who can access it and why? is it up-to-date and accurate? how long will you keep it for? how will it be safeguarded and how do you reach accountability?

In this paper, we will give the main privacy challenges in the context of smart cities systems. Also, we will give you an overview of the current steps to respect the users' privacy in smart home and smart cities environment under GDPR regulation.
The paper is structured as follows. In section 2, we present the key privacy challenges in smart cities systems. Section 3 gives a summary of the main findings of the current work. Section 4 will conclude and highlights new opportunities.

II. Privacy challenges in smart cities

This section introduces some background about GDPR and privacy challenges in smart cities.

A. Privacy under GDPR

The GDPR regulation aims at delivering a harmonized, consistent and high-level data protection across Europe. The GDPR sets out seven key principles for the processing of personal data in which it highlights requirements and privacy challenges. This new regulation has created a challenge for many organizations in terms of how to maintain compliance with the new data protection and privacy laws while continuing to use data for analytics. These principles are stipulated in Article 5 [6] as follow: personal data shall be processed lawfully, fairly and in a transparent manner in relation to the data subject (Lawfulness, fairness and transparency), personal data shall be collected for specified, explicit and legitimate purposes (Purpose limitation), personal data shall be adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed (Data minimisation), personal data shall be accurate and, where necessary, kept up to date (Accuracy), storage limitation of personal data, integrity and confidentiality and finally accountability which requires stakeholders to take responsibility for what they do with personal data. The purpose of this legislation is to give consumers better control of their personal data as it's collected by businesses.

B. Privacy challenges in Sensing layer

Regarding the privacy principles, both consent and purpose limitation principles should be considered before beginning the collection phase. Each data owner has the right to know the reasons behind collecting each data by his smart device. Thus, the respect of these two principles can help data owner to set his preferences about the collection frequency, the data granularity and the set of information he allows to disclose to third party applications. Preserving privacy in the sensing layer is essential and can affect the whole data life cycle. Thus, data minimization and purpose definition principals have to be applied starting from the sensing phase.

C. Privacy challenges in Data Collection layer

Smart cities typically tend to collect data from diverse sources and without careful verification of the relevance or accuracy of the data thus collected. This can clearly false analysis results. For example, in the field of e-health, incorrect data about the patient health or environment can lead to erroneous diagnosis which puts his life of the user in danger. Anomaly detection systems are required for accuracy. Indeed, it is important to make sure that data is not modified during the transmission phase and to detect malicious entities that try to inject data in order to congest the network or influence the analysis results.

D. Privacy challenges in Data Processing layer

In this layer, data is stored and processed to provide advanced information for the applications layer. Regarding the privacy principles, European data privacy laws, such as GDPR, state that personal data collected and stored within a European Union country territory should be stored for a well-defined time duration [6]. Thus, data retention and disclosure limitation are required at this phase. In particular, necessary mechanisms need to be deployed for destroying data when expired. Furthermore, a lot of data is collected for non-defined purpose mainly for Big Data analytic that require the maximum of input to improve algorithms' accuracy. However, the blunt statement that the data is collected for any possible analytic is not a sufficiently specified purpose. Another challenging issue of securing a smart city is data sharing. For example, road traffic data can be collected by deployed cameras or travelers' smartphones and GPS in a crowd-sourcing way. During global road planning, it is challenging to define the access policy and enable privacy-preserving data sharing among the involved applications and services. Therefore, smart city data storage and sharing require the deployment of appropriate techniques in order to respect the user consent and privacy while providing innovative analytic processing for different purposes. It follows from the above that the core data protection principles are, for the most part, in contradiction with some of the key features of smart cities and big data analytic. Nevertheless, rethinking some processing activities but also IT developments may help respecting privacy, notably by having well-managed, up-to-date and relevant data. Ultimately, this may also improve data quality and thus contribute to the analytic.

E. Privacy challenges in Applications layer

Third party applications have access to the analytic results calculated from citizen data. The communicated information, even anonymous, may reveal private data. It is important that data sharing is controlled and done following the citizen' consent. The challenge consists in the big number and diversity of applications using data. They can communicate from sensing to analytic layers. Tracking data access and data breach notification is still an open issue.

III. Current security solutions for smart cities

Smart cities might help to mitigate many health-related issues, its ability to gather unprecedented amounts of information could endanger the privacy of citizens. Protecting privacy and securing the infrastructure is an inescapable challenge the research community is still struggling to address going from the sensing layer to the applications layer. To materialize the notion of security and privacy in smart cities, balanced and pragmatic solutions are desired. In this section, we introduce recent related works for security and privacy protection schemes for several emerging smart cities.

For sensing and collection layer, authors in [3] describes how to protect citizen data by securing the WiFi based data transmission system that encrypts and encodes data before transfer from source to destination where the data is finally decrypted and decoded. The proposed system is embedded with authentication method to help the authorized people to access the data. Also in [10], an IoT Databox model is proposed providing the mechanisms to build trust relations by providing a designed device in order to minimise data collection. Many other techniques and standards are used such as QR codes (Quick Response Code) [11]. It is selected in the case of protecting Personal Identifiable Information(PII) in case of device loss. Secure Communication Protocol could be also the suitable approach to secure communication [12].

For the processing and applications layers, we proposed in [8] an implementation of a GDPR Controller in IoT systems. The controller gives the data owner a full control of his data: setting security policies, modifying them on run time, tracking data flow and notifying him for any illicit access. The controller architecture is validated using an e-health use case. The evaluation study shows a compliance with GDPR with acceptable overhead on the system performance. Also In [9], we proposed a security model for data privacy and an original solution where GDPR controllers are integrated as Complex Event Processing (CEP) systems and are deployed following the edge computing. We show, through a smart home IoT system, the efficiency of our approach in terms of flexibility and scalability.

IV. Guidelines

The current study as well as our survey on GDPR in Big Data systems [7] illustrate the numerous challenges in the implementation of privacy in smart cities and in IoT in general. The main difficulties consists in tracking data and implementing data consent especially in legacy systems that are developed without having privacy respect in mind. Consequently, ”privacy by design” [6] approach seems the most promising approach for privacy implementation. The term “Privacy by Design” means nothing more than data protection through technology design. Organisations need to consider appropriate technical and organisational measures which are designed to implement data-protection principles, such as data minimisation and purpose verification in the design of their systems. At the implementation phase, they integrate the necessary safeguards into the processing in order to meet the privacy requirements defined at the design time. These techniques, such as encryption and access control policies, should be applied to control the amount of personal data collected, the extent of their processing, the period of their storage and their accessibility [1]. End-to-end data tracking and notification brokers are key elements to let users informed about their data flow and access. To impliment GDPR many steps need to be followed such as:

- Role definition. An organisation must define who is the Data subject, the controller, the processor, the data protection officer and the supervisory authority [6].
- Consent policy definition. An organisation must define the structure of a consent policy. In that policy we should define What data is being collected? From whom is data collected? Why is the data being collected? How is the data being processed? What is the legal basis for each processing operation? Where is the data being stored? How long is the data retained? Who has access to the data? To where and to whom is the data being transferred?
- Security Component definition. After the definition of the role and the adequate consent policy, a set of security component need to be implemented in order to provide compliance and privacy respect for each layer in the architecture as mentioned in [7].

V. Conclusion

In this paper, we provided an overview of smart cities concept and highlighted the main privacy challenges for each layer. As future work, we plan to implement a security solution to implement users' consent under GDPR and to evaluate the overhead of GDPR-compliance implementation mainly on smart cities system performances.

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User-centric privacy implementation in smart home systems

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***Abstract*—The Internet of Things (IoT) emerged as a paradigm in which smart things work together among them and with other physical and virtual objects utilizing the Internet so as to perform high-level tasks. Among the most prominent examples, we cite smart energy grids, smart transportation networks, smart homes and cities, etc. In smart cities, data are rich in sensitive data and data owner-specific habits such as the location and habits of individuals, patient's vital signs, etc. Thus, while smart cities promise to ease our lives, they raise major privacy concerns for their users. The GDPR (General data protection regulation) as a recent privacy and data protection law call for more involvement of users in protecting their data by enabling them to control what is collected about them, when, by whom and for what purposes. In this paper we propose an original solution where a GDPR consent manager is integrated using Complex Event Processing (CEP) system and following the edge computing.**

***Index Terms*—Smart city, Privacy , GDPR**

I. Introduction

Internet of Things, IoT, consists of several digital devices, individuals, services and other physical objects which have the ability to reliably connect, interact and trade data about themselves and their environment. This makes our lives more straightforward through a digital environment that is sensitive, adaptive and responsive to human needs. For example, smart home sensors collect data that is utilized to monitor users' activities, status and environment to make automated decisions for users' well being. However, a great number of users encounter critical challenges concerning the protection of their personal data. It is crucial today for an individual to be sure that what he has shared is exactly what he wants to be shared, to whom, for what purpose and when. Individuals must have control over their data and can give or revoke permission to access their data for a given service whenever they want. They also have to be notified about illicit access to or unauthorized storage of their data.

These requirements are actually imposed by the recent General Data Protection Regulation (GDPR) [1], which defines the main principles for how organizations can share EU citizens' personal data. Indeed, GDPR compliance imposes building solutions to answer *5W* questions: *where* data is going to be stored? *what* personal data is being transferred? *who* has the right to access to the data? *why* those with access have access? and *when* does the transfer take place? Implementing consent managers face the main challenge that consists of shifting the role of data control and management to the data subject. He becomes the administrator of his data in charge of setting and updating his security policies and notified about any security leakage. A consent manager have to deal with rule-based access control and to continually involve the user informed about his data usage. Furthermore, GDPR consent managers' implementation that introduces data interception and analysis has to be performed without a costly overhead of engineering and system performance. In this paper, we are interested in providing a GDPR consent manager for modern IoT smart home systems. These systems are based on event-driven processing for event detection and notification [5]. For example, they are used to remotely detect fire, flood, security attacks or health problems [7], [8], [9]. Central to these systems is the use of Complex Event Processing (CEP) [2] which deals with the detection of complex events based on rules and patterns defined by domain experts. The classical architecture of a smart home that integrates a CEP engine is shown in figure 1. Data flow respects the following steps. First, data is collected from sensors by the GW component that can perform filtering and aggregation processing. Then, the GW sends this data as primary events to a CEP engine that detects more complex events based on a set of predefined CEP rules. Finally, complex events are sent to remote services like Energy service or security service.

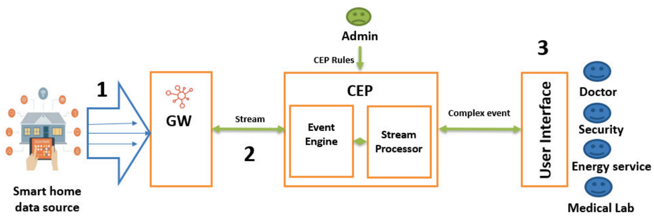

Fig. 1. A smart home use case

Combining CEP and edge computing is very interesting for IoT because it is intended to manage real-time big data. In this context, we build a GDPR consent manager that takes

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advantage of both these best of breed IoT technology features. The idea is to use CEP as a component that centralizes and controls data dissemination between sensors, services and people. Primary events and user data are annotated at the edge (at the gateway level) following the *5W* GDPR policies defined by the data subject. Security policies are dynamically calculated for complex events based on policies defined for primary events. This paper is structured as follows. Section 2 presents some background on CEP and GDPR. In section 3, the architecture of the GDPR consent manager is presented. Section 4 describes our first implementation and evaluation results. Finally, section 5 gives a summary of the main findings and the conclusion.

II. Background

In this section, we describe the fields in relation to our contribution, that is CEP and GDPR.

A. Complex Event Processing

Complex Event Processing is the technology that interprets and combines streams of primitive events to identify higher-level composite events [2]. CEP has been used in many areas, such as sensor networks for environmental monitoring, continuous analyzing of stocks exchange to detect trends in the financial domains such as stock markets and credit card fraud detection [2]. It relies on several techniques, including Event-pattern detection, Event abstraction, Event filtering, Event aggregation and transformation, modeling event hierarchies and detecting relationships [3]. Nowadays, big data technologies provide a new generation of CEP engines (such as ESPER [10], Apache Flink [13], WSO2 CEP [11]). They open new doors for highly scalable and distributed real-time analytics thanks to the convergence of batch and stream engines and the emergence of state management and stateful stream processing. With the stateful nature of stream processors, Stream SQL statements can be applied directly in the streaming engine and dynamic tables can be created rather than the static tables that represent batch data, dynamic tables which are changing over time.

B. General Data Protection Regulation

GDPR [6] sets new rules on security through 99 articles and 173 recitals and aims to protect the rights and freedoms of natural persons. Every organization that deals with data has to comply with GDPR, to protect these rights and to be accountable while improving business models [4]. Accountability aims at demonstrating how controllers comply with data protection principles. In a previous work [17], we defined a framework that allows testing GDPR compliance in Big Data systems. We defined 10 components that need to be implemented to fulfil the GDPR 7 principles: Lawfulness, fairness and transparency, Purpose limitation, Data minimisation, Accuracy, Storage limitation, Integrity and confidentiality and Accountability. This framework is a helpful tool that allows us to evaluate the GDPR compliance of our solution.

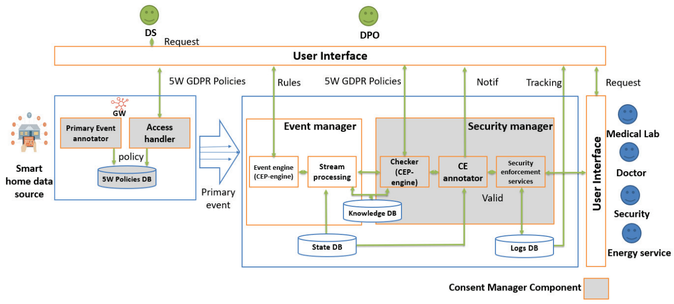

Fig. 2. CEP based smart home security architecture.

III. The proposed architecture

The GDPR consent manager architecture is represented in figure 2.

A friendly user interface provides the data subject DS with the ability to express his *5W* GDPR preferences and the ability to update them. The Access Handler component translates and stores user preferences in the *5W* policies DB in JSON format. These *5W* policies are used by the Primary event annotator component to annotate events coming from the data source: the smart home sensors. Note that, at GW level, to aggregate and filter data sources, lightweight CEP [15] can be deployed. Like at server side, security annotator is then necessary to calculate the labels of generated events. In this paper, we only consider CEP at server side.

The user interface communicates with the server that stores user preferences in the knowledge DB. The server-side software is composed of two main components: the event manager and the security manager. The event manager is responsible for complex event detection and stream processing of received primary events. After processing and detecting complex events, comes the role of the security manager component. Security manager component is the central part of the GDPR consent manager, it is in charge of the security checking of complex event annotation. Indeed, the checker component, which is a CEP-engine, executes a security checking algorithm and implements as a rule.

When the security checker (CEP engine) receives an event it extracts the *what* value. Then, it looks, in the knowledge DB, for the values of the other *4W* preferences of the owner and stores the values of each *W* in a list. Afterwards, it verifies if the *4W* of the event are less restrictive than the user preferences using a CEP pattern.

At CE annotator component, the complex event annotation is calculated. Finally, before delivering the ce to the set of services, it has to be protected by the security enforcement service. In our solution the administrator can act as the data protection officer DPO that evaluates GDPR-Compliance and provides the accountability principle. The provided log DB archives all event history and is used for visualization and data tracking for both data subject and DPO. It keeps a detailed log of all requests and responses of policy setting and updates as well as exchanged data history. The security enforcement service provides a set of services such as cryptography, logs, right to erasure and many other services. As explained in section IV, we use a third party service for security enforcement [16]. The main idea is to use a token that stores the *who* and *when* policies. Tokens are attributed to data consumers (services and persons in our case) to access the events sent by the server. Once the authentication is successful, that is the consumer is the *who* list and the target of processing data is the same as defined by *what* policy, the data consumer receives a token that is unique. The token allows the access to decryption services for the authorized period defined in *when* policy. If this period expires, the encryption keys are revoked and the user can no longer decrypt received events. If the data subject modifies the *who* policy by removing an authorized consumer of his data, the same revocation occurs. A user interface is provided to administrators (DS and DPO) to interact with the consent manager and to receive notifications. Also, it gives the ability to fix or update rules in both event engine and the checker (CEP-engine). In our architecture, we have three databases: policies DB, log DB and state DB. The state can be a dynamic table that contains the history of streams for a given period. This component can be queried to help the CEP component in the annotation process, for example, it can give us the set of events in a chosen window of time to check if event annotations are modified or not. In addition, the state database is used to change the annotation of events if a user updates his preferences.

IV. Implementation

This section will describe briefly our first implementation. At the GW level, data is annotated in JSON format. As CEP, we used Flink [13] since we take advantage of its CEP engine and its Stream processing features such as the Table API. Dynamic tables are the core concept of Flink Table API and SQL support for streaming data. For the state database, we are essentially building a table from an INSERT-only changelog stream to keep the history of events and maintain a state so to be used and queried for a given window and to check policies update at run time.

We used Hashicorp Vault [16] for the log and security enforcement component. Vault is a tool for securely accessing secrets. A secret is anything that you want to tightly control access to, such as API keys, passwords, certificates, and more. Vault services are accessed through HTTP API. The enforcement component is a particular Vault client that acts as a root asking for tokens in behalf of data consumers (services and persons). Policies, in Vault, can govern what a client is able to do, and they are attached to the token. Tokens also store a bunch of metadata in addition to the policies, so information like the time to live and the duration of the token. In the enforcement component, we translate for each user, the *who*, *where* and *when* policies to Vault token metadata. Tokens are provided to data consumers with authorized *what* policy only for the purpose defined by the user. The *where* policy is translated as a particular data consumer (using data for storage). In addition, we used Vault Encryption as a Service (EaaS) to fortify data during transit and at rest. In our consent manager, we used a java implementation based on Vault Java Driver [14]. Vault encrypts the events so that they are delivered to the right destination and with the constraints defined in the *who* and *when* policies. When, *who* value changes or *when* value expires, the event token will be revoked automatically and data consumers have no longer access to data. Also, the DPO can, dynamically, track data (request and response coming into vault) and receive notification using Kibana [12] visualization interface.

V. Conclusion

This paper presents a security model for data privacy respect under GDPR. We introduce a CEP-based architecture that provides GDPR consent manager for modern IoT systems. We show the efficiency of our solution in the context of a smart home. To the best of our knowledge, this is the first work that combines CEP and edge computing features in GDPR context.

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Taoyuan Smart City Prospects

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Since December 2014, Taoyuan has been officially upgraded to a municipality and has become one of the six capitals in Taiwan. Due to its proximity to the Taipei Metropolitan Area, a number of major public utilities(metro, airport, etc.) and investments are located here. Taoyuan City has the largest international airport in Taiwan, and the 2017 Taoyuan MRT Airport Line is open to traffic, speeding up the convenience between the Taoyuan High Speed Rail Station and the airport. The unique geographical and traffic environment makes Taoyuan City develop rapidly in recent years, attracting a large number of people from other counties and cities to move in.

Taoyuan is the largest industrial science and technology city in Taiwan. More than one-third of Taiwan's top 500 manufacturing industries have set up factories in Taoyuan. The industrial output value is about NT$2.87 trillion, ranking the top in Taiwan for 14 consecutive years. The population is a fusion of many ethnic groups such as Minnan, Hakka and Aboriginal people. Because of the industrial development, Taoyuan is also the municipality with the largest number of foreign workers from Southeast Asia and the largest number of Vietnamese new residents.

Taoyuan is also honored as the 2019 Intelligent Community of the year by the Intelligent Community Forum (known as ICF), we will continue to build Taoyuan as a smart city, and build a smart city solution platform with the functions of solution on-demand, quick access, and agent service. The goal of this platform is to export smart solutions based on local industrial technology to connect Taoyuan to international cities as our alliance partners.

INTRODUCTION

Taoyuan's primary strength is well-known by most: the average trip from Taoyuan to other Asian countries is 3 hours. Taiwan Taoyuan International Airport connects Taiwan to 34 countries and 144 airports. We believe these connections are what bring the world closer to Taoyuan. Second, its fully developed transportation system and industrial clusters have attracted 145 thousand people to the city in the past four years, resulting in an increase in the housing market. Third, Taoyuan City has both the largest industrial density and industrial output in all of Taiwan. The city is also famous for its electronics, auto parts, and textile manufacturing. The total dollar value of trade and transport by air is ranked highest in Taiwan and indicates the potential for the city to become an aerotropolis. Additionally, Taoyuan's fourth strength is that it is Taiwan's youngest city and has the fastest growing population. Every year, Taoyuan City cultivates more than 26,000 students—providing new talent for the industry. Lastly, Taoyuan's fifth strength is its diverse ethnic culture. We care about people from different parts of the world and would like to provide them with the best services and counselling.

Given these advantages, Taoyuan has gradually promoted the construction of smart infrastructure and smart services over the past 10 years. Some examples include the ability for Taoyuan residents to participate in city governance decisions as well as the ability for residents to enhance their quality of life in Taoyuan by accessing smart services with a citizen card. Moreover, the availability of digital education bases across middle schools—with each base offering a different education focus—has produced a significant outcome: Taoyuan residents are now the most educated in robotics compared to others in Taiwan. The bases have also become essential to robotics education in the country. Furthermore, the establishment of Youth Entrepreneur Bases help support young entrepreneurs throughout the first-mile, making Taoyuan the largest entrepreneurial cluster in Taiwan. Lastly, the construction of social housing allows young, professional or disadvantaged citizens to own their own homes.

SMART CITY PROJECTS

Wireless Network Implementation

By using a wireless network platform, municipal information and application services can be widely used while improving service quality. In the city's administrative agencies, township offices, libraries, health centers, tourist attractions service centers and the establishmentf of a convenient and friendly digital environment, providing free wireless internet access for the public. Not only can the municipal government's electronic services be more efficient, but also facilitate the faster and smoother exchange of information among government, enterprises and development institutions. Besides, Taoyuan City owns Taoyuan International Airport. In addition to providing free Wi-Fi in the entire airport, it also builts 4G broadband network and wireless Wi-Fi for passengeers along the Airport MRT, making it accessible to both the public and foreign tourists to pose the convenience and caring service of a smart city.

In order to facilitate the use of the public, since 2016, the" i-Taoyuan 2.0 Free Wi- Fi" has been opened in the business districts such as the Taoyuan Zhongzheng Arts & Cultural Zone, Zhongli Liuhe Commercial Circle and other business districts, and the hotspot has been upgraded into a hot zone. The bandwidth has also been upgraded from 1M to 5M. The exended-length AP(Access Point wireless network access device) has expended the coverage to 200 meters and the number of users has been upgraded to 250, so that people no longer have to suffer the slow internet access quality against the distance or the number of users. What users only need to do is open Wi-Fi device to search for "i-Taoyuan 2.0" wireless network signal, then they can connect to the Internet, and save the steps to enter the account password. Up to the first quarter of 2018, Chunghwa Telecom CHT Wi-Fi already set up 16,001 Hotspots in Taoyuan City, which are located in major public places(such as government agencies, academic institutions, major supermarkets, catering companies, financial institutions, travel agencies, tourist attractions, etc.), the etstablishment of wireless Internet software and hardware equipment, to provide the public services.

Using Full Coverage Monitoring System to Increase Public Safety

Taoyuan City Government deployed cameras through the global network. As of August 2018, there were 18,003 cameras in the system, including 9,277 license plate recognition functions, accounting for 52% of the total number of cameras. The camera also has a large bandwidth and wireless transmission function. After the fiber-optic network was built in 2012, it is more convenientross to read images across the region. It can be used together in police, fire and transportation and also to improve its economy and utilization rate.

In addition, the intelligent image query access management platform can control and start image access function, while collecting operation and monitoring execution and system status, complete recording of the overall system operation history track. The platform also has a camara rate identification function to detect abnormal conditions such as disconnection, and automatically notify the maintenance manufacture. Also, the GIS geographic information system supporting Google Street View, nesting each camara and equipment chassis and shooting direction, camera image review evaluation and selection, and provide relevant search function to shorten image search time. The license plate recognition system to actively identify the license plate data, enter the car number to find the location where the car has appeared, save time to view the video screen one by one, and avoid the possibility of omission. The exchange of the capture method road license plate identification system to strengthen the mastery of the vehicle-related vehicles involved in the case. This AI smart search, the leading police agency in the country, is the first in the nation to introduce the identification function that can detect and identify 50 types of car models and 9 kinds of car colors. The functions of the "Specific Target Instant Alarm System", such as the "Specific Target Instant Alarm System", greatly reduce the scope of the search and improve the efficiency of the search. Lastly, the image enrichment query sysetem quickly removes the image by removing the invalid information, saving the time for viewing the image.

Innovative Industry Talent Cultivation Flagship Project

At the end of August 2018, the proportion of young people aged 15-64 in Taoyuan had reached 77.82%, which is higher than the national average. It is one of the cities that has the highest proportion of young people in the country, also, there are many universities in this city. In addition, Taoyuan also has the most potential for young people to become involved in entrepreneurship. In order to create a better industrial environment and industrial drive in Taoyuan, the cit government established the Taoyuan Young Can Entrepreneur Command Center(TYC) and the Global Taiwan Business Innovation and Entrepreneurship Forum in 2016. In the following year, the Taoyuan City TYC Innovation and Entrepreneurship Resource Network was established. By combing them together, the Taoyuan City Government has created a good entrepreneurial base. Moreover, the City Government also provides innovative courses and a platform for experience sharing and idea communication, which creates a friendly space for creators and the possibility for sponsorship. In addition, in 2018, the City Government cooperated with several local organizations to promote the experimental field for the youth's and enterprise's innovation and entrepreneurship.

In 2018, the flagship project was been created, and, as of September 10, 2018, the City Government has held 30 innovative industry courses and two innovative industry internship Expos. in April and May. The project successfully created 60 internship contracts to 13 different companies in the summer; industry companies such as Internet of Things, AR, cloud technology, environmental technology, new tourism, smart machinery and social enterprises. In addition, the City Government cooperated with Singapore Sea Group to hold an e-commerce and e-sports industry recruitment briefing on June 15th. In addition, from September 2nd to the 8th, the Group brought 20 young people to learn about the operations of the e-commerce and e-sports industry of the Sea Group business. The project has enhanced Taoyuan youth innovation, entrepreneurial knowledge, and international vision. Through practical operations, visits, and other activities, the project will help young people get ahead of the future workplace and increase their employment competitiveness.

Smart School / Digital School

In conjunction with the promotion to the "Asia Silicon Valley" project, we will create smart classrooms at all levels of schools, totaling 2,200, promoting projects such as creativity, robotics, maker alliances and science eduation. In 2017, 15 primary and secondary schools were cultivated and connected into digital bases with different characteristics.The "Taoyuan Maker Alliance"was to promote the "learning by doing" education concept. In 2018, new schools were invited to join the summer teacher training and student summer camps and sent seed teachers go to remote schools to teach. In 2017-2018, about 570 students and 360 teachers will benefit. The establishment of the website will promote the sharing of results to the city's teachers(http://maker.csps.tyc.edu.tw/web/index.aspx, in order to achieve the purpose of promoting maker education, with smart environment,interactive design and hardware and software construction, so that our children have the future capabilities. In the promotion of robot education, in 2017, 41 schools got subsidized to implement creative robot teaching implementation plans, increase students' understanding of the principles of electromechanical and mechanical principles, and encourage schools to develop according to their characteristics. In 2018, Robots and AI Maker Summer Camp started. In addition to training for teachers, it also provides opportunities for remote and students from poor family to contact robot ecucation. A total of 30 techers and 88 studens participated.

In the smart classroom, teachers use the smart teaching system to make data decisions in the classroom with data analysis system, implement differentiated teaching, narrow the learning gap, and improve learning outcomes. In addition, data collection and analysis of teaching behaviors are also carried out. After the class, the system automatically produces AI artificial intelligence Socrates films, including teaching films, artificial intelligence analysis reports, teaching behavior data characteristics, and digital viewing of all attendees. The record if used to improve teaching and learning and achieve professional development of teachers. At the same time, they trained the Taoyuan smart Teacher Team and won the 2017 and 2018 Cross-Strait smart Classroom Invitational Championships.

Smart Street Lighting Demonstration Project

The Taoyuan High-Speed Railway Station is used as a demonstration street for smart streetlightings. At the same time, it is the first demonstration field in Taiwan to build a smart city through street lamps. In the future, Taoyuan will take advantage of the intensive construction of street lamps as the backbone of urban network development, and integrate functions such as energy saving and carbon reduction of street lamps, environmental quality control, network hotspot deployment, local tourism promotion, traffic guidance, disaster prevention and security. Further, Taoyuan will provide an experimental field for R&D and design of high-quality, new-generation groups through an open network platform. In the future, people can learn about local tourism features, convenience of life and food information through the digital signboard on the light pole. It is expected to benefit advertising and big data analysis and provide more high-quality public services, so that smart cities are no longer just a slogan, but truly felt by all citizens.

Establishmwnt of Citizen Card Service Office

Since the Taoyuan City Government was upgraded to a municipality in December 2014, in order to improve the city's competitiveness and the convenience of citizens' lives, and the new trend of smart cities, the Taoyuan City Citizen Card was planned. It was officially issued in September 2015, Taoyuan City Citizen Card. As of October 31, 2019, more than 1.49 million citizen cards (including physical cards, mobile citizen cards and credit joint cards) have been issued, in order to continuously improve the service quality of Taoyuan City Citizen Cards, and to introduce domestic and international innovations in Taoyuan by using service needs. Through the establishment of the "Citizen Card Integration Service Project Office", the planning and maintenance of the Citizen Card Services, including analysis services, will be carried out through the establishment of the "Citizen Card Integration Service Project Office", which is co-ordinated by the Information Technology Services Bureau. Models, planning management points, setting operational instructions, delineating the division of work and business details, deciding to promote timelines and implementing operational services; and regularly reviewing and improving existing services and continuing to develop emerging value-added applications. To enhance the efficiency of public card services and the efficiency of resource use.

Love and Tolerance - New Residents Learn Everything

In order to improve the resilience of new residents, the Taoyuan Municipal Government established the New Immigrants Family Service Center in Taoyuan City in 2006. At the mean time, the New Residents Affairs Committee was established, spanning five bureaus, in social welfare, Health care, employment training, education and learning, maternal and child protection, policy recommendations and counseling functions. And in 2017, it was included in the Family Service Centers of all districts to provide services, expand the service network and improve the service proximity.

To assist new residents who have financial difficulties, the Taoyuan Municipal Government's employment service was stationed in the New Residents' Joint Service Center in 2017, and in July 2018, the City's New Residents' Cultural Center was opened by the employment service staff to provide new residents for job hunting and employment. Services such as counseling and employment mediation guide them to enter the workplace as soon as possible, increasing their job-seeking skills and workplace adaptability.

Attraction of the Global Coming to Taoyuan

1. Taiwan Lantern Festival in Taoyuan

Taoyuan City was seeking an opportunity to promote itself after upgrading to a municipality in 2014. In 2016, Taoyuan City Government actively sought and received approval to host the Taiwan Lantern Festival, which incorporated the characteristics of Taoyuan's ponds and multiculturalism. During the event, the City Government made use of corridor space from the THSR Taoyuan Station Plaza to the Blue Pond Park (total length of 2 Km, area of 32 hectares) to create a "Smart Technology Light Exhibition Zone" that established the image of a "smart city" for Taoyuan. Since then, Taoyuan City Government has created five other lantern areas with different themes, such as Fairyland Dream Works Lantern Festival, Taoyuan Story Lantern Area (the very first 500 meter-long narrative gallery), Multiple Cultures and Exchange City Lantern District. The use of optoelectronics and lantern technology created an image of multiculturalism, a high tech society, and a place where dreams happen, while simultaneously presented the charming appearance of Taoyuan very well and provided visitors with the charm of a new traditional festival.

2. Taoyuan Land Art Festival

The idea for the Taoyuan Land Art Festival originated from the Japanese Land Festival, which is used for the revival of the local consciousness. It has been held from August to September every year since 2013. The picturesque scenery of the city is used as a exhibition space for the art produced during this event. Since 2015, the artworks have been added to the international forum with the goal of strengthening local culture and art. In 2018, the Taoyuan Landscape Art Festival was held from September 14th to the 30th. It was distributed among three exhibition areas with the theme of "Old Town, New Art,•Water Young Taoyuan". The activity was held for three major purposes (to promote awareness of the local culture, improve the local community experience, and to improve the local artistic platform) as well as four main values (to promote local features, local involvement environmental sustainability, and circular economy), which helped to connect people to the environment and allowed people to taste the past, present, and future of Taoyuan.

3. Taoyuan Agriculture Expo.

The Taoyuan Agricultural Expo began trial operation in 2017. The Taoyuan Municipal Government and the Agriculture Committee cooperated with the circular economy as a whole. The park covers 30 hectares, with sustainable, low carbon, green energy, ecology, industry, culture and education. For the elements, design 8 exhibition areas, 2 theaters, 4 market sets, 3 corporate image areas and 3 landscape areas, and show the main axes of circular economy, green life, landscape art and science and technology agriculture. The life of the hundred arts and crafts, into the agricultural expo in the circle of the people's life, invite the community to participate, and create a farmer's APP to facilitate the guidance of the public park, combined with tourism to promote the upgrade of Taoyuan's agricultural industry, the use of solar power to supply park power, for urban development The model of green energy, combined with wisdom technology and green energy industry, forms a new development direction and demonstrates the strength of Taoyuan agriculture.

Green Energy Project Office to Promote Green Energy Policy

In order to accelerate the promotion of the green energy industry, Taoyuan Municipal Government has established the "Green Energy Project Office" in February of 2018 to coordinate various green energy policies with the goal of creating low-carbon green energy cities in environmental monitoring, energy conservation and carbon reduction, and publicity. Implementation and promotion of various aspects, implementation of sustainable wisdom management. The purpose is to make renewable energy a feature of Taoyuan development. Besides, In order to improve the environment in Taoyuan City and prevent the spread of pollution, in 2015, the original environmental protection report center was established, and the whole station established the "Environmental Pollution Monitoring Center". The monitoring center integrates the air/water pollution, business waste, noise pollution into the E-Dispatching system through the inspection vehicle dispatch monitoring, inspection tablet APP and inspection control information system. Image monitoring and data transmission allow inspectors to quickly locate the source of pollution and report the information immediately. Information such as control systems, map systems, audit dispatch systems, and GIS geographic information provide auditors with complete control information to assist in judging audit time.

Conclusion

There were several key elements that played important roles to make Taoyuan a smart city, such as the implementation of a complete urban traffic network, the establishment of the Asian Silicon Valley, and the launching of the Aerotropolis project. Besides, we have experiences of integrating smart city related projects, including Citizen Card Integrated Applications, Energy Sustainability, Environmental Sustainability, Smart Transportation and Green Transportation, Sensor-Network Construction and Application, Development of Youth Entrepreneur Bases, Smart Education, Robotics and Semantic Service Applications, Smart Medical and Long-Term Care, and Public Safety and Disaster Prevention. By applying these major initiatives, Taoyuan has become the smart city that we all know and enjoy today.

Regardless of the types of smart services used in the city, the ultimate goal of the city governance is to make Taoyuan an ideal place to live, while also providing good employment and entrepreneurship opportunities. We will continue to build Taoyuan as a smart city, and build a smart city solution platform with the functions of solution on-demand, quick access, and agent service. The goal of this platform is to export smart solutions based on local industrial technology to connect Taoyuan to international cities as our alliance partners.

5G Data-based Smart City Applications: Beyond Infrastructure

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***Abstract*—As a novel solution to recent urban problems, smart cities collect information through ICT to provide services that improve citizens' quality of life. The growing market of smart cities indicates global efforts to employ communication technology in urban decision-making and further devise strategies for sustainable cities. For the implementation of the smart city, connectivity has become a key factor that allows massive data sharing between different urban sectors. The development of 5G technology is expected to satisfy such requirements in high speed and with high reliability. These advances in 5G network technologies will enable a variety of smart city applications in our society. In this study, several 5G applicable technologies for smart cities are introduced: self-driving car technology, safety applications, and digital healthcare services. In the future, the application of 5G Data from hyper-connected trillion sensors will be the basis of smart city operations to provide public services. Smart city is an opportunity to solve the rapid urbanization problem and strengthen national competitiveness by improving economic growth, productivity, and quality of life.**

Keywords—Smart City, 5G Technology, ICT, IoT, Hyper-connected Data

I. Growing Need for Smart City

Urbanized modern cities are suffering from various problems such as the deterioration of facilities, traffic congestion, energy shortage and environmental pollution, that preclude the efficient use of urban resources. The smart city has emerged as a novel alternative to those urban problems by analyzing information collected through ICT (Information and Communication Technology). A smart city is defined as a new

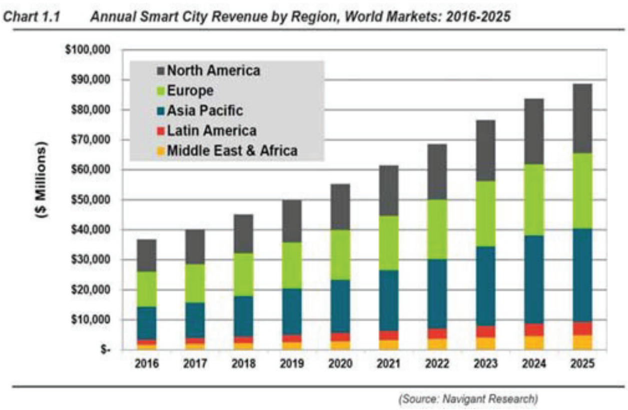

Figure 1. Expectation of global market scale on smart city (2016-2025) [1]

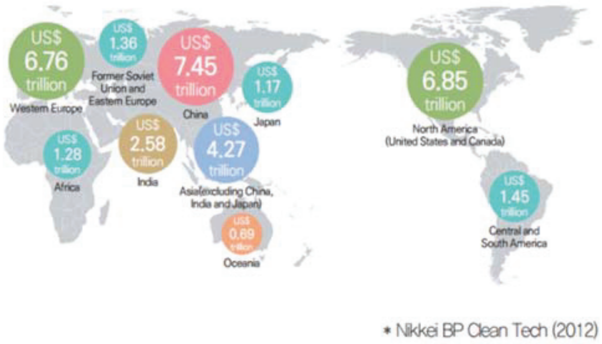

Figure 1. Smart city investment scale by region (2010-2030): the original statistics from [2] were re-visualized in [3]

concept of cities that integrates the Internet of Things (IoT), cloud computing, and big data, for the provision of smart services on urban planning, development, and management (ISO & IEC, 2015). Thus, based on urban infrastructure, connected to ICT, a smart city offers diverse urban services for sustainable city, and further improves the citizens' quality of life.

The global market scale on smart cities also implies its importance in that it is expected to result in rapid growth (Fig. 1). Several leading countries have been investing heavily on implementing a smart city to preoccupy the emerging smart city market (Fig. 2). Asian countries are expanding their investments on urban development and infrastructure construction, while Western countries are focusing on the development of services to solve existing urban issues [1].

A smart city is theoretically composed of three components: infrastructure, data, and service [4]. Firstly, infrastructure includes not only physical and ICT infrastructure, but also geospatial infrastructure that fuses real space with virtual space. Secondly, urban data is acquired from the IoT network and shared on platforms. Then, the collected data goes through processing and analysis before being provided as a service. The quality and reliability of services should be considered part of its implementation.

The unique feature of a smart city is its citizen-centric approach to urban problem solving beyond simply providing infrastructure. In comparison with the conventional U-city approach, smart cities optimize efficiency through collection and application of information, rather than through the expansion of physical urban infrastructure. Both methods share a common aspect of applying ICT to urban environments, but ultimately have different goals and governance (Table 1).

Table 1. Comparison of U-city and smart city [5]

	U-City	Smart City
Business	- Provide infrastructure - Public service-based	- Provide data-based solution to urban problems - Public/private service
Information	- One-way transmission - Time-delay	- Two-way sharing - Real time
Role of Citizens	Demander (passive role)	Producer and supplier (active and leading role)
Governance	Government	Open-governance (include government, cooperation, citizens)
Use of Urban Data	- Operate in separate urban sectors - Difficulties in sharing and application of data	- Connection between urban sectors - Data sharing platform - Able to develop private solution
Urban Management	- Limitations in efficient use of urban resources - Top-down	- Efficient distribution of urban resources based on sharing economy - Bottom-up

Global attempts to adopt the smart city model showed successful results in various applications using urban information. The "LinkNYC" project in New York, was considered a successful state government policy that enhanced accessibility to information through the installation of automatic machines with smart interfaces. Meanwhile in Barcelona, big data obtained from sensors on the roads were used to control traffic flow and alleviate congestion. Amsterdam and Vancouver are currently running two representative smart city projects focusing on environmental issues, by aiming to reduce carbon emissions. Additionally, in Korea, Sejong City and Busan Eco Delta City were selected as national testbed sites for smart cities in 2018, for introduction of smart energy management systems [6].

As previously mentioned, the key feature of a smart city is sharing information from different urban sectors (or information sources). Therefore, connectivity has become a crucial factor for its implementation so that the required data can be shared anytime and anywhere. In this respect, current 3G/4G systems are limited in reliability and by time delays. However, recent development of 5G satisfies hyper-connectivity conditions with very high reliability (greater than 99.9999) and short time delay (around 1ms) [7].

II. Development of 5G Communication Technology

5G communication technology provides high speed at a large capacity, while guaranteeing the reliability of services even with a large number of occupations. To be specific, the features of 5G can be summarized as (1) high speed, (2) high capacity, (3) high density, (4) high energy efficiency, (5) low latency, and (6) high reliability (Table 2). These six features of 5G imply the feasibility of constructing missions that are critical in the IoT environment, which is required for reliable medical services and autonomous driving. By fully activating the IoT network, 5G will enable the digitalization of all industries by covering every receiver, service, and industry [8].

In terms of spectrum bands, 5G employs wavelength ranges including sub 1GHz, 1-6GHz, and those above 6GHz,

Figure 3. 5G features satisfying the requirements for smart cities [15]

denoted as mmWave [10]. Considering the fact that the wireless communication industry utilizes national resources (frequency band), the 5G development plan is usually coupled with national policy. China, USA, Japan, and Korea are currently evaluated as the well-prepared nations for the implementation of 5G technology.

In the case of China, the government has been preparing 5G policies since 2013 and finished the 5G Stand Alone test in 16 cities, meaning that 5G infrastructure is ready for use. Along with the Chinese authorities, the China Mobile cooperation is planning to commercialize 5G services by 2020, and has already constructed approximately 100 base stations in several main cities [11]. In the USA, 5G strategies are led by multiple leading enterprises including Verizon, AT&T, SPRINT, and T-Mobile. The former two companies are concentrating on investing fixed wireless access based on 5G infrastructure, while the latter two are focusing on mobile-based services [12]. Japan is also building up a systematic background for the commercialization of 5G technology by defining the level of technology required and assigning frequency ranges. Based on national needs, NTT DOCOMO set 2020 Tokyo Olympics as a temporal goal to showcase 5G commercial services worldwide [13]. In Korea, KT and SKT telecommunication enterprises have taken on the task of developing and hastening the actual implementation of 5G technology by contributing to the global standardization of 5G. Thus, KT pre-launched a 5G test service in the 2018 Pyeongchang Winter Olympics and started the world's first mobile 5G commercial service on April 3, 2019 [8].

Table 2. Features of 5G communication technology [8][9]

Feature	Description
High Speed	100Mbps (User experienced data rate) 20Gbps (Peak data rate)
High Capacity	10Tbps per km^2 (1,000 times larger area traffic density than 4G)
High Density	1,000,000 devices per km^2
High Energy Efficiency	10 times lower power consumption than 4G
Low Latency	Less than 1ms
High Reliability	Zero mobility interruption

Energy, utility, transportation, and public safety are considered the representative application fields that will benefit most from 5G technology. In energy management, energy consumption devices are connected to smart grids with 5G. Then, based on the collected data, resources are optimized so as to reduce the energy cost and monitor the conditions of utilities. In the same context, the capacity of roads can be maximized by connecting the vehicles and infrastructure. With the advent of autonomous driving, traffic congestion can be alleviated, and fuel consumption reduced. In addition, as 5G can transmit large amounts of data with high speed and high reliability, public safety can also be reinforced through applications such as monitoring high-definition CCTV and applying AI-based face recognition for criminals and missing people [14].

III. Smart City Applications in 5G Network

The benefits of 5G technology can be used to optimize technology with various applications in smart cities. 5G Networks with enhanced mobile-broadband, massive machine-type communications, and low latency, that have evolved from the existing LTE network, will accelerate the development of smart city technology. The 5G technologies that apply to smart cities are as follows: Self-driving cars, safety applications, digital healthcare service, and so on.

A. Self-driving Car Technology with 5G Network

A self-driving car is a kind of intelligent car, which arrives at a destination based on information obtained from automotive sensors [16]. In other words, it is a computer-controlled car that drives itself. Until now, the technology of self-driving cars has been focused on sensors for positioning as well as driving control inside the vehicle. In the future, when 5G networks are available everywhere, hyper-connections will allow us to rapidly exchange large amounts of information with numerous environments outside the vehicle and advance autonomous driving technologies.

Figure 4. Features of 5G C-V2X car concept in Qualcomm [18].

Many tech companies, including Ericsson, Nokia, Qualcomm, and Huawei, started developing the C-V2X (cellular-vehicle-to-everything) concept with advanced 5G network infrastructure [17]. Devices in the city, including road and traffic lights, traffic information system, parking, and even other cars and pedestrians, would be connected by a trillion sensors. Following coordinated 5G-based autonomous driving, the 5G-based infotainment in vehicles is also expected to grow rapidly.

B. Public Safety Applications with 5G Network

5G networks will bring new opportunities to safety applications [19]. Faster and more robust networks mean that large-capacity video transmissions can now be achieved in a short time. Furthermore, better quality images and faster streaming accelerate surveillance applications for public safety. Also, real-time disaster alarms are made possible through 5G networks as all users would be able to benefit from the hyper-connected 5G by receiving alerts on detected disaster information in real-time [20]. Another feasible example is a 5G-based robot that solves the problem of areas that are inaccessible to humans, such as nuclear no-go zones and disaster situations. A robust disaster-response system was developed by Professor Sven Behnke and his team through a project called Centauro [21]. The robot is controlled by a human from a safe place with various 5G-based sensors.

Figure 6. Tele-operated robot Centauro can fulfil tasks such as climbing stairs, navigating obstacles and using power tools. Image Credit -© Volker Lannert/Uni Bonn [21].

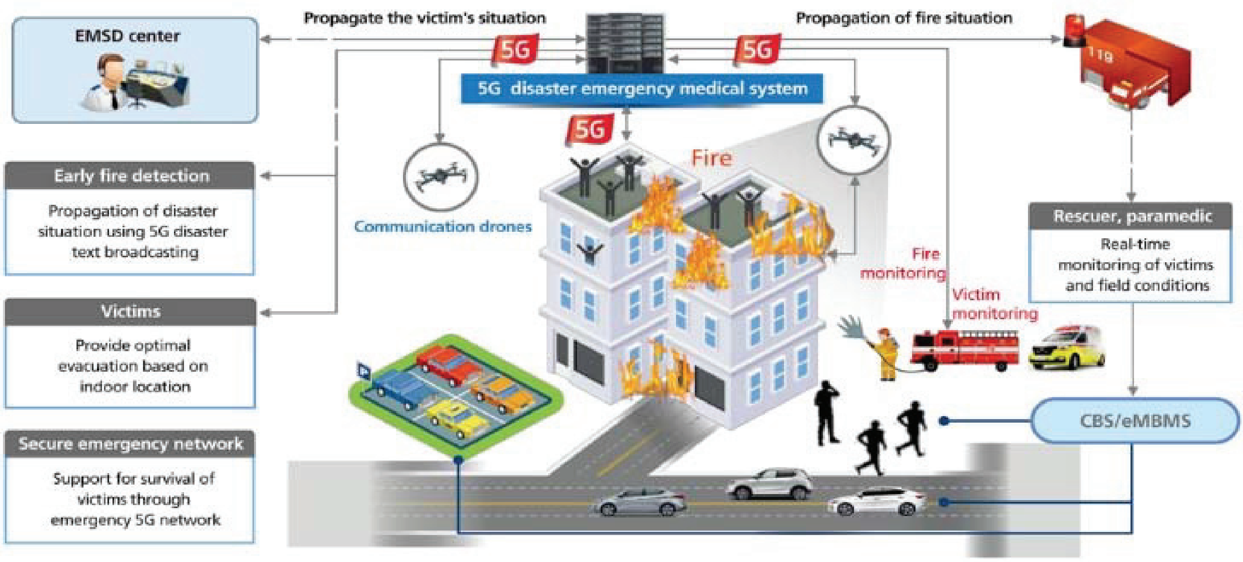

Figure 5. 5G-based disaster emergency medical system integrating monitoring and rescue [20].

C. Digital Healthcare Service with 5G Network

As a result of developments in 5G networks systems, smart healthcare services are also expected to evolve significantly. Firstly, 5G technology helps in the treatment of emergency patients through real-time communication of large amounts of medical information such as electrocardiograms, blood pressure, heart rate, and massive medical sound and images, or video data. Recently, the Korean tech giant Samsung partnered with Spanish telecommunications company O2 to help build connected 5G ambulances for the national health service. The ambulances will be equipped with new technologies including support for real-time video and field data collection [22]. Also, the Korean telecommunications company LG Uplus has partnered with Eulji hospital to create an AI smart hospital (AI-EMC) for inpatients with reduced mobility through 5G networks [23].

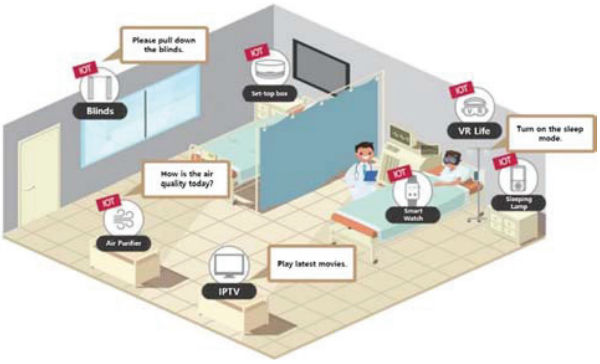

Figure 7. 5G-based AI smart hospital [22].

IV. Suggestions for Effective Smart City Design

Smart cities ought to be developed using 5G data with real-time, hyper-connectivity as well as independent infrastructure. Data from trillions of hyper-connected sensors will form the basis of smart city operations in providing public services. Like self-driving car technology, future cutting-edge technologies require a top-down approach that selects and operates a national pilot city where experimentation is possible. Declining cities require a bottom-up policy approach that uses problem-solving 5G titration technology, such digital healthcare and public safety applications, in a smart city. With proper policy support, this smart city model provides an opportunity to solve the rapid urbanization problem, as well as strengthening national competitiveness through economic growth and quality of life by improving productivity.

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Community Mapping for Enabling Response to Urban Flood

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Abstract—Recently, there has been growing interest in public participation GIS (Geographic Information System) technology that enables spontaneous public response to increasingly frequent flood and drought events. Accordingly, social and economic demands are increasing on portal services that are designed to help cope with natural hazards such as earthquakes. By focusing on a specific hazard, urban flood, this study designed a prototype of a disaster response portal and its service system. Specifically, the study aimed at realizing the base technologies and component technologies that are employed in creating and/or operating web portals related to community mapping. By considering the compatibility with VGI (volunteered geographic information) portals, the study created a system environment by employing universally used open-source software programs such as Apache Tomcat, GeoServer, GeoNetwork, and PostgreSQL/PostGIS. Furthermore, by utilizing standard web technologies as well as GIS open standard services and interfaces, the study designed and realized four types of functions: GIS common, community mapping, map style management, and data sharing and managemen

Keywords— VGI portal, urban flood, GIS, public participation GIS

I. Introduction

Climate change-related natural hazards and disasters have been frequent in recent decades. The impacts have rendered it necessary to promptly gather, disseminate, and update related information. As a practical solution to the problem, interested parties may consider obtaining the information expeditiously through web-based volunteered geographic information (VGI) portals. As companies and the public sector are considering increasing citizen participation, such participation is gaining more momentum along with the expansion of social networks and collective intelligence. Furthermore, public participation smartphone applications have enabled citizens and laypeople to participate in disaster prevention processes, offering them a tool with which they can aid the setting up of realistic, reasonable, and comprehensive prevention plans (Ki, 2012).

Plans established in this manner can be more practical if the information providers have resided for a substantial period or are spending substantial amount of time in the area. With assistance from specialists or civil servants, the citizens and laypeople could participate more assertively in the process of planning and implementation. Currently, the government is endeavoring to build an integrated urban disaster prevention database and web tool platform, which is based on coordination and combination of data from a number of related systems. Furthermore, the administration is implementing a participatory geographic information portal through community mapping where citizens are engaged in the process (National Geographic Information Institute, 2015).

This study designed a prototype of a public participation spatial information portal for urban flood response, i.e., a volunteered geographic information (VGI) portal. Furthermore, the study realized major functions of the portal and suggested methods to utilize the website to ensure maximum availability for users.

II. Trends in Community Mapping

Since the 2000s, advancements in Web GIS and mobile devices have allowed a migration of the core user of spatial data from expert groups to laypeople or ordinary citizens. As a result, there have been systems wherein the spontaneous participation of citizens is resulting in the creation, update, and maintenance of spatial data. Nevertheless, questions are being continuously raised about the positional and logical accuracy of such spatial data created by non-experts. This problem has also been subjected to many strategies proposed by organizations and agencies that provide VGI mapping services (Goodchild and Li, 2012; Van Exel *et al.*, 2010). Despite the efforts, VGI maps are markedly expanding their presence in markets in recent years because of their cost competitiveness, freedom in data use and speed, and the greater variety of themes being addressed when compared to the existing data produced by government agencies and commercial spatial-data providers

Community mapping is a form of public participation GIS (PPGIS). PPGIS involves the use of the Internet and GIS in the citizen participation process, which allows laypeople to partake in spatial data decision-making processes through mapping and GIS analysis. The number 2.0, denoting later version, refers to the grating of the Web 2.0 concept into spatial information services, thus allowing users to add information to the maps or access other types of services they require. Similar developments have enabled real-time voicing of opinions of citizens as they are based on spatial information, UCC (User Created Content), and other multimedia inputs. Furthermore, Goodchild (2007) proposed a concept called “volunteered geography (VG),” wherein individuals have the opportunity to participate as active geographic information creators, and combined VG with GIS and named it VGI (Volunteered Geographic Information).

III. Development of Public Participation Spatial Information Porta

A. System design considerations

Advancements in Web GIS and mobile devices have allowed a migration of the core user of spatial data from expert groups to laypeople or ordinary citizens. As a result, there have been systems wherein the spontaneous participation of citizens is leading to the creation, update, and maintenance of spatial data (Hong, 2012). Nevertheless, questions are being continuously raised about the positional and logical accuracy of similar spatial data created by non-experts. This problem has also been subjected to numerous strategies proposed by organizations and agencies that provide VGI mapping services. Despite the efforts, VGI maps are markedly expanding their presence in markets in recent years because of their cost competitiveness, freedom in data use and speed, and the greater variety of themes being addressed when compared to the existing data produced by government agencies and commercial spatial-data providers.

Open-source geographic information systems (GIS) have recently started to reinforce their structure such that they can replace the system of GIS product groups of commercial GIS providers, while the commercial GIS companies themselves have started to adopt open-source GIS models by modifying their own products to be open source (Jang *et al*., 2016). The previously prevalent issues with respect to quality verification and maintenance and repair are being addressed by the arrival of commercial open-source GIS providers and their implementation of continued upgrades and maintenance and repair. Hence, it is necessary for public participation spatial information portals to actively incorporate the user VGI, open source platforms, and open standards that are part of the latest technologies set forth by the UN-GGIM (United Nations Committee of Experts on Global Geospatial Information Management).

B. Creating public participation spatial information portals

The software that was employed to create public participation spatial information portals was various open source programs with verified stability and universality (Fig. 1). GeoServer was employed for GIS software that can process geographic spatial data. For DBMS server, PostgreSQL was adopted as it is employed widely in open source DBMS. PostGIS, which adds support for geographic objects to PostgreSQL, was applied to create the system. GeoNetwork was employed for the catalog engine that manages spatial metadata storage and CSW services.

C. Major functions of public participation spatial information portals

With respect to the major functions of the public participation spatial information prototype, development was undertaken in each area such as (a) GIS common, (b) community mapping, (c) map style management, and (d) data sharing and management. First, GIS common involves map control, map layer management, and calculation functions (a line, plane, distance, and area on the maps). Community mapping offers functions such as viewing attributes of a feature appearing on the maps; creation, modification, and deletion of spatial data geometry (point, arc, polygon); and storage of the created maps and other registries as metadata in compliance with ISO19115-1 standard. In terms of map style management, the prototype classifies data by utilizing the attributes of spatial data, and sets up vector and raster data symbols. Last, in data sharing and management, newly developed functions are CSW server registry and effectiveness test and server-registered record search.

IV. Realization of VGI Portal Prototype

A. Realization of GIS common and community mapping functions

To ensure flexible services employing community mapping techniques, map maneuvering by users was rendered convenient with the realization of basic GIS functions such as map control, layer management, distance/area measurement, and full-screen view (Fig. 1). Furthermore, editor functions were added to allow the addition, modification, and deletion of user-created spatial information and data (points, lines, polygons) (Fig. 2). When realizing these editor functions, WFS transaction service (an OGC standard service) was utilized to enable data storage.

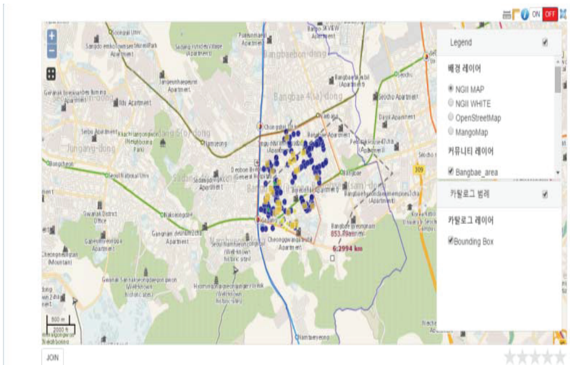

Fig. 1. Image of Portal Map

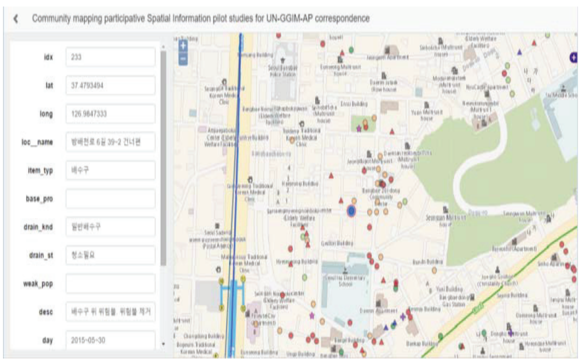

Fig. 2. Image of Editor

B. Map style management and data sharing and management functions

For wide ranges of visualization of community mapping data, a stylizing tool was realized by utilizing the OGC standard-based symbol SLD (Styled Layer Descriptor). Figure 4 illustrates the realization of various classification methods that are aligned to the data characteristics. In Fig. 4 the filter, rule, polygon symbolizer, line symbolizer, and point symbolizer functions are also illustrated. Furthermore, the prototype offers classification methods that were realized to classify spatial data by using various inputs values. The prototype also facilitated the application of various color classifications of the spatial data by utilizing

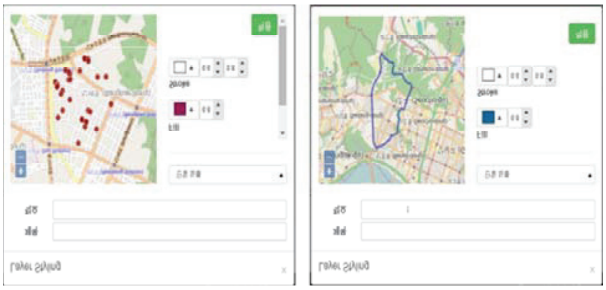

Fig. 3. Tool for Creating Spatial Data SLD

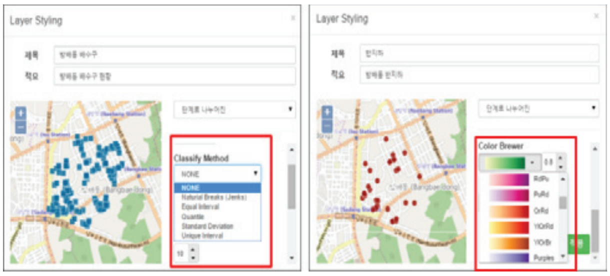

Fig. 4. Classification Method and ColorBrewer

V. Conclusion

Community mapping in disaster situations can enable citizens to expeditiously upload relevant information to online platforms in real-time and thus help others quickly obtain such information and evacuate in risk situations. This research paper describes the development of a community mapping portal and its service system, which are based mostly on citizen-participants in order to help better cope with urban flood, a form of natural hazard. The designed service prototype of a public participation spatial information portal has utilized various open-source software programs with verified stability and universality.

The results of the system design and prototype development exercise are as follows: (a) through the use of the eGovernment Standard Framework, an embodiment of a verified standard framework that ensures high levels of security and stability as well as superior maintenance and repair feasibility; (b) incorporation of various verified GIS open-source software programs, which allowed cost saving during the software program realization and reduction in the time required for development; and (c) processing of GIS data that are in compliance with the OGC as well as the international spatial data processing standard (ISO) to increase the universality of the prototype.

Along with global warming and the resulting climate-related incidents, there has been a sharp increase in the occurrence of natural hazards and disasters, which in turn has increased urban residents' requirement for securing safety and convenience of their lives. In this context, this study presented various application possibilities of the web-based portal that has been developed by combining spatial information technology and citizen participation to help cope better with hazards and disasters, a realm conventionally perceived as that of the government. The vast amounts of information and data that are produced through public participation spatial information platforms can be utilized in wide varieties of manners when re-produced as disaster prevention information. Depending on the purpose of such utilization, the re-produced data can be employed for disaster analysis, disaster prevention for specific areas, public policy decision-making, etc. The results of the study imply that in future, further research is to be conducted on: the quality of public participation data, which is posing challenges in increasing the utilization of the portal; effective operation of the developed portal; maintenance and repair strategies; and, in particular, user requirements.

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Analysis of Geospatial Technology for Smart City Development: Case Study of South Korea

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***Abstract*— Spatial information is a fundamental resource required to overcome the various issues in urban areas for the development of smart cities. However, the current spatial information sector was determined to lack global, technological competitiveness and preparation for the future. To effectively implement and maximize the potential of smart technologies, there is a pressing need to review and improve upon the core technologies driving smart cities, namely, multi-sensor spatial data acquisition, continuity and connectivity of spatial information, and developing an effective data processing and management platform. To provide relevant background information and context to smart city technology, this paper introduces various technologies in the 4th Industrial Revolution, foreign and domestic policies, and global market trends related to the spatial information sector. Various applications of spatial information are also presented in this paper to offer insight into the components integrated into a smart city framework.**

Keywords: Smart city, core technologies, geospatial technology, spatial information

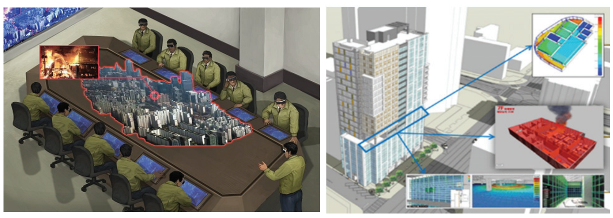
I. Introduction

The increase in urban populations have resulted in the advent of novel urban and societal challenges at various regional scales. The majority of these problems occur in the spatial domain, demonstrating the need to optimize urban management and planning. To address these problems, geospatial techniques can provide crucial information using methods such as Geographic Information System (GIS), remote sensing, and Global Positioning System (GPS) [1]. These methods can be applied to collect georeferenced spatial data, which can be used to analyze various phenomena of the Earth using models, simulations, and visualization approaches. However, an effective approach to analyze spatial information, particularly from big data sources, is still a difficult task. With the rapid development in the 4th Industrial Revolution, cities are trending towards sophisticated 5G hyper-connected networks and "smarter" systems. A platform capable of encompassing multi-dimensional spatial analysis and convergence of the relevant technologies would provide a possible solution to these shortcomings. In this paper, we introduce "Smart City" technology and the use of intelligent geospatial information as an effective means to resolve the aforementioned urban issues. In more detail, this paper aims to present the current state of geospatial technology and the relevant core technologies with respect to the development of smart cities in South Korea. This research paper is structured in the following order. First, Section II provides a trend analysis of current technologies, policies, and global markets in the spatial information sector for smart city development. Then, Section III introduces the core technologies required for developing intelligent geospatial information, and ultimately, implementing a smart city framework. Next, Section IV describes various applications using geospatial technology and their potential when incorporated in smart cities. Finally, to conclude this research, Section V illustrates the potential and limitations with respect to geospatial technology and the future of smart city.

II. Trend Analysis

A. Technologies in the 4th Industrial Revolution

The Cyber-Physical System (CPS) provides the ability to connect reality with the virtual world. Goals defined within the cyber domain can thus be converted to the physical world for real-situation decision-making. Many developed countries are striving to expand and optimize spatial information utilization through the convergence of key technologies driving the 4th Industrial Revolution (Artificial Intelligence (AI), Internet of Things (IoT), big data, and spatial information). In particular, many countries are promoting the convergence of spatial information using CPS simulations in virtual environments (including virtual, augmented, mixed, and extended realities) such as by digital twin technology. These smart spatial technologies can be used for applications such as fire emergency response and facility management systems. At the forefront, ESRI provides 3D spatial information through their "3D CityEngine" software and Dassault Systems offers urban planning services in a 3D simulated space using their "3D Experience City" software.



(a) (b)

Figure 1: (a) Smart visualization methods of geospatial information using CPS-based technology (b) Location tracking using simulated digital domain for effective decision-making

B. Policies on smart cities and geospatial information

The application of intelligent geospatial information in many developed countries are trending in open-distribution, convergence, and virtualization of geospatial data. In light of this global direction, smart cities have been used as a potential solution to overcome urban and societal challenges. Already, smart city policies have started to be implemented in several major cities.

First, in USA, plans to implement smart city technology were suggested by applying CPS with spatial information through the Networking and Information Technology Research and Development program. Second, since many major cities in Germany, notably Berlin, are facing problems with living space, urban infrastructure, energy, and waste, the “Smart City Berlin” project was initiated in hopes to alleviate the urban issues. Last, due to the rapid urbanization and ensuing issues in India, there are plans to build 100 smart cities across the country by 2022. In addition to the use of spatial information itself, various attempts to improve utilization were made through the convergence and integration with other relevant fields. In the United Kingdom (UK), the Ordinance Survey integrates GIS and public services to address the needs of the citizens. In Australia and New Zealand, Geocoded National Address Files using spatial information are developed as effective decision-making and referencing tools for administrative works, statistics, and elections. In this manner, location-based data and spatial information can be combined for new value-creation opportunities.

Domestic policies on spatial information in South Korea were established and promoted based on the open distribution of information and convergence with other fields. Three key basic plans were issued recently, starting in 2018. First, the 6th National Spatial Information Policy Master Plan ('18 to '22) was established by National Spatial Data Infrastructure for the continual development of the spatial information industry, support for human resources, and emphasis on collaborative works with other sectors. Second, the 2nd National Land and Transportation Information Basic Plan was created by the Ministry of Land, Infrastructure and Transport for effective virtualization of geospatial data in the land and transportation sector. Last, the 4th Basic Plan by the Ministry of Science and ICT was established for mid-to-long term policies for future key tasks in science and technology development.

C. Global market trends in the geospatial sector

The 3D spatial information market continues to grow globally due to the growing number of 2D to 3D map transformations [2]. Accordingly, digital twin and smart city markets are expected to grow remarkably with the development of key technologies, such as big data/cloud and IoT technologies. In quantitative terms, the global 3D mapping and 3D modeling market was valued at approximately $ 1.9 billion in 2015, and is anticipated to grow at an average annual growth rate of 55% to $ 17.9 billion in 2020 (Fig. 2(a)). Based on this estimate, the US market is projected to have the highest share, while the Asia and Pacific markets, albeit with smaller shares, are projected to escalate at a faster rate in the near future due to the economic growth in China and Japan.

The global smart city market is expected to grow to $ 12 trillion by 2022, at an average annual growth rate of 23.1% from $ 422.4 billion based on the data for 2017 (Fig. 2(b)). In 2016, the global digital twin market was estimated at $ 1.8 billion in 2016 and is projected to grow at an annual growth rate of 38.9% and estimated to be $ 15.7 billion in 2023 (Fig. 2(c)). Based on these estimates, the North American market has the highest share at 32%, while the European market and Asia Pacific market have shares of 30% and 24%, respectively (Fig. 2(d)).

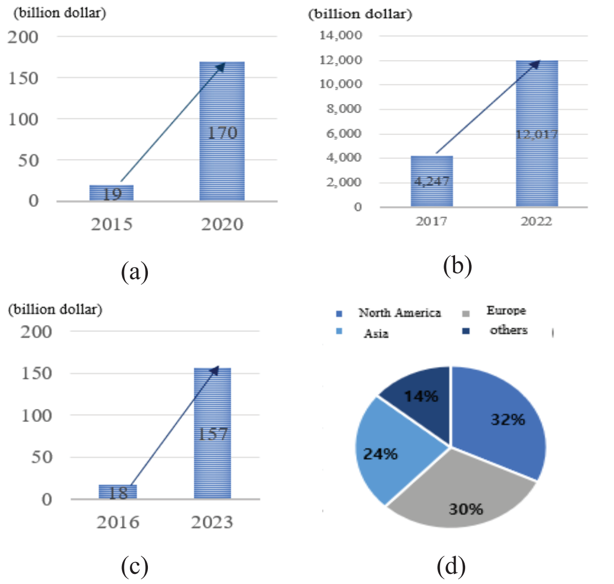


Figure 2: (a) 3D mapping and 3D modeling global market size and future prospects, (b) Smart city global market size and future prospects, (c) Digital twin global market size and future market size, (d) Market share in percentage given by each continent.

III. Core Technologies for Smart Cities

The core technologies integrated into smart cities are based on developing a platform that can efficiently construct, connect, process, and manage spatial information. These technologies are also in line with the key technologies fueling the 4th Industrial Revolution. The three core technologies are presented in the following sub-sections.

Figure 3: Collection of multiple data acquisition methods to obtain real-time, location-based spatial information in static and dynamic forms.

A. Multi-sensor spatial data acquisition

In order to obtain static and dynamic spatial information efficiently, the integration of multiple sensors and data acquisition methods is essential. The fusion of multi-satellite and sensor images can provide observations in inaccessible, remote areas. However, since each sensor has different characteristics and requirements, there are many standards to follow. For instance, when combining indoor and outdoor sensors, a dynamic position accuracy of less than 50 cm is required. For 3D spatial data, the data must be generated quickly within 0.5 s. With current technology, given the real distance error is within 5 cm for 3D spatial data using a fixed camera, new technologies are required to acquire the data within 0.5 s.

For the development of smart cities and virtual land monitoring, real-time acquisition and complex utilization of 3D dynamic spatial data are required. Hence, maximizing the extensive spectrum of data acquisition methods is beneficial. Multi-source satellite images, long-term drones, and aircrafts can be used for producing spaceborne and airborne images. Real-time monitoring by CCTV networks, smartphone images, indoor/outdoor sensors, and other ground-based methods can be incorporated as well. Together, these data sources can be combined together to automate the production and analysis of dynamic spatial information, as suggested by Fig. 3. In this process, AI and machine learning methods can be adopted to maximize the performance and efficiency.

B. Continuity and connectivity of spatial information

Due to the diversity of sensors used for data acquisition, addressing the continuity and connectivity of the acquired spatial information under a common standard or framework is a complex issue. One method is to link real-world objects with spatial information. This "object-spatial information" method requires an automation rate of about 80% or higher to connect aerial videos, UAV, CCTV, vehicle footage, and point cloud data. Mapping with objects in space requires an accuracy of more than 90%. Real-time generation of multi-source big data and LiDAR-based, high-precision data collected from autonomous vehicles can be used to create real-time, multi-source spatial big data. Due to the real-time nature and large storage volume required to manage geospatial data (such as images acquired from 3D LiDAR, drone, and smartphone camera), the error must be less than 5%. Also, data reception, consistent spatial information indexing, and consistent data connectivity of over 90% are other factors to consider as well.

C. Developing an effective data processing and management platform

Open-distribution and real-time processing of spatial big data and next-generation convergence technology are required to process and manage spatial data more effectively in the future. For virtualization purposes, the coordinate system and spatial data must be compatible using a standardized system to properly process the spatial information. In addition, the spatial information must be updated with real-time feedback. In order to establish smart cities in the future and to fully realize next-generation convergence technologies, new services need to be developed with consideration to 5G networks, IoT-based technology, edge computing, and operability on mobile environments and virtually simulated domains.

IV. Applications of Geospatial Information

A. Smart transportation

Real-time traffic data, traffic signal data, and traffic situation data can be integrated into a "smart" traffic support system which operate by conducting time series and multi-dimensional traffic analysis [3].

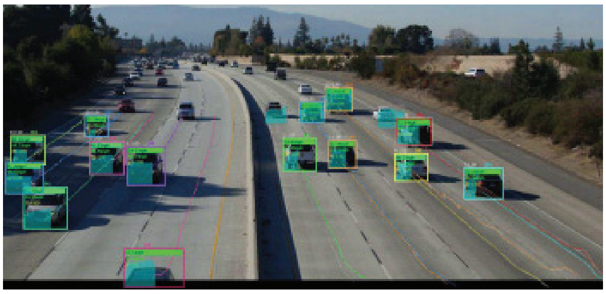


Figure 5: Example of traffic flow analysis [4]

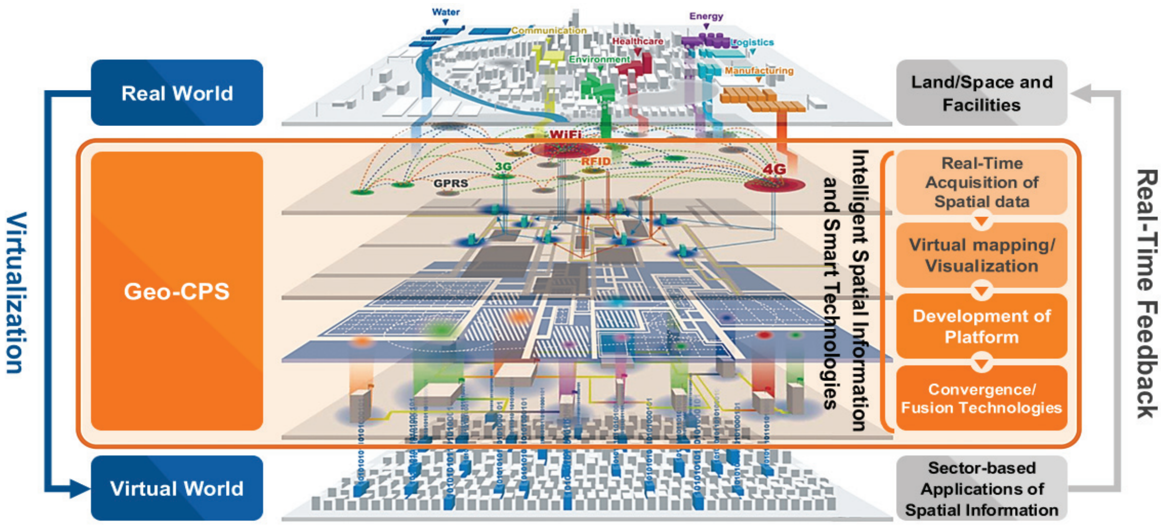


Figure 4: Smart space framework using CPS visualization technology and intelligent geospatial information showing the numerous interactions and platforms required to develop smart city technology

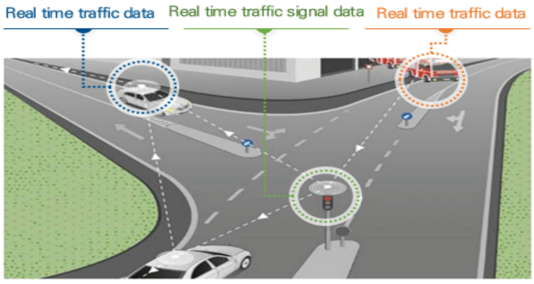


Figure 6: Smart transportation support system

B. Transportation support for the handicapped

Geospatial information can be extremely helpful for the handicapped. Door-to-door and barrier-free navigation services for the handicapped can be provided through real-time situation and public service data on the CPS domain.

(a) (b)

Figure 7: (a) Route for vehicles transporting the handicapped based on floating population mapping (b) Real-time updates of crowdedness in public transport.

C. Precise positioning technology

Through the connection of multiple, nearby sensors, precise location tracking is possible. For instance, precise identification of a criminal and their vehicle's location is possible by accurately tracking the locations of neighboring vehicles and using their black box devices or nearby CCTV footage to reflect real-time traffic conditions and thus determine the most optimal route. The route-searching algorithm would also consider real-time traffic information and route options within a virtualized 3D environment. In this manner, geospatial information can be applied to administer safer neighborhoods and more efficient decisions.

D. Urban planning through CPS simulations

As simulations of entire cities become more feasible, urban planning has become more scientific and systematic, such as through digital twin technology or 3D CityEngine and 3D Experience City software, as shown in Fig. 7. To note, the key is to understand the influence of each element with its surroundings. An example is transportation planning for a region of heavy traffic. New plans consider the traffic flow and road networks to produce a more efficient output, as presented in Fig. 8.

Figure 7: Urban planning in a 3D simulated space (Virtual Singapore) using 3D Experience City software

(a) (b)

Figure 8: Example of smart traffic plan: (a) Traffic analysis (b) Smart transportation planning using data from surroundings

V. CONCLUSION

Through this research, the current spatial information sector was determined to lack global, technological competitiveness and preparation for the future. As a result, there is an urgent need to address these shortcomings and to confront the aforementioned urban and societal issues. As a response, smart cities present an aspiring solution to these fast-developing problems. Core technologies for the implementation of smart cities include multi-sensor spatial data acquisition, continuity and connectivity of spatial information, and developing an effective data processing and management platform. However, the spatial information industry still suffers from a lack of established databases, high dependence on foreign hardware/software, and declining level of competitiveness in the global market. Furthermore, the climb towards a smarter future has demonstrated the need for intelligent geospatial information.

Overall, production and storage of spatial information requires more innovative methods to cater to the public's needs. This process includes providing detailed, up-to-date, accurate locations of spatial data via fully automated methods. Also, the convergence of multi-sensor spatial information and connectivity with 3D data and real-time sensor information also requires improvement. Simulation models using virtual land mapping technology can be used to map present and predict future scenarios for trend analyses. Through these steps, the development and establishment of smart city technology will be able to influence and present a potential solution against the urban challenges of the present and the future.

VI. REFERENCES

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