Inter-American Development Bank

International Case Studies of Smart Cities

Pangyo, Republic of Korea

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PANGYO

REPUBLIC OF KOREA

IDB-KRIHS Joint Research

IDB

THE REPUBLIC OF KOREA

KRIHS Korea Research Institute for Human Settlements

GDPC Global Development Partnership Center

Abstract

This case study is one of ten international studies developed by the Korea Research Institute for Human Settlements (KRIHS), in association with the Inter-American Development Bank (IDB), for the cities of Anyang, Medellin, Namyangju, Orlando, Pangyo, Rio de Janeiro, Santander, Singapore, Songdo, and Tel Aviv. At the IDB, the Competitiveness and Innovation Division (CTI), the Fiscal and Municipal Management Division (FMM), and the Emerging and Sustainable Cities Initiative (ESCI) coordinated the study. This project was part of technical cooperation ME-T1254, financed by the Knowledge Partnership Korean Fund for Technology and Innovation of the Republic of Korea. At KRIHS, the National Infrastructure Research Division coordinated the project and the Global Development Partnership Center provided the funding.

Pangyo is a new city built from 2003 onwards near Seoul with a vision to become the Silicon Valley of Korea. Approximately 75 million USD of the development gain was allocated to smart city implementation which took place in one shot within 3-4 years along with the city construction. Pangyo classifies its services into smart portal, facility management, security, disaster, and environment. Interesting aspects of Pangyo are the use of smart kiosk media boards for information provision and real-time management of street lights and waterworks. Key advantage of Pangyo is the low concern for investment overlap from simultaneous development of new city and smart city system, which also enabled high degree of integration of various functions in a spacious smart city operation center as well as utilization of fiber-optic network. Pangyo is currently making various attempts to generate revenue to cover maintenance cost through attracting advertisement on media boards and kiosks, and providing education contents to citizens at low charge.

JEL Codes: L86, L91, L96, O18, Q55, R41

Keywords: Smart city, intelligent transport system, crime and disaster prevention, new town development, urban management, real-time information, environmental management, business model

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Executive Summary

Pangyo is one of the most representative cases of a cutting-edge smart city in the Republic of Korea. It is a fast-growing new city built in a former greenbelt located 20km south of Seoul since 2003. Pangyo is a planned city that is environmentally friendly as well as a traffic hub situated at the intersection of the two most significant roadways of Korea, Seoul-Busan highway and Seoul ring road. The city hosts large number of IT company headquarters and strives to grow into a Silicon Valley of Korea. Approximately 75 million USD of the new city development gain was allocated to the implementation of smart city system that provides various civic services to citizens.

Pangyo smart city was implemented in one shot within 3-4 years along with the new city construction which is a different case compared to cities like Anyang where smart city implementation took place gradually in an existing city. In the Information Strategic Plan (ISP) set up in 2006, Pangyo classified its smart city services into U-portal, U-facility management, U-security, U-disaster, and U-environment where U represents the concept of ubiquitous service provision.

U-city kiosk media boards managed by the integrated operation center are one of the key elements of Pangyo smart city which provides various information such as disaster, emergency, weather, pollution, traffic, civic news, culture and tourism. The real-time management system of various civic facilities such as street lights and waterworks is another representative smart city function of Pangyo. Especially the waterworks leakage management system monitors the rate of flow and water pressure in order to secure the timely water supply and minimize the pollution caused by leakage. This kind of water management solution can be a benchmark for especially developing countries that require innovative solution for basic infrastructure management.

The key advantage of Pangyo smart city is that there is low concern for unnecessary overlapping investment due to service upgrade or expansion considering that the smart city system was installed in a planned manner simultaneously with the new city construction. This one-shot development also enables high degree of integration of various functions in a spacious smart city operation center of 2,227m^2 as well as the utilization of 270km fiber-optic communication network that enables powerful and fast information service. One particular noticeable smart city service is the operation of vehicle speed enforcement and alert system by special CCTV installed in areas of large elderly population and school zones which largely contributes to the citizen safety.

Pangyo city is currently focused on creating various revenue-generating services that can secure the operation and maintenance cost of the smart city system. The city is making various attempts such as attracting advertisement on media boards and kiosks, and providing charged contents or education materials directly to citizens and receiving low-cost usage fee. Pangyo's approach may provide ideas for other cities as one of the most important success factors of all smart city projects is the securement of sufficient operation and maintenance budget.

Pangyo, Korea (Source: Sungnam City Internal Data)

PANGYO, Korea

1. Introduction

1.1 General City Overview

'Pangyo new city' is an area developed within Sungnam city, Geonggido of the Republic of Korea. In May 1998, the site was designated as prearranged development land in Seongnam city's basic plan. As construction deadline expired at the end of 2001, Seongnam city promoted reasonable urban city development as unplanned and improper urban development was forecast. Housing development was pushed ahead to assist in providing housing development in the Greater Seoul Metropolitan Area through planned public land development.

New city development was started from 2003 to 2009 with the aim to include 87,795 populations in a total area of 9,294,000m2. The city has diverse and vibrant city aspects with new residents having finished moving in at the current 2015.

In the vicinity of Pangyo, Kyoungbu express highway, Seoul express highway, national highway 23 and 57 are connected, providing the most comfortable transportation in the area. It has also been designated as a green area of Seongnam city, having restricted development since May of 1976.

Pangyo City is located within 20km of the center of Seoul, 10km away from Gangnam and borders Bundang City which may assist the area to grow as the hub of GSMA's eastern and southern area with its geographic advantages. More than 70% of the development land is composed of forest and farmland while Unjoong stream and Geumto stream flows through the eastern and western part of the foot of Cheonggye Mountain, allowing optimal conditions to build a eco-friendly housing complex.

To the north, Kyoungbuk Express highway and Seoul outer beltway passes by and is accessible within the area through Pangyo Junction and Pangyo Interchange. To the east, Bungdang-Naekgok express highway and Bundang-Suji express highway links Seoul and Bundang line and Seongnam road links Seongnam with new Bundang line in full operations. Local roads in north and south passes by 23 and 57 national roads in east and west direction to respectively connect Seoul, Yong-in and Anyang.

Location	Within Bundanggu, Seongnamsi, Gyeonggido
Area	9,294,000 ㎡
Duration of Project Development	2003.12 ~ 2009.12
Project Implementer	Gyeonggi Province, Seongnam City, Korea Land Corporation
Population / Number of Household	87,795 people / 29,265 household (Group: 27,201 household, Single: 2,064 household)

Table 1 Overview of Pangyo new town

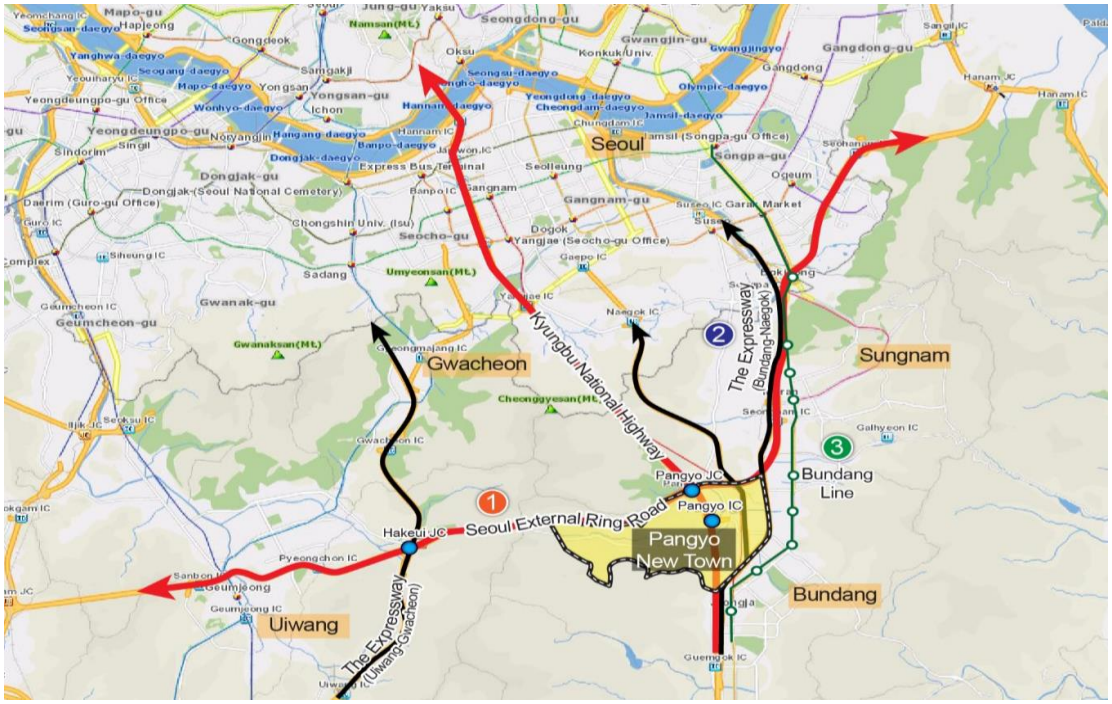

Figure 1 Location of Pangyo Ubiquitous City (U-City)

From the start of development planning, Pangyo City established land use plan by dividing development area and nature preservation area through various studies on land, wind, water and the flow of energy to maximize the preservation of the natural environment. Eco-village and natural streams were formed to provide for the city's ecological system and ensure convenient rest for residents. Special theme parks were created including nature preserved Geunrin Park, Mountain Bird Park, Forest Park and Riverside Eco Park which offers various experiences.

With the aim of becoming a self-serving, cutting-edge city, the city has transformed itself to become Korea's next 'silicon valley' and connected with specialized IT education facilities to form an industrial complex with talented human resources and cutting-edge field.

An information hall, library and museum is located over an area of 10,000 km^2 in the entrance of the West Pangyo Central Park. This is systematically linked to form a cultural complex, and established itself as a city of culture.

1.2. Smart city overview

1.2.1. Development background and history

Pangyo U-City has been developed with the theme 'Ubiquitous Pangyo: Co-existence with nature and city'. Pangyo U-City strategy was drawn up on August 2005 and finished ISP and working drawing by 2007.

Date	Development Progress
2001. 12	Designated as planned area for land development
2003. 12	Approved of Pangyo City Land Development Plan by Ministry of Construction and Transportation
2005. 08	Established Pangyo Area U-City Strategy Plan
2006. 12	Services of Pangyo Area U-City
2007. 02	Established Pangyo Area U-City Working Design
2008. 09	Pangyo U-City Arrangement (Seongnam City↔Korea Land Corporation)
2008. 11	Launched Project
2009. 02	Notified the approval of Ubiquitous City Development Project by Ministry of Land, Infrastructure and Transport
2011. 05	Completed Pangyo Area U-City
2011. 08	Received Pangyo Area U-City Facility
2011. 09	Started Pangyo Area U-City Operations

Table 2 Pangyo U-City development progress

In 2008, Seongnam city, the main body of the

new city development along with Korea Land Corporation signed the 'Pangyo U-City arrangement'. The project started on November 2008 and finished on May 2011 with total project budget of approximately USD 6,670,000 (KRW 78 billion). On August 2011, Seongnam city officially took over Pangyo U-City facility from Korea Land Corporation and has been operating from September of that year.

1.2.2. Vision, current and future projects

Seongnam City took charge of 305 all-purpose CCTV stations, VDS, traffic signal controllers, 252 traffic facilities, 307 media converter and unified lighting system controllers, 128 Bus Information Terminals, 5 air/water observation posts, 5 certificate issuing machines as well as 1,117 u-facilities covering 14 public service sectors.

Afterwards, Seongnam city unified existing crime prevention situation room and expanded its function and capacity to establish a new Seongnam U-City unified center on September 2014. Seongnam U-City unified center operates through employing existing CCTV, intelligent traffic system, bus information system and disaster control room to swiftly manage any disaster related accidents and provide citizens with convenience and information. Seongnam city has proposed a vision entitled 'Providing touching administration service and citizen centered unified service fitting a ubiquitous society in the information age to be in line with its policy of leading innovations in the administration sector.

2. Service spectrum

2.1. Overview of the Smart services and high level functions

Pangyo U-City is by far composed of 5 services including U-portal, U-facility management, U-crime prevention and disaster prevention, U-traffic and U-environment. U-portal service is composed of area portal service, mobile civil complaint service and media board service. U-facility management service manages unified lighting system control service, water supply leakage management service and on-site facility management.

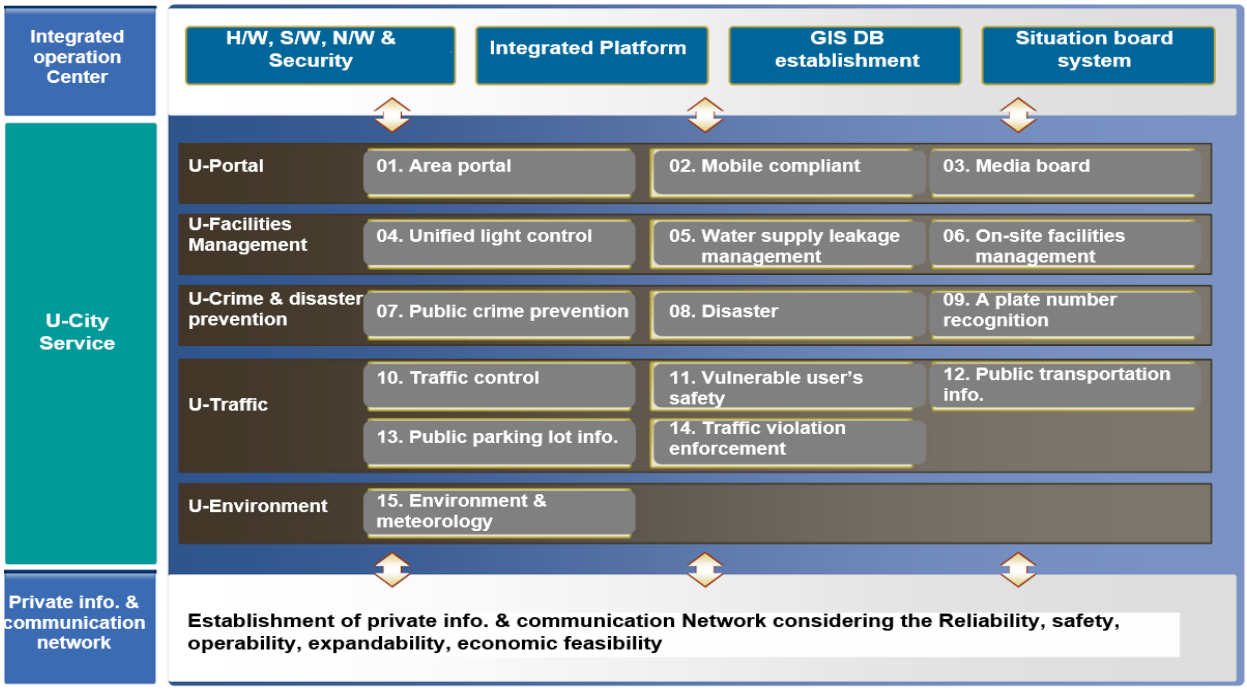

Figure 2 Pangyo U-City Service Configuration

U-crime prevention and disaster prevention is composed of public crime prevention service, disaster prevention service, vehicle number identification service. U-traffic service is composed of traffic control service, transportation vulnerable group safety service, public transportation information service, public parking lot information service and clamp down on traffic violation service. U-environment service is composed of environment and meteorology service. As real-time information is collected through various devices installed on-site and sent to unified operations center through the communications network, the center analyzes and processes information that is helpful to citizens and relevant organizations.

To achieve this, Pangyo U-City considers overall factors including reliability, safety, operability, expandability and economic feasibility to establish and operate an information and communications network. Also, various hardware, software, network and security solutions have been applied to develop unified platform in the unified operations center. GIS based database has also been established to provide real-time city control system on a large situation board.

2.2. Transportation and urban mobility

Pangyo City has established and operated U-traffic service including public transportation information, public parking lot information, traffic vulnerable group safety, traffic violation clampdown and traffic control; all in an effort to assist the free flow of road traffic, safe driving and convenient transportation use of Pangyo City residents.

Traffic control enables active traffic management through changes in traffic situation, improving traffic efficiency and traffic flow and limits intersection traffic. Safety for traffic vulnerable group is ensured by installing DFS (Driver Feed-Back System) and CCTV nearby school zone and elderly welfare facilities. Public transportation information is collected through real time bus location information to provide residents with bus location, arrival time, and route. Public parking lot information is provided in real-time to drivers of available parking space and parking lot location. Traffic violation policing utilizes illegal parking policing system to minimize traffic congestion and induce safe driving with signal and speeding policing system.

Pangyo U-Traffic Service has following effects.

- Provide convenient traffic environment by limiting time in intersection
- Provide customized and differentiated traffic information
- Ensure safety for traffic vulnerable including students and elderly
- Minimize traffic accident through CCTV surveillance and strengthen before & after response measure
- Increase convenience of citizens through providing various convenient information
- Provide traffic information including on schedule arrival time
- Minimize traffic congestion by decreasing illegal parked and stopped vehicles
- Minimize unnecessary loitering vehicles
- Strengthen traffic safety for children in school zone
- Strengthen safety for city traffic through policing

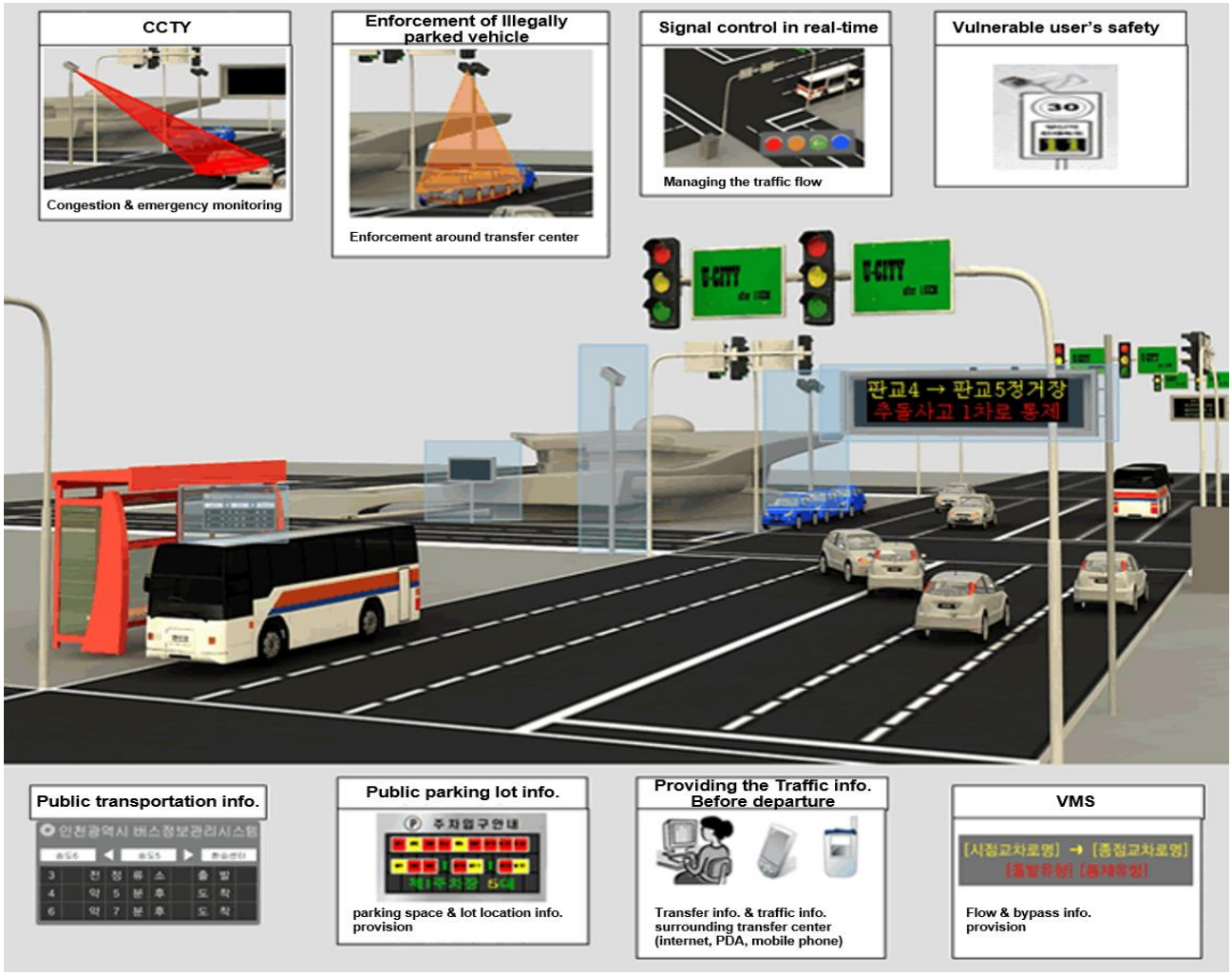

Figure 3 Pangyo U-Traffic Service

2.3. Safety and Emergency response

Pangyo City's U-Safety service, which assures safe living for citizens through fire monitoring, suspected vehicle tracking and monitoring of crime prone area within the city, is composed of public crime prevention, vehicle number identification and disaster prevention. Public crime prevention employs crime prevention CCTV camera to monitor crime prone areas and responds to accidents and incidents in a fluid manner. The city is providing advanced services to become a safe city without crime. Vehicle number identification uses vehicle number identifying camera to swiftly determine involved vehicles upon accident and to respond in a fluid manner, realizing a safer city. Disaster prevention uses thermal camera to monitor 24 hours for 365 days.

Pangyo City's U-Safety service has the following characteristics and advantages.

- Unmanned and automatic forest fire monitoring of 24 hours, 365 days
- Intelligent monitoring (Effective nighttime monitoring through use of low illuminated camera
- and high performance projector)
- Support safe city life and crime prevention
- Store imagery data

Pangyo U-Safety Service has the following effects.

- Prevent escalation of large forest fire through early response upon forest fire detection

- Ensure resident safety through cutting-edge crime prevention infrastructure establishment
- Ensure crime prevention effectiveness
- Utilize as evidence of recorded data upon crime occurrence
- Support swift and accurate response upon accident and incident
- Ensure safe living standards of citizens through 24-hour crime prevention monitoring

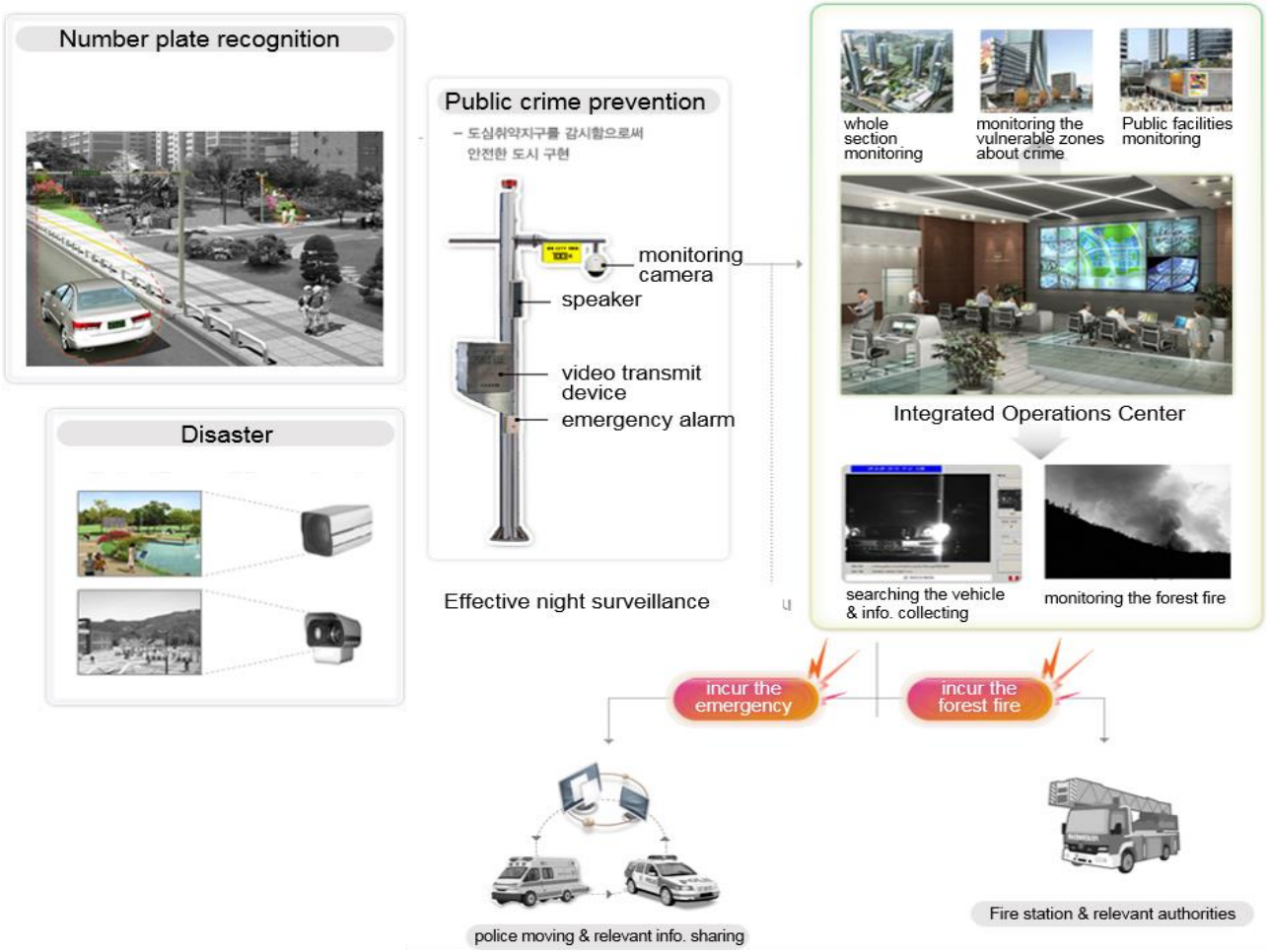

Figure 4 Pangyo U-Safety Service

2.4. Environment

Pangyo City's U-Environment Service installed air/water pollution measurement equipment and weather monitoring station which provides various environment pollution related information and weather information to residents to ensure a comfortable living environment and to support establishment of an effective environment policy. Pangyo U-Environment Service has the following effects.

- Strengthening surveillance function of environment pollution in Pangyo area
- Prevent harm through various warnings and forecast
- Improve environment through continuous environment policy
- Support forest fire prevention through weather forecast

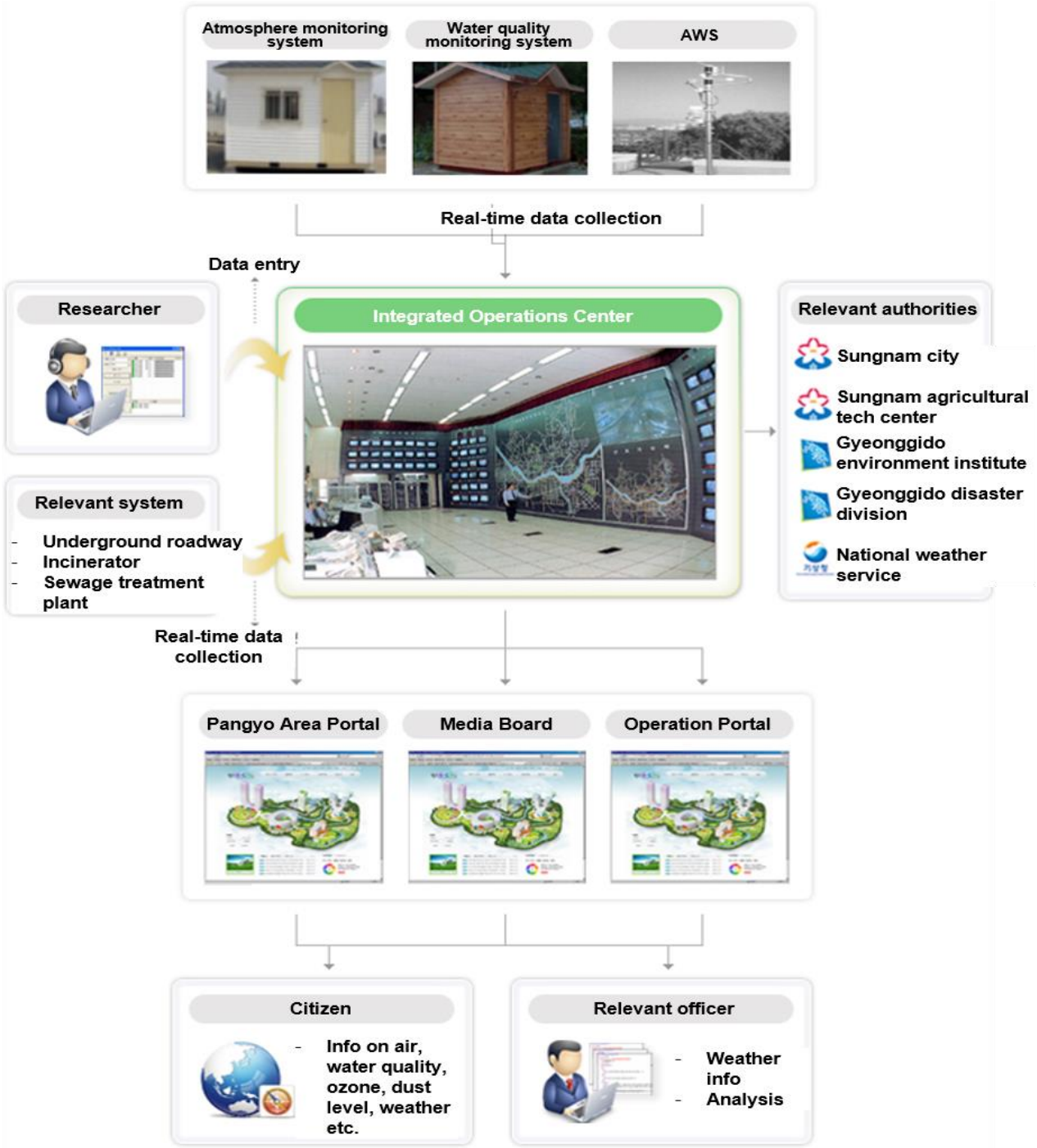

Figure 5 Pangyo U-Environment Service

2.6. Citizen interaction and communication mechanisms

Pangyo U-City is ensuring communication with citizens through media board use. Content and information such as disaster situation, weather, environment pollution, traffic, city/district office PR, culture and tourism have been provided through large display device to harmonize with a urban landscape of the city planning department. The service is a landmark service that anyone who visits Pangyo area including the residents may experience U-City to its fullest extent.

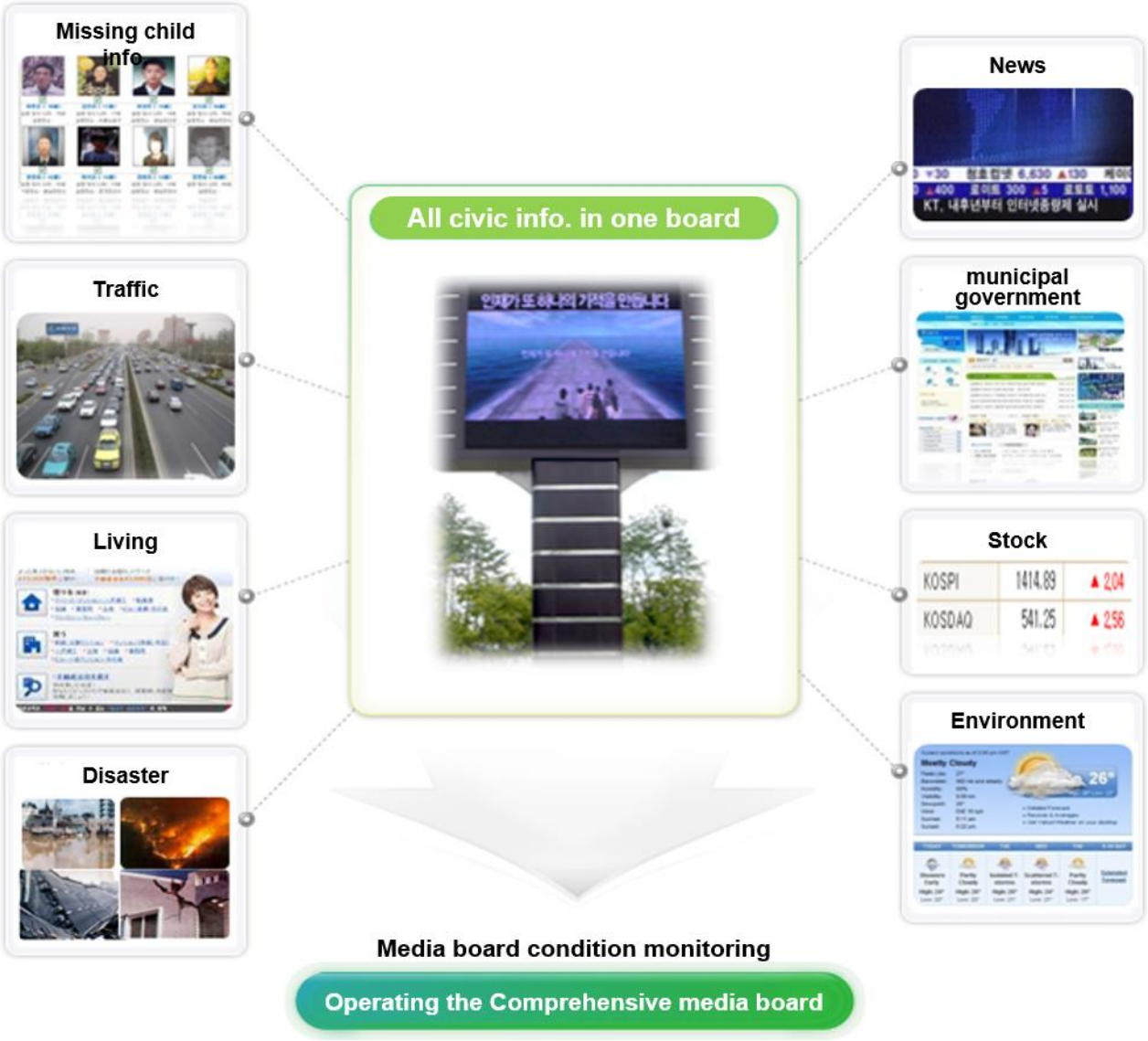

Figure 6 Pangyo U-City Media Board

Pangyo U-City's Media Board has the following service characteristics and advantages.

- Swiftly display real-time disaster and living information
- Relay HD class video in real time through communication network
- Operate disaster prevention campaign and inform main events
- Ensure safety and robustness of facility through cutting-edge material use

Pangyo U-City's Media Board has the following effects.

- Provide real time and realistic living information, environment and disaster

information to urban residents

- Form a regional consensus through introduction of city and district administration information
- system
- Operate at maximum 1.5 year extension of media board through efficient operations and system design

Pangyo U-City is providing U-City portal service, traffic information, environment information and employment information through kiosks installed throughout 6 areas in the new city along with the media board.

The kiosks are installed within main points within the city that is accessible to everyone. Unified service can be provided through various channels of web service and mobile service and be provided with consistent service on any device. The accessible devices may be conveniently used without any regards to age or disability.

The kiosks are the most accessible and convenient service that is provided by U-City services as it encourages improvement of citizen's quality of life through providing information that is relevant to actual life.

Figure 7 Pangyo U-City Kiosk

2.7. Facility management

Pangyo U-City facilities are unified and managed that allows for safe and stable facility management services provided by U-facility management. This management system includes unified lighting facility control, water supply leak management and on-site facility management.

Unified lighting facility control remotely operates and manages the city's lighting facilities and monitors the status in real time that allows for swift response in case of emergency situation. Water supply leak management is managed through real time monitoring of the flow and pressure of the water

supply, improving water flow rate and water quality as well as real time monitoring of water pollution through leakage. On-site facility management is done through inter connection with geographic information system by supporting on-site tasks through establishment of mobile geographic information system of ground and underground facilities.

Pangyo U-Facility Management Services has the following effects.

- Improve water flow rate and reduce running water through water leakage prevention
- Minimize citizen's inconvenience through taking prior actions of malfunction
- Prevent influx of pollutants from water supply damage
- Establish a pleasant city environment through remote control by situation
- Prevent citizen's inconvenience and secondary accident through swift response
- Maintain pleasant city landscape and environment through swift and accurate on-site facility management

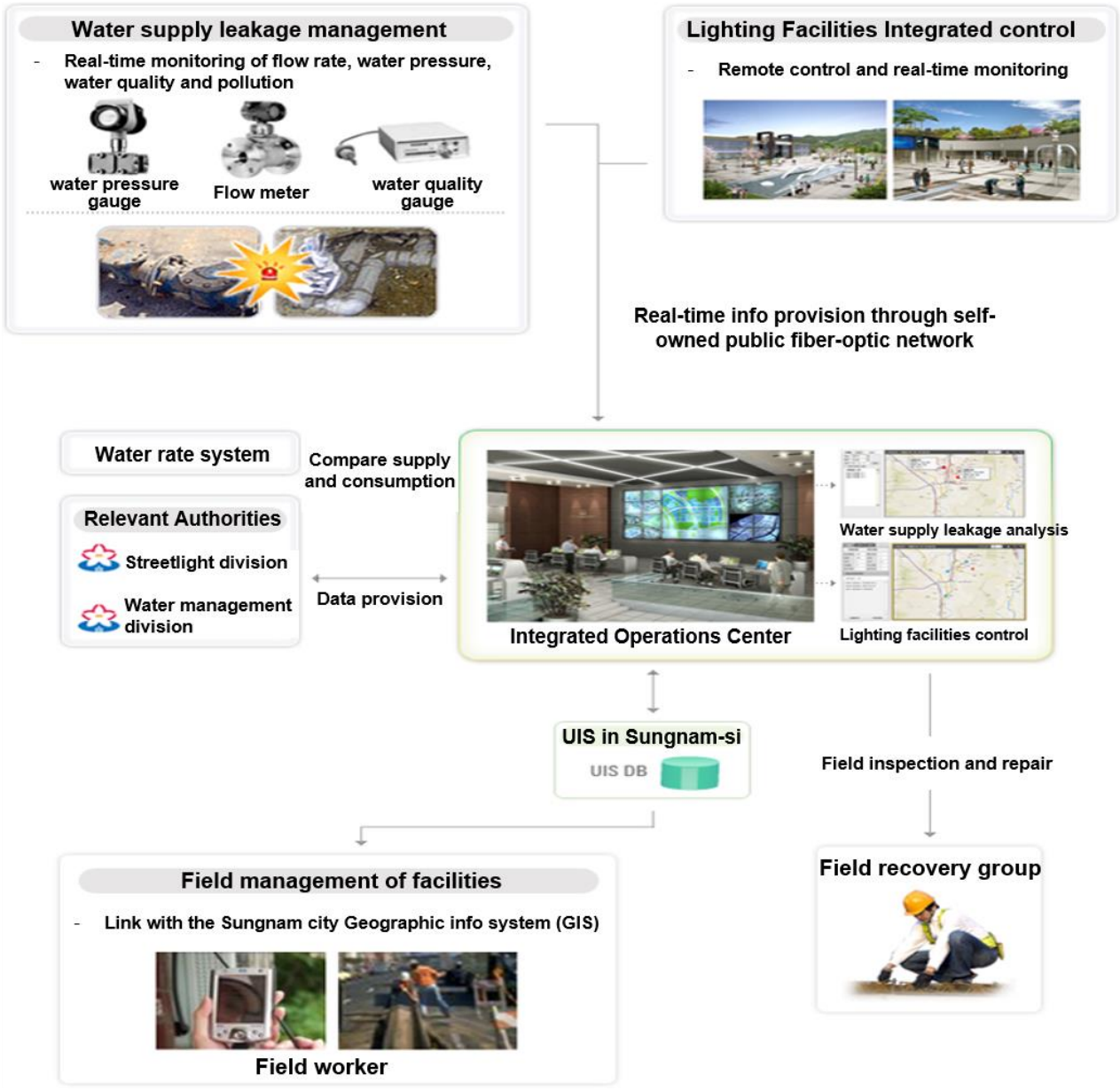

Figure 8 Pangyo U-Facility Management Service

3. System Configuration

3.1. Overview

Pangyo U-City aim to establish a progressing city model through its ubiquitous technology application and maximize U-Service value through fusion of public services. Furthermore, it established a service applicable to Seongnam City at large.

Unified operations center established U-City platform to provide traffic, facility, safety, environment, education and portal service through core technology platform, system management platform, U-Control platform and U-service platform.

Various on-site sensors and CCTV were connected to local government through the communication network and strengthened the system security through internet connection by Pangyo residents, commercial facility and managers.

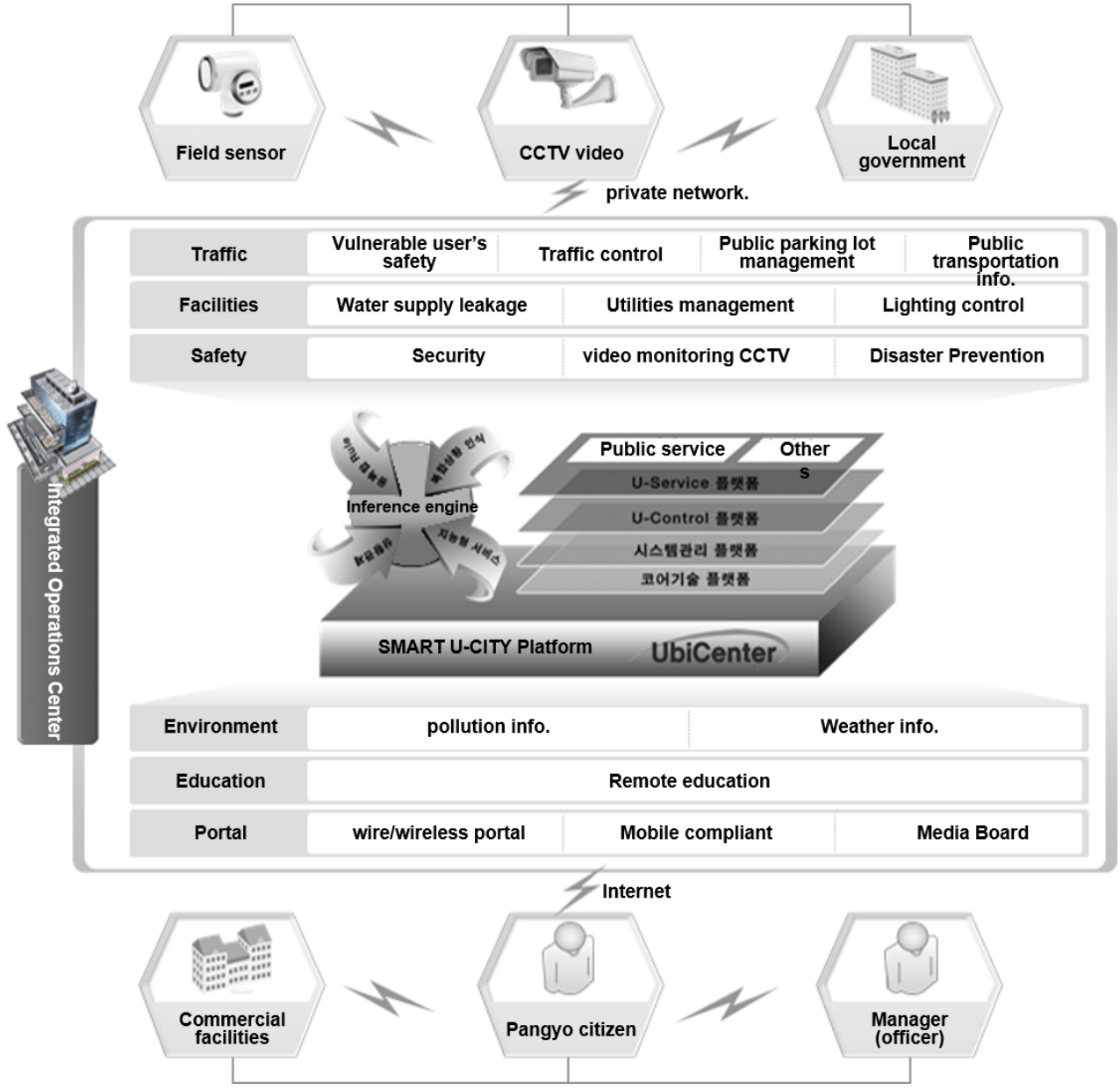

Figure 9 Pangyo U-City System Configuration

3.2. Level of physical system integration and interoperability

Pangyo U-City has established a connection system with government entities, local government and government office, broadcasting stations, banking organizations, infrastructure medium and other U-City centers through wireless, commercial and external communications network to exchange information with external organizations.

Unified platform's exterior organization link is a separate and independent echelon that is in charge of connection with city based infrastructure and external organizations. By running operations separately, the system may be effectively operated through limiting damage upon system error and dispersing potential overload of system.

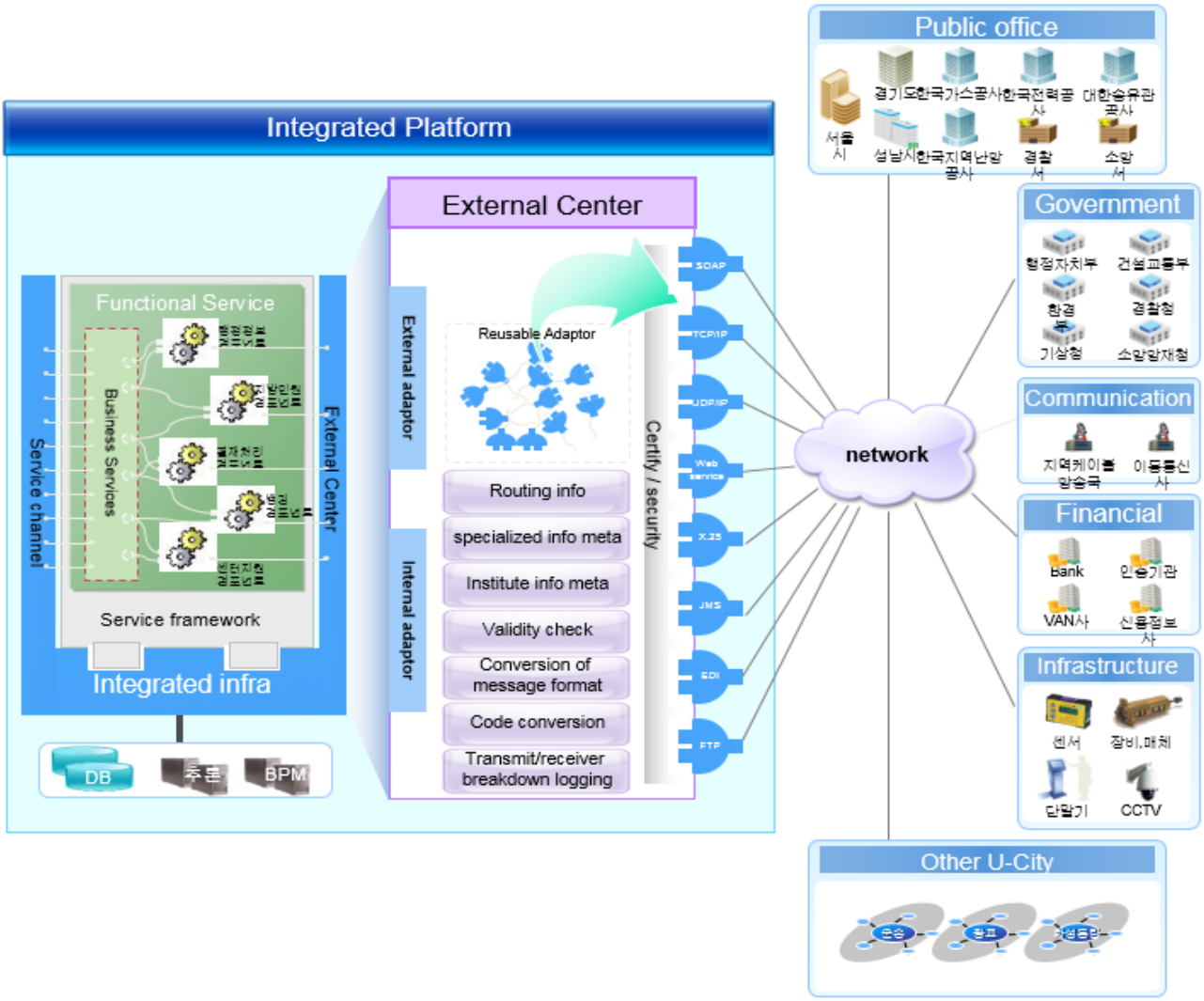

Figure 10 Pangyo U-City External Organization Configuration

Also, the expandability, flexibility and effective operability of the system has been increased by applying adapters through standard protocol. Expanding possible structure through adding communications adapter upon new protocol has been established. Furthermore, the structure has been fit to disperse overload upon a specific organization's increased transaction.

All connected information abides by various information exchange standard set forth by the Korean government in regards to the type, definition, characteristic, information exchange method, the rank/grade of the information producer and authorization. The shared information is implemented based on Korean government's standard node link system.

3.3. System architecture

3.3.1. System layout

Pangyo U-City has established a unified platform operated on convergence and fusion engine, interior and exterior connection hub, u-Service platform and unified control platform to form a systematic service system interconnected with various interior and exterior system.

Figure 11 illustrates Pangyo U-City system's logical configuration. The center's system is largely composed of unified platform domain, U-service domain and user interface domain.

Unified platform is composed of unified control platform, GIS platform, u-service platform, unified DB, unified authorization, convergence and fusion service engine and interior and exterior connection hub. User interface is composed of unified portal, operations portal, area portal and multi-channel. U-service is composed of traffic, crime and disaster prevention, environment, facility management, portal and 15 other specific services.

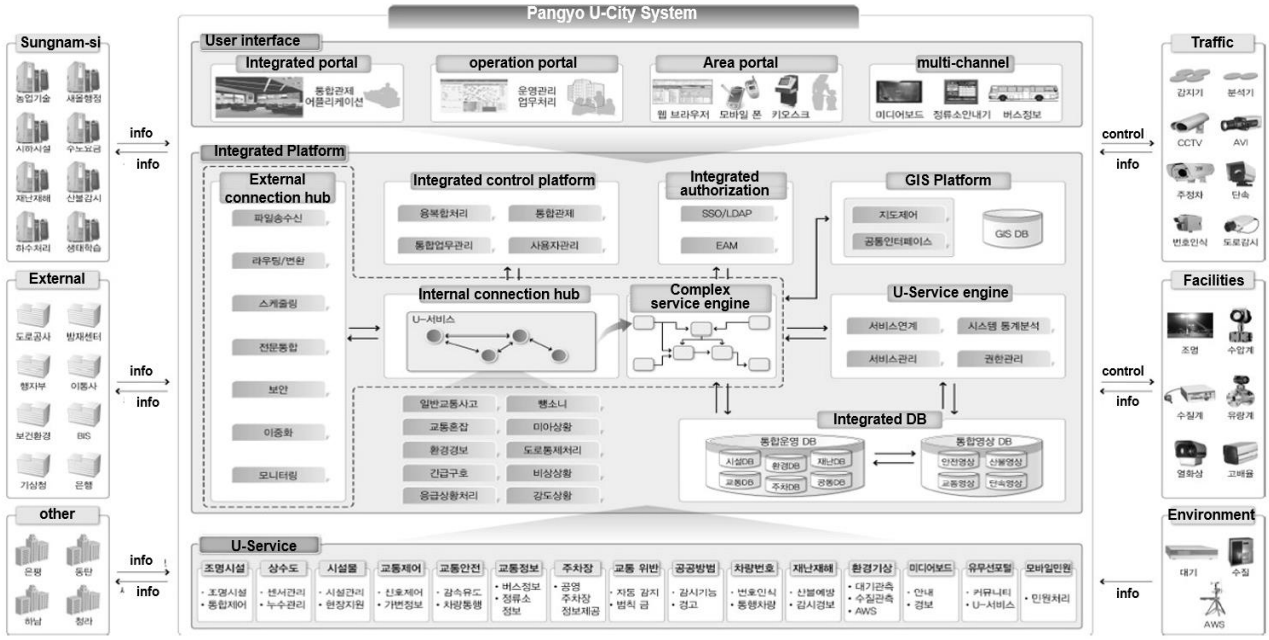

Figure 11 Pangyo U-City System

3.3.2. Information flow

Pangyo U-City collects data every moment through the on-site equipment, provides citizens with information through the analyzed and processed results and repeats the process. Therefore, the center's efficient information processing and management is directly associated with the quality of service and stable operations of the system.

Pangyo U-City center has optimized the flow of information between stratum through Remote Method Invocation (RMI) signal, Jaba Database Connectivity (JDBC) connection and message conversion and classified 5 steps of information flow (collection, processing, connection, storage and provision) considering the flow of information and the stratum of unified platform.

To do this, integration and dispersion was arranged considering mutual communication traffic and method between commercial software and developed application. Managing agent was placed on all servers to measure usage, a basic of utility computing.

Furthermore, by reflecting the Service Oriented Architecture (SOA) and Business Process Management (BPM), the least function amount was separated and developed application by service was module separated through unified

platform's stratum. The message type between applications decided the connection method.

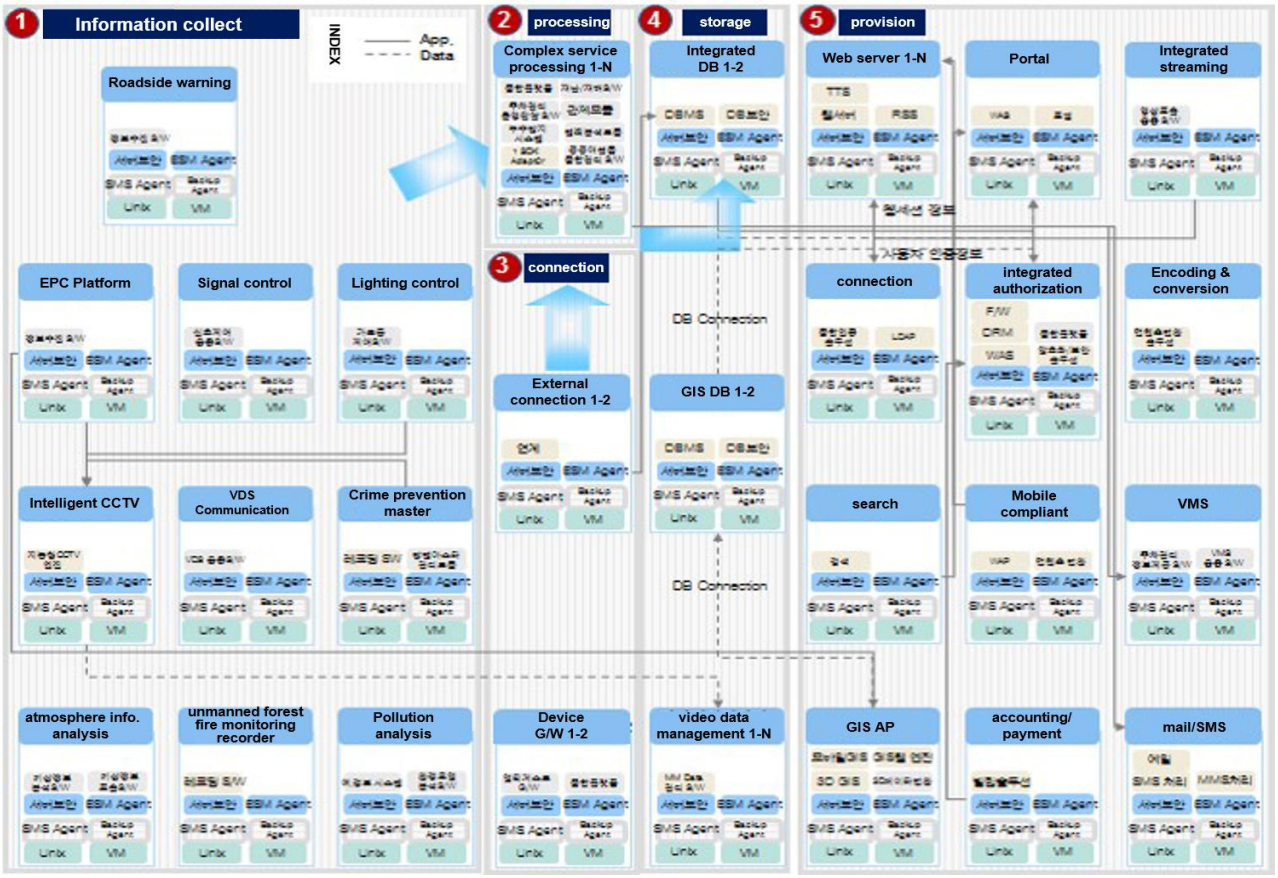

Figure 12 Pangyo U-City Unified Platform Data Flow by Stratum

3.4. Unified Center System

Seongnam Pangyo U-City unified center provides real time collected city information through comprehensive analysis of collected information from the relevant facilities and effective manages and operates it. The center is located on the 8th floor of the west section of Seongnam city hall with 2227m². Seongnam Pangyo U-City unified center operates u-portal, u-environment, u-traffic, u-safety, u-facility management and other functions. Drawing 9 illustrates Seongnam Pangyo's U-City Unified Center Functions

Figure 13 Seongnam Pangyo U-City Unified Center

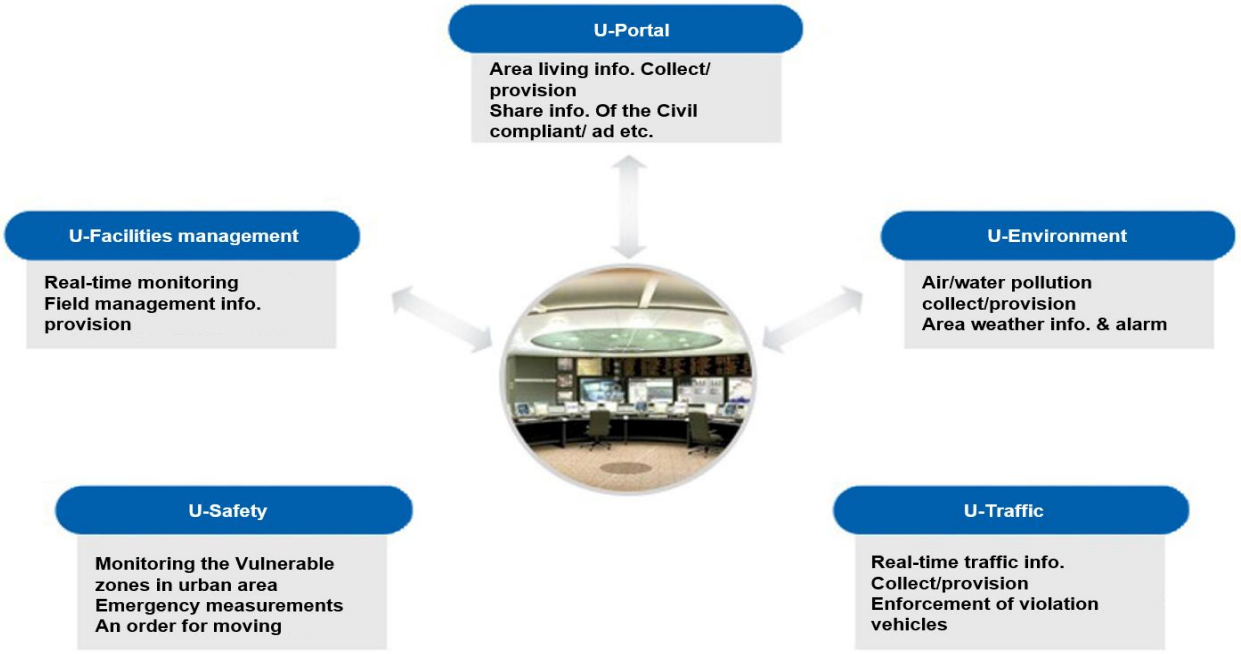

Figure 14 Seongnam Pangyo U-City Unified Center Functions

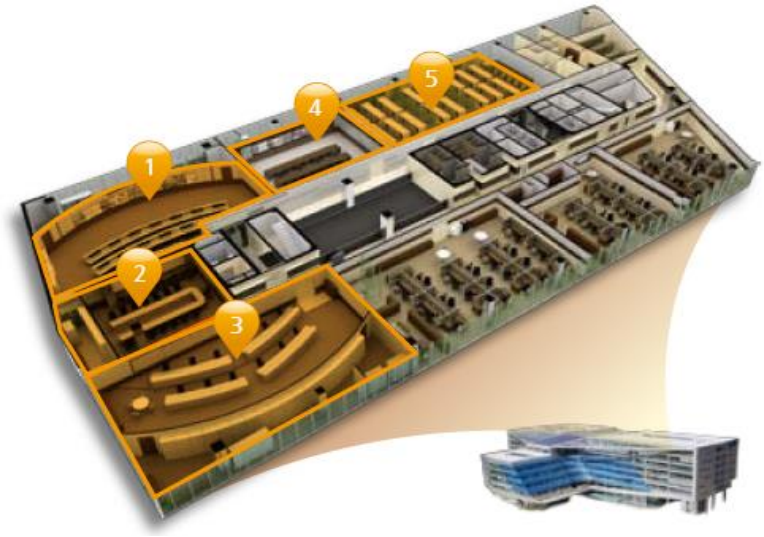

Figure 15 Pangyo U-City Unified Center Space

No.	Name	Function	Area(m^2)
1	CCTV Situation Room for Supporting life environment of residents	U-Safety (Monitoring of Safety, Dispatch)	268
2	Disaster Control Room/Exhibition Room	Disaster control and command, Viewing by Visitors	119
3	U-City Situation Room	U-portal, U-facility management, U-traffic, U-environment	253
4	Unified CCTV Situation Room	U-traffic(Redzone in Bus Terminals, Illegal parked and stopped vehicles, Illegal trash disposal)	140
5	Communications and Equipment Room	Data processing and communications equipment	290
	Maintenance Room		50
Office		u-policy chief	285
		Disaster management	223
Others		Lounge	101
		Meeting Room	45
		Extra Space	452

Table 3 Seongnam Pangyo U-City Unified Center Space Organization

Unified operations center situation board, which is the display system of U-City's traffic, crime prevention, environment and various facilities, has been separately established within U-City situation room and crime prevention situation room.

U-City situation room is operated by Seongnam city hall, Crime prevention situation room is operated by Seongnam Police Station and each is composed of 2 columns and 13 rows of DLP cube. It is composed of hardware, software, information security and network provided with 15 services including information collection, information procession, information connection, information storage and information provision with 52 cubes on imagery display. Figure 16 illustrates Seongnam Pangyo U-City Unified Operations Center's Hardware and Network Configuration.

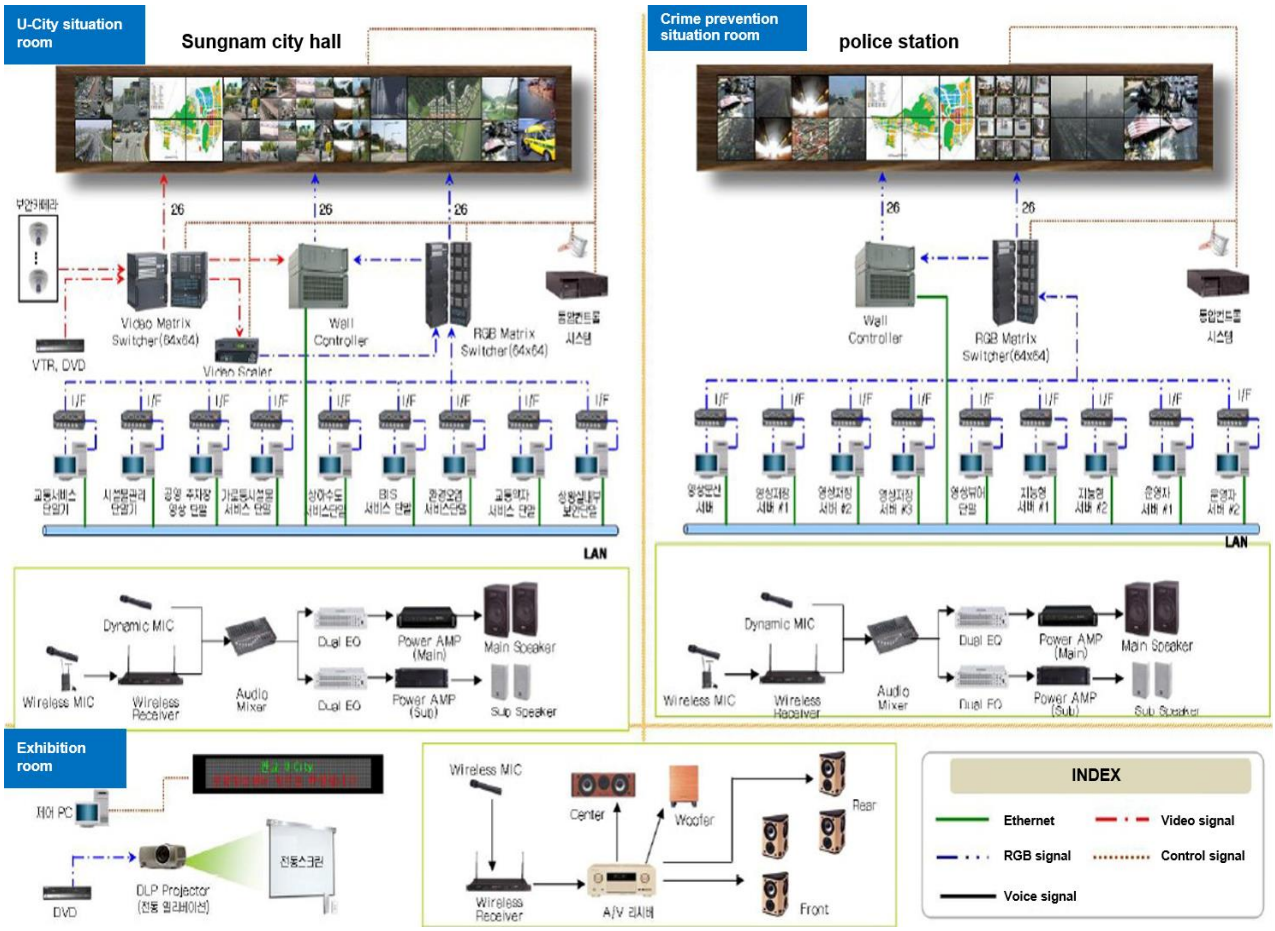

Figure 16 Seongnam Pangyo U-City Unified Operations Center Hardware and Network Configuration

Equipment	No.	Location
Server	151	Data processing equipment room/U-City situation room
Network equipment	44 type	Data processing and networking equipment room
Software	91 type	
Security software	10 type	
DLP Cube(50inch)	100	Situation room
DLP Projector	2	Disaster situation room/Meeting room

Table 4 Seongnam Pangyo U-City Unified Operations Center Main Equipment

3.5. Field system

Pangyo U-City has installed total 1,090 on-site facilities of 23 types in 5 service sectors. Also, there were total 812 on-site facilities in 8 service sectors including u-traffic service, u-safety service and u-environment service installed in existing Seongnam City. Table 5 illustrates Pangyo and Seongnam City's main U-City facility type, number and location.

Service Sector	Facility	Pangyo U-City		Seongnam City
		No.	Location	No.
U-portal	Portal Kiosk	6	Square(1), Children's Park(1), Hwarang Park(2), Geunrin Park(1), Pangyo Library(1)	-
	Un-manned automatic certificate machine	5	Community Service Center(4), Pangyo Library(1)	-
	Media Board	2	Hwarang Park, Maesong intersection	-
U-facility management	Lighting facility control	308	Main roads and Parks	-
	Water pressure gauge	22	Expanding or Limiting point of Water Supply	-
	Water quality gauge	15	Influx or Discharge point of Water Supply	-
	Mobile PC	20	Within Pangyo area	-
U-traffic	Traffic Signal Control	81	National Road 23 and roads within Pangyo	-
	Traffic CCTV	17	Main roads within Pangyo	51
	Traffic Vulnerable(DFS)	19	In vicinity of school zone	-
	Bus Information Terminal(BIT)	134	City and Bus stops along National Road 23	223
	Illegal Parked and Stopped Vehicle CCTV	32	Commercial area	74
	Signal/Speeding Camera	14	Main expressway	-
	Traffic Board(VMS)	18	Main roads in the city	27
	Vehicle Detection System(VDS)	54	Main roads within city and tunnel	28
	Area (AVI)	18	Main roads within city	24
U-safety	Resident life support camera	305	Park, Shopping district, detached house, Expressway bus stop, in vicinity of school	356
	Thermo vision Camera	6	Clean tower post: 2, Green belt : 4	-
	Vehicle number detection camera	9	Pangyo outskirt service road	29
U-environment	Air pollution measurement equipment	2	Unjung-dong Office rooftop, in vicinity of Baekhyun intersection	-
	Water pollution measurement equipment	1	Unjung stream, Geumto stream junction area	-
	Weather measuring station	1	8th Geunrin Park Office rooftop	-
	Water level monitoring system	1	Ssang-ryong Bridge	-

Table 5 Pangyo City and Seongnam U-City Main Facilities by type, numbers and location

3.6. Communication system

Pangyo U-City has established equipment to receive the demands of all network of U-City service through the PON based tree structure communications network centered on community service center and 10G MSPP based ring structured trunk net. Pangyo U-City is wired with 270km of fiber optic cable.

Broadband unified network based ALL-IP Network in 10G Dual-Ring structure has been established to procure stability and ample bandwidth. Backbone facilities have been installed through establishing 4 nodes by region and provides stable service through dispersing traffic and duplication of main equipment.

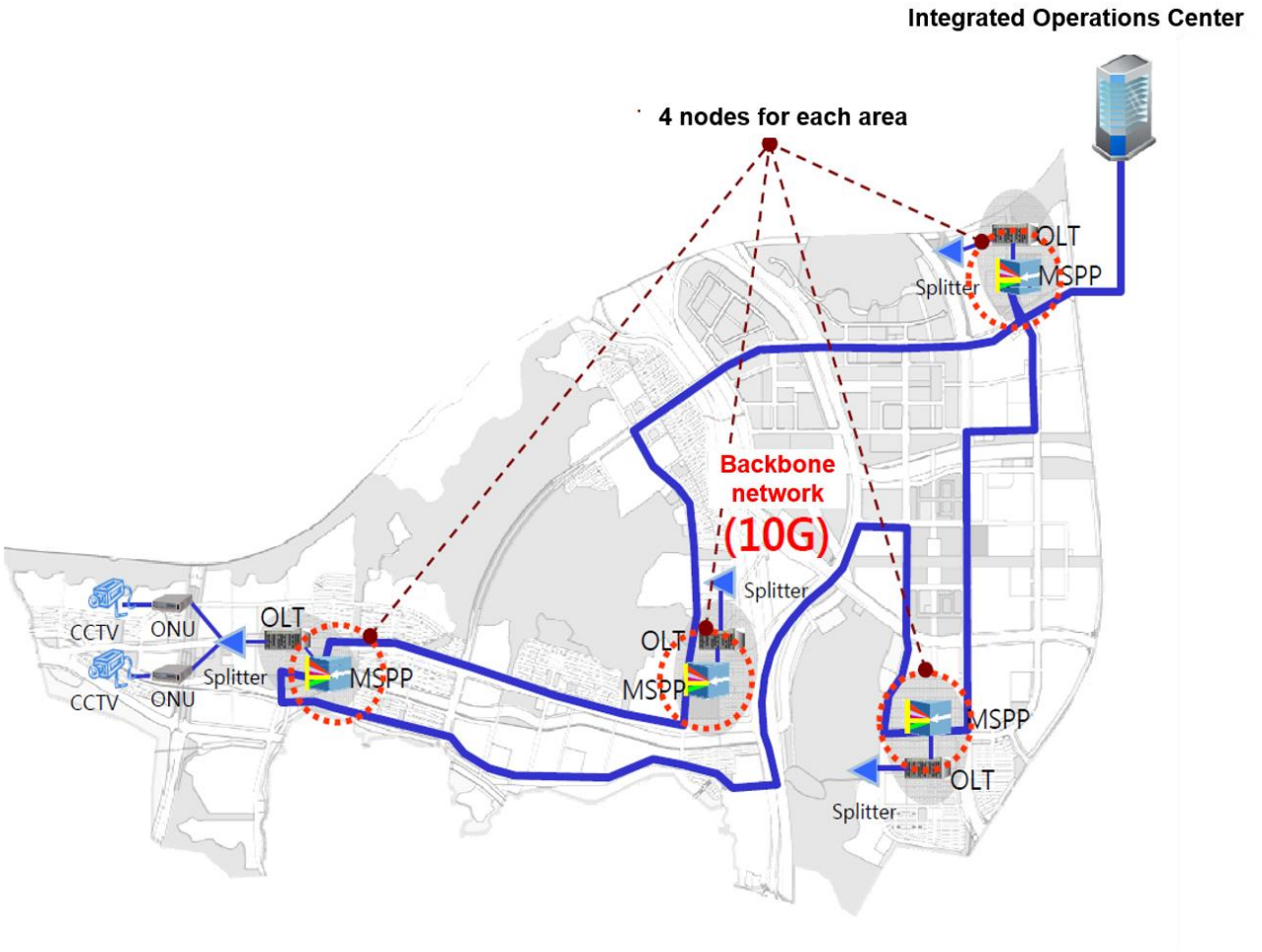

Figure 17 Pangyo U-City Network Configuration

3.7. Sub-systems and functions

3.7.1. Transportation and urban mobility

A. U-Traffic Service

U-traffic service is in charge of handling active traffic management through changes in traffic situation. Unified operations center is composed of traffic signal control system, unexpected situation management system, basic information collection system and basic information provider system. The center is connected with on-site detectors, CCTV, VDS, VMS and communications network. Also, the center uses unified platform to connect with safety for the traffic vulnerable, public transportation information, public parking lot and traffic offense monitoring system and is directly connected with Gyeonggi Province Traffic Information Center at the top.

Currently, total of 54 vehicle detection sensors (VDS) are installed to collect basic information on the site. VDS has been installed considering a comprehensive look from traffic management, environment and maintenance and management aspects. The following factors to consider from traffic management aspect are the following.

- Over 90% detection rate during day and night time
- Possibility to reset during power failure
- Correction according to detection environment (detector calibration)
- Possibility to send still imagery upon request of the center
- Collection of traffic rate, speed, possession, standby, etc : 30 seconds
- Possibility to change processed data and transmission cycle
- The following factors to consider from environment aspect are the following.
- Adoption of equipment to combat damage from sea water and storm/flood
- Protection of equipment through sturdy closure structure and surge suppressor
- Consideration of graceful exterior and structure design

The following factors to consider from maintenance and management aspects are the following.

- Strengthen operator's access through unifying equipment management
- Information detection possibility to maintain various system requirements and fault information
- Recovery function and self-diagnostic function
- Monitoring possible within the center through transmission of information from on-site equipment
- Identify detection status of detector through LCD, LED

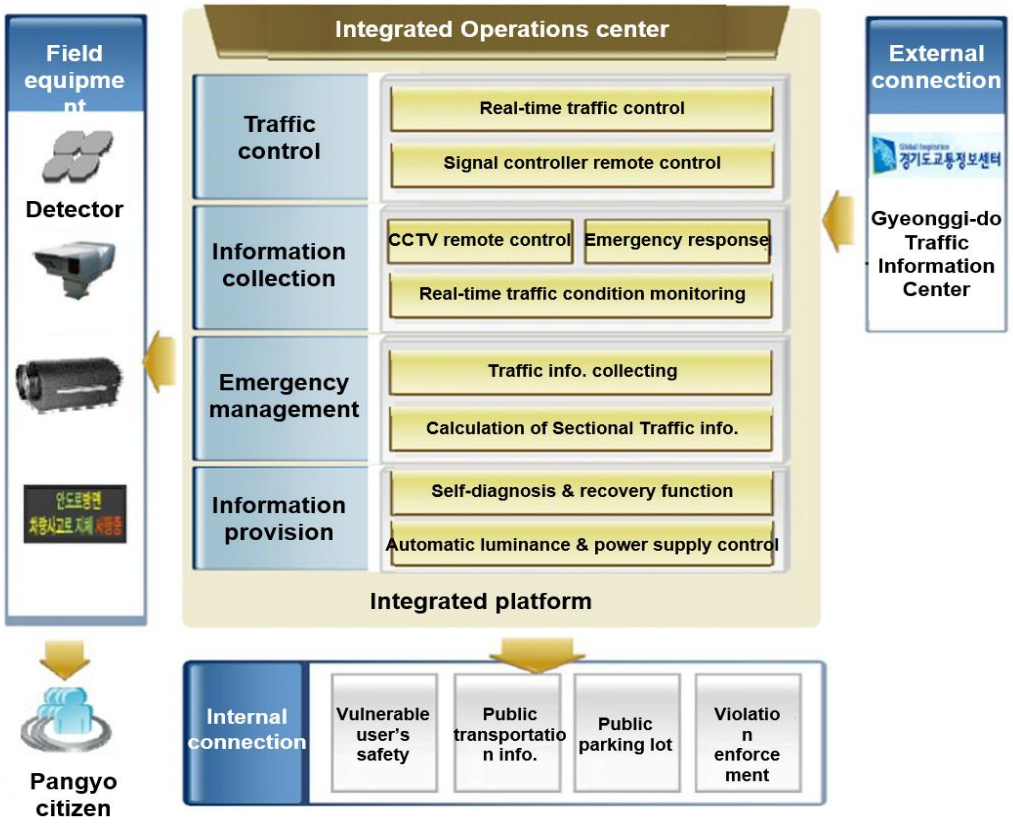

Figure 18 U-traffic system concept diagram

B. Safety service of traffic vulnerable

To assist the traffic vulnerable, low floor bus information is provided. To promote safe driving in areas requiring vehicles to reduce speed such as children protection zone and inform the dangers of speeding, information including deceleration area warning is provided to drivers by the roadside.

The Driver Feed-Back System (DFS) and CCTV has been installed in vicinity of school zone and elderly welfare facilities to improve safety of the disadvantaged and safe driving of drivers. The Driver Feed-Back System (DFS) in the deceleration area is monitored through the road monitoring cameras, controller and speed indication equipment installed on-site to detect and display vehicle speed.

Further, public transportation information providing service has been expanded to include information on low floor bus.

Function	Details
Information Collection	Control Driver Feed-Back System(DFS) and collect speed information on individual vehicles (DFS)
Operating Terminal	Raw data management, monitoring and information search
Dispatcher	Collection of bus operating information and supply processed information for analysis
Information link and supply	Supply and link processed information such as bus arrival time

Table 6 Traffic vulnerable safety service function

Figure 19 Traffic vulnerable safety service system diagram

C. Traffic control service

According to changes in traffic situation, active traffic management has led to efficient road use and flow of traffic which has minimized intersection delay and improved average traffic time.

The center's effective performance of collection/processing/distribution/feedback of real time traffic information has led to minimizing Pangyo resident's traffic inconvenience through traffic control services.

According to the volume of traffic at the intersection, support for improving average traffic time of Pangyo city has been placed through providing traffic information including signal control, collection of reliable traffic information and diverse medium. On the site, traffic signal control system, vehicle detector, CCTV and VMS are included.

The traffic control service system collects traffic information from information collection equipment such as VDS/CCTV and signal controller at appropriate traffic situations, processes in the center and displays through VMS to promote free flowing traffic.

Function	Detail
Signal control by Traffic Situation	According to the changes in traffic situation by time and area, active signal control improves average traffic passing time and minimizes intersection traffic
Collection of traffic information possible	By managing traffic, traffic information collection has been possible which allows for traffic control, estimating and predicting traffic time
Real time monitoring of road conditions	Arranging swift responsive measures during unexpected situation by monitoring the on-site video in real time at the center
Supply traffic information	On the basis of the collected information, supply drivers with accurate and various information to disperse traffic and promote free flowing traffic

Table 7 Traffic control service function

Figure 20 Traffic control service system diagram

D. Public parking lot management service

By supplying parking information to drivers beforehand or during driving, it provides convenient options and reduce unnecessary loitering time and illegal parking issues. Through various vehicle detection methods, accurate parking information is collected and provided to drivers to ensure convenient parking. After collecting/processing reliable information from the real time parking information collection equipment, it expands resident's convenience to swiftly park through the various information supplying devices.

Function	Detail
Collection of Parking Information	• Collect information by installing detection equipment in each parking lot entrance and in case of transfer parking lot, parking information is collected through detection of each parking surface. • Detect vehicle's path through dual roof detection method • Collect vehicle information through AVI use to compensate for error of loop detector • Introduce parking location information and individual parking surface detection method in the transfer parking lot
Processing of parking information	• Calculate possible use of space by parking lot and establish plan to compensate for error of loop detector
Supply parking information	• Through use of collected, processed information, supply various information to driver including parking lot location, available parking space, etc. • Provide parking information by floor and area, search parked vehicle through kiosk

Table 8 Public parking lot management service

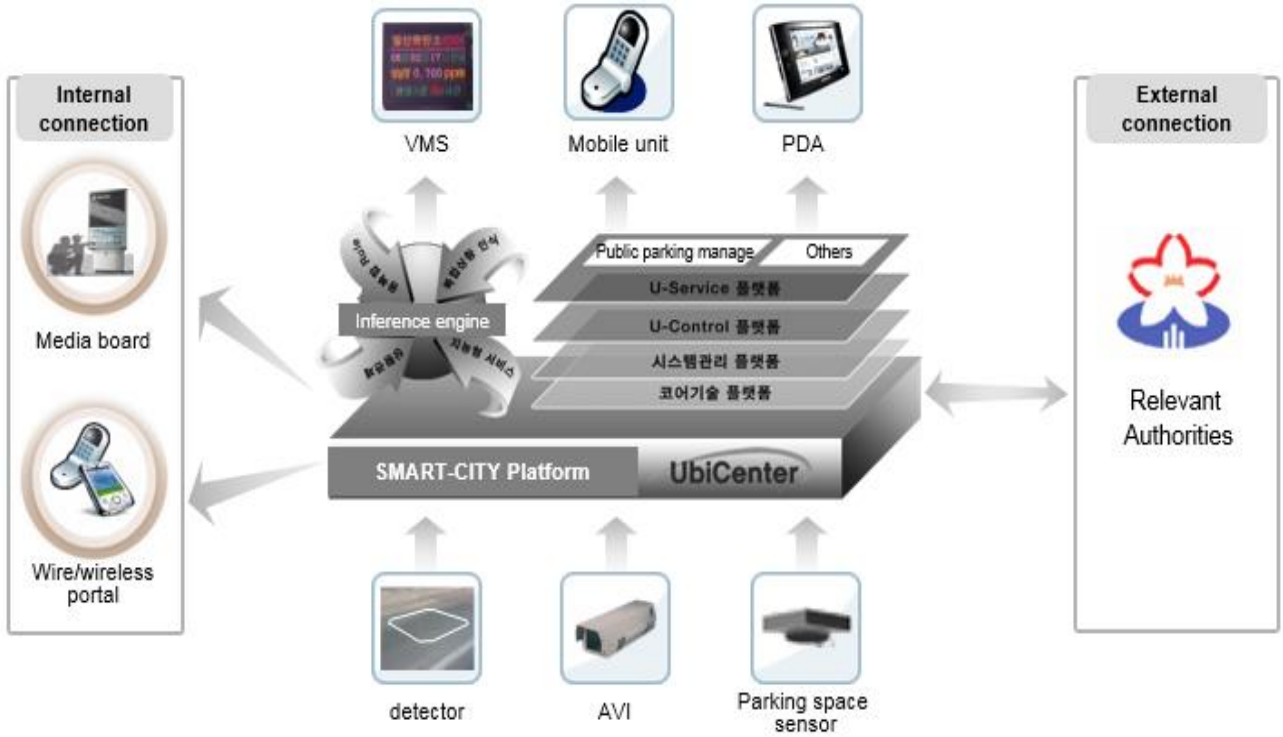

Figure 21 Public parking lot management service system diagram

E. Public transportation information service

By collecting and processing vehicle location information through GPS from the BIT, bus passengers, drivers, passengers in bus stops receive bus arrival time information, traffic situation information, which allows for adjustment of intervals of operating bus and real time vehicle management.

Public transportation information service includes operation management, route and bus stop management, information supply and link. Through the link of Gyeonggi Province Traffic Information Center and wide area BIS center, collected/processed bus operations and management information such as arrival time is supplied to Pangyo residents. Also, the BIT has been installed to provide information such as bus operations, unexpected situation, administration PR, etc to Pangyo residents.

Functions	Details
Operations Management	Supply and analyze processed information through collection of bus operations information
Operations On-board equipment	Manage bus operations plan and analyze and monitor traffic
Route and Bus Stop management	Manage route and changed bus stop locations
Information link and Supply	Supply and link processed information such as bus arrival time

Table 9 Public transformation information service

Figure 22 Public transformation information service system diagram

3.7.2. Safety and citizen security

A. Safety service

The RFID reader device, installed in the front and back gate of the school, recognizes RFID tag of elementary students to determine whether the student is going to and out of school. The information is then sent to the parent's mobile phone through SMS and safety service and CCTV surveillance service installed in the school surroundings are linked. If potential problem is expected with the student, the center can trace the location of the student through using CCTV imagery and verify the student's safe return.

Function	Detail
SMS notification	SMS is sent twice per day to the designated parent's mobile phone regarding the child's going to and out of school
Image storage search	Link with CCTV to search/play recorded imagery in the storage

Table 10 Safety service function

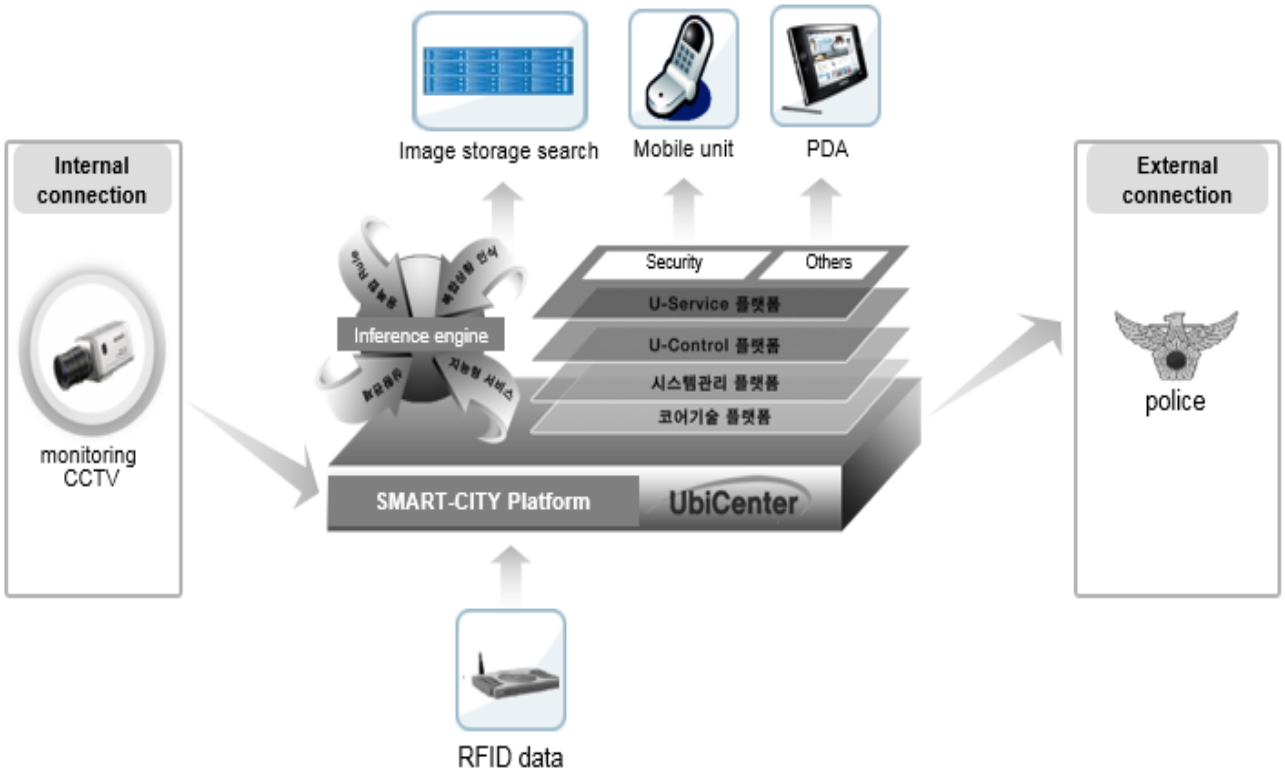

Figure 23 Safety service system diagram

B. Imagery surveillance CCTV service

By installing 360 degrees rotating and access search possible intelligent CCTV, crime prevention effect through imagery surveillance is possible. During emergency situation, CCTV surrounding Pangyo area will be utilized to monitor escape route. The following function is also provided: emergency bell response, analytics rule based intelligent surveillance and tracking location through GIS link during emergency situation.

Function	Detail
Emergency bell response	Monitoring personnel maintains surveillance on screen, two-way communication upon ringing emergency bell
Intelligent Surveillance	Operating object tracking intelligent camera in access-control needed area
Tracking location with GIS	Link, manage and establish DB with GIS Map

Table 11 Imagery Surveillance CCTV Service function

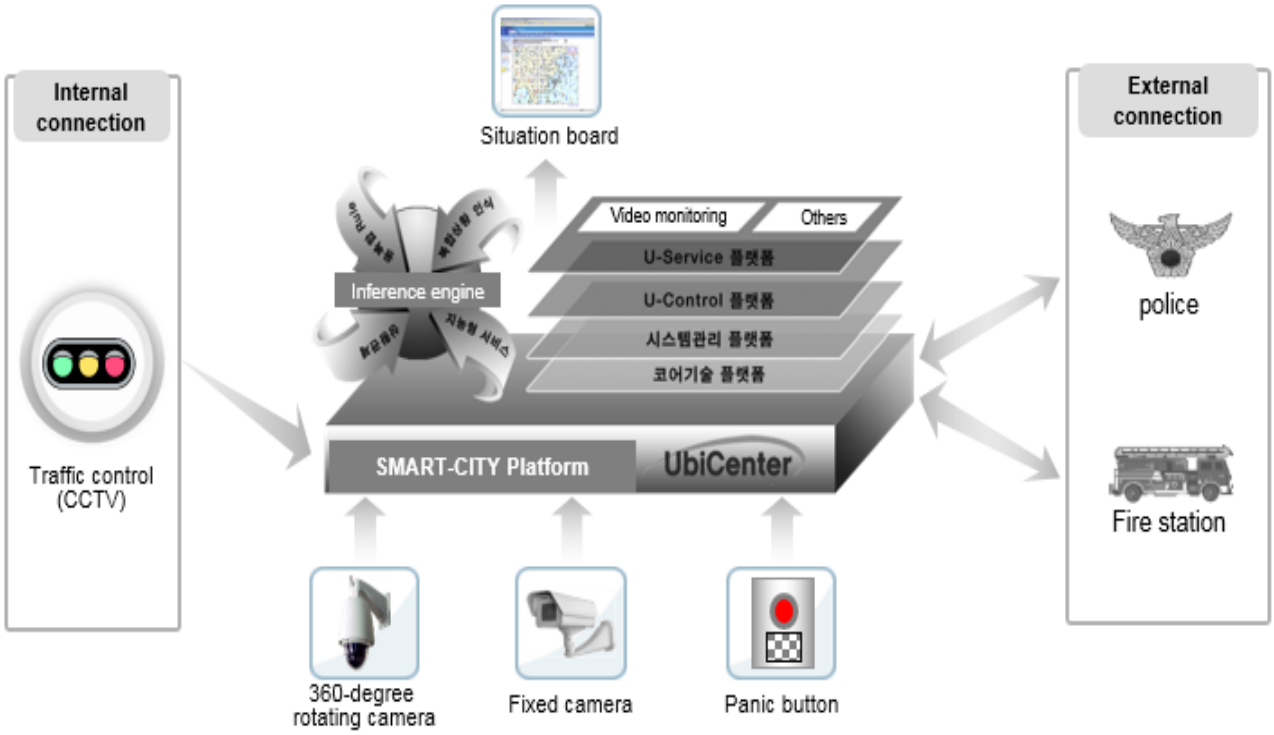

Figure 24 Imagery Surveillance CCTV Service diagram

3.7.3. Emergency and response

Pangyo U-City disaster prevention service provides unmanned monitoring of forest fire through thermal camera and automatic alarm system. The service supports living safety of Pangyo area through utilizing fire sensor, monitoring and warning/forecast service.

By employing unmanned forest fire surveillance system which automatically monitors temperature changes of Geumto mountain, Shinchon Park, Baekun mountain and Cheonggye mountain and swiftly disseminating disaster information within Pangyo area which includes and living safety warning/forecast, damage is minimized.

The service provides unmanned forest fire surveillance, living safety and warning/forecast service. Forest fire surveillance is composed of a thermal and standard camera set. The thermal camera detects temperature difference and standard camera can zoom in 50 fold to closely identify the cause.

Function	Detail
Forest fire surveillance	Complementary forest fire surveillance system using thermal camera and standard camera (50 fold zoom capacity)
Forecast/Warning of Living Safety	Provide forecast/warning of living safety to Pangyo residents from Fire Station and DB
Disseminate disaster information	Swiftly disseminate information during disaster such as flood, storm, typhoon, etc

Table 12 Disaster prevention service

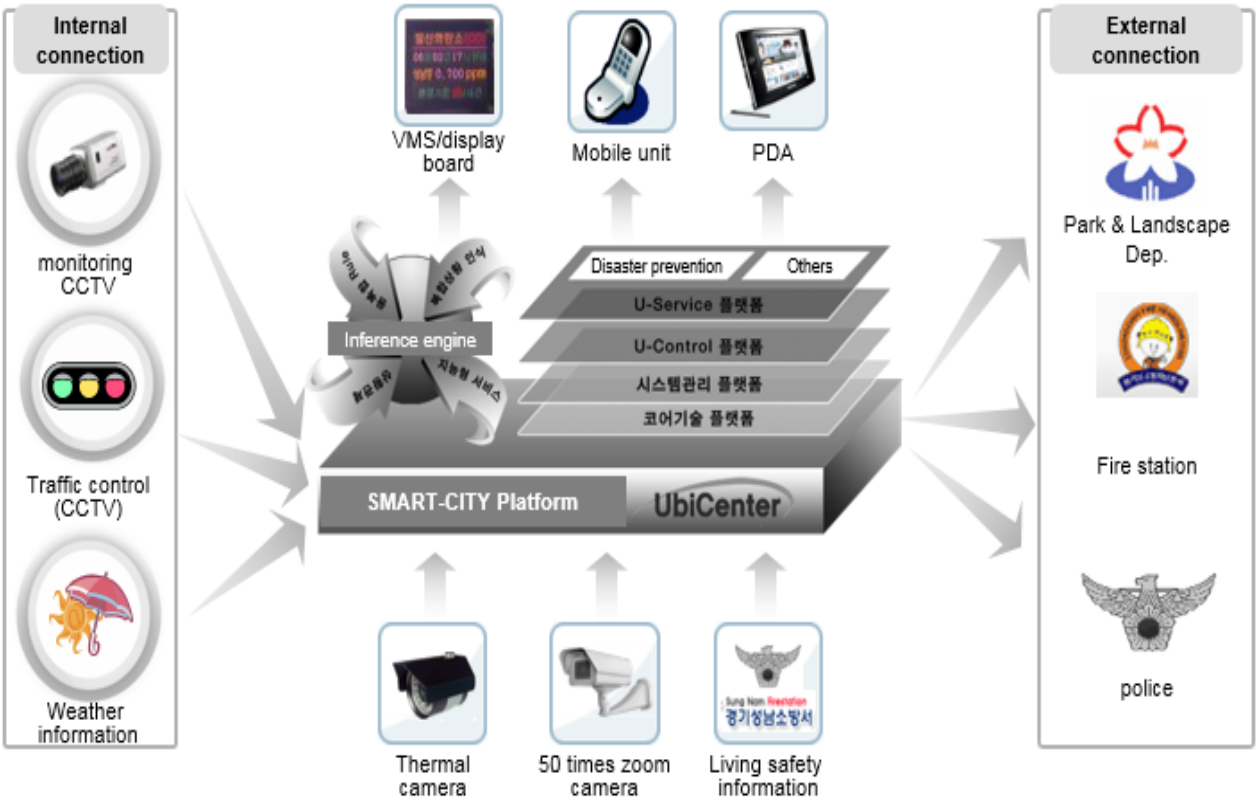

Figure 25 Disaster prevention service system diagram

3.7.4. Environment

A. Pollution information service

By providing the measured environment index of Pangyo's nature and facilities, pleasant living environment is provided through environment monitoring, prevention and evasion.

Through collecting pleasant city environment information in real time, information is processed/distributed/feedback to high performance equipment such as environment sensors. The processed data is shared through related organizations and the information is ensured access to all citizens.

Function	Detail
Atmospheric environment monitoring	Collect information on air quality, water quality, noise pollution, foul smell
Water environment monitoring	Monitor water level, quality, quantity and green belt
Improvement of air quality in public institution	Index of living activity, air quality, yellow dust warning, eco-village
Waste management	Waste collection and management of large waste, automatic waste collection facility control

Table 13 Environment pollution information service function

Figure 26 Environment pollution information service system diagram

B. Weather information service

Weather information service links weather information with the National Weather Service and data collected from regional weather observation sensors to process data which is provided to residents in real time. The various services and information are provided through various mediums including VMS on the road, electronic display on the city and portals.

The weather information collected from the National Weather Service and Pangyo's AWS is gathered as climatic change information and disseminated to Pangyo City's mediaboard, VMS and through the web.

The climatic change information with the regional forecast data is comprehensively analyzed and disseminated to Pangyo residents in real time, which is then utilized as preparatory information for any weather damage.

By providing preventive weather information, the system helps to minimize financial damage of the citizens.

Function	Detail
Forecast/Warning of Yellow dust	Provide weather information related to fine dust, yellow dust, ozone, etc
Warning of Typhoon, Flood	Warning of flood water level in Pangyo City after comprehensive analysis of rainfall and water level
Forecast/Warning of earthquake	Index of living activity, air quality, yellow dust warning, eco-village information
Heavy snow, advisory for fog	Forecast/Warning of road situation due to heavy snow fall and fog
Information on agriculture environment	Provide agriculture environment analysis of rainfall, atmospheric pressure, humidity and temperature

Table 14 Weather information service function

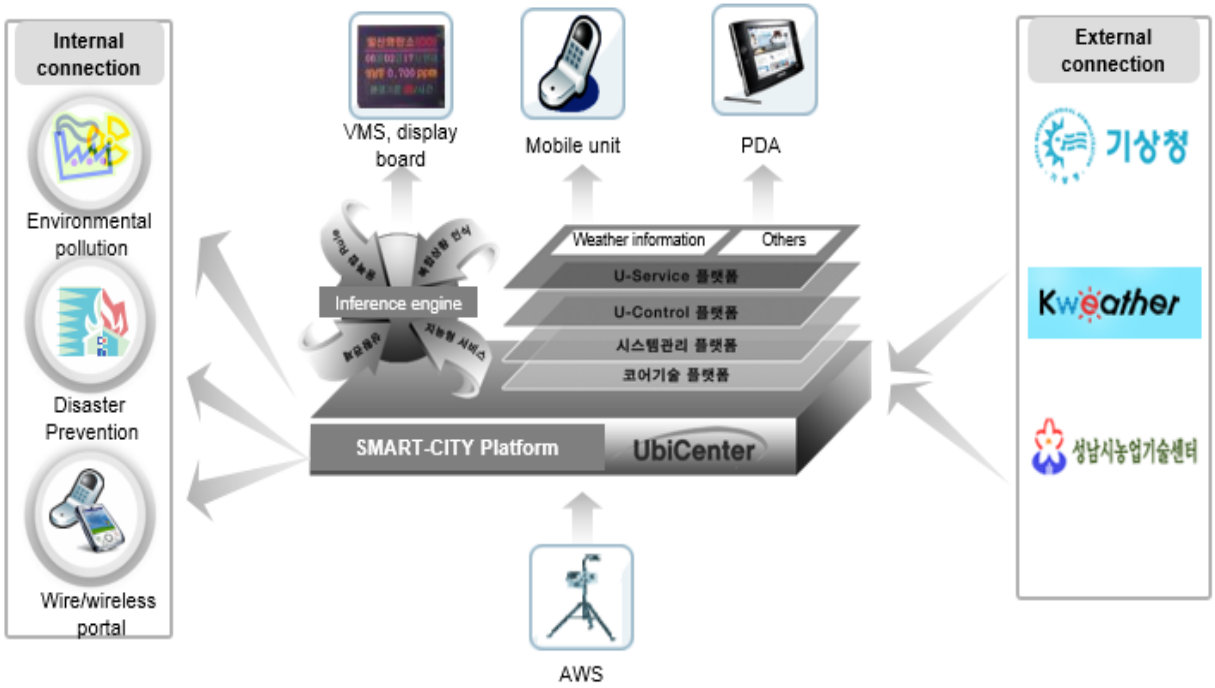

Figure 27 Weather information service system diagram

3.7.5. Citizen interaction

A. Wire/Wireless Portal Service

The service provides limitless participation through Web 2.0 based customized portal service that is open and intelligent wire/wireless environment based. Various city life information is provided to Pangyo residents as well as appropriate user interface, considering information that is individually enjoyed.

By linking with public information service and related organization system, users may conveniently utilize the portal system. This system support PC, IPTV, mobile and kiosks while including a flexible structure to accommodate web, mobile, IPTV environment. Through IPTV, users may access public service information during TV viewing (children location information, road conditions, parking lot situation, bus arrival time, etc).

Targeted for the middle aged group who experience difficulty with PC or mobile appliances, various information (tourism, leisure, education, learning institute, restaurant, shopping, transportation, etc.) are provided through the TV remote control.

For web and mobile appliances, location based information and traffic information is provided without any restraints on time or location with 3D/Hybrid(satellite) Web-GIS and Mobile GIS. Abundant information through various multimedia service is provide through the use of web browser in the PC environment. Customized service is provided in the mobile environment and convenient and easy-to-use IPTV service is provided for middle aged group. Kiosk was installed after an accessible location was selected to provide information, convenience and access to anyone and wire/wireless portal service is provided as well.

Function	Detail	Service Media
Location of children	Provide children's location through 3D Web-GIS	Web, mobile, IPTV
Remote education	Provide education contents for elementary, middle and high school students	Web, IPTV
Media Information	Provide public information, living information and PR contents	Web, IPTV
Environment Information	Provide information on air, water, noise pollution, foul smell	Web, mobile, IPTV
Road imagery information	Real time traffic imagery of main road/areas through 3D Web-GIS	Web
Parking lot Information	Provide Parking lot location and available space information through 3D Web-GIS	Web
Weather Information	Provide weather information	Web, mobile, IPTV
Disaster information	Forecast/warning of living safety, disseminate disaster information	Web, mobile, IPTV
Civil complaint information	Provide complaint, proposal, opinion, civil affairs documents	Web, mobile
Public transportation information	Provide bus/subway route, bus arrival time, real time traffic information	Web, mobile, IPTV
User customized function	Customized information and placement function (widget function)	Web, mobile
User participation Function	Provide tool to create personal UCC	Web
Remote control set-up function	Select information through remote control	IPTV

Table 15 Wire/wireless portal service function

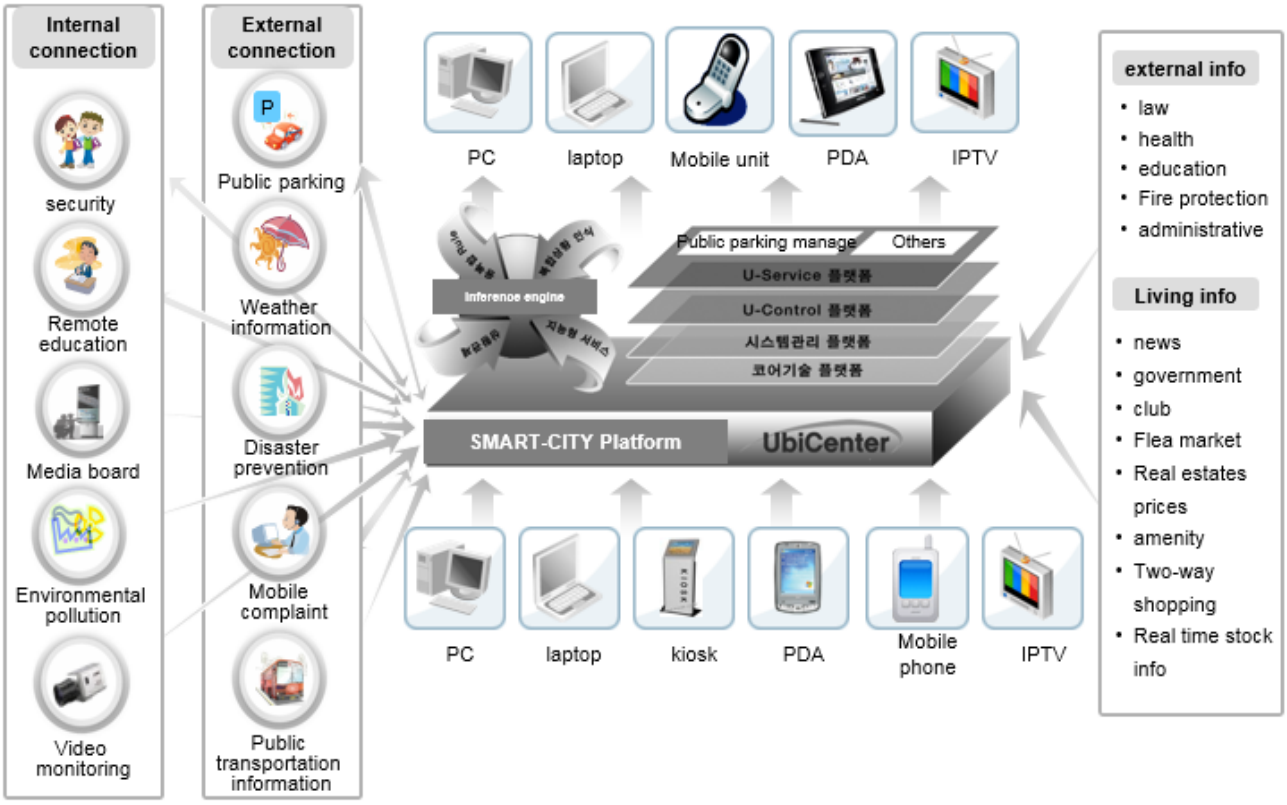

Figure 28 Wire/wireless portal service system diagram

B. Mobile civil complaint service

Mobile civil affairs service is composed of civil affairs, resident participation service that provides customized One-stop service without any restraint for space or time through use of mobile and kiosk.

Civil affairs and consultation service is provided to Pangyo residents through mobile gadgets and provides personalized information such as reporting, application of details, current processing status and more.

Mobile civil affairs service provides personalized, customized service that informs civil affairs and consultation service including notification of application status and confirmation note.

Mobile civil affairs service automatically detects one's location through the location based civil complaint UCC service.

By logging on to mobile/PDA/kiosk and registering the civil complaint, the government employee in charge of civil complaint will provide to the civil petitioner and relevant person. Complaint search, application of details, system link will be provided through the service.

Function	Detail
Logging in through special numbers	Log on to civil complaint webpage through inserting #1234+nate or etc.
Mobile Certification	Obtain mobile certification for payment and complaint registration on the mobile
Automatic location search	Link with telecommunication company's LBS which automatically searches for the mobile location
Mobile GIS	Provide and control 2D/3D map on mobile through Pangyo GIS use
SMS	SMS service provide notification of report/complaint process situation
Resident Participation	Mobile based report/complaint process situation through SMS/MMS service

Table 16 Mobile civil complaint service function

Figure 29 Mobile civil complaint service system diagram

C. Media board Service

Internet based multimedia screen was installed in area frequented by Pangyo residents, providing real time public information such as news, environment and traffic information. Furthermore, UCC or resident proposed item was posted to induce resident participation and create profit through advertisement.

Advertisement and contents submitted by residents are received and undergo review to post on the media board along with public information and living information needed by Pangyo residents. Advertisement and contents which will be posted are managed, linked with other services and provided with remote maintenance of media board operation status.

Systems that are provided are contents management system, which easily manages various contents and advertisements and system considering stable streaming environment and user interface.

Function	Detail
Contents management	Management of service contents
Attract and manage advertisement	Marketing system to attract and manage advertisement
Device management	Management/maintenance of media board device status
Link information management	Management of meta data to link with various services

Table 17 Media board service function

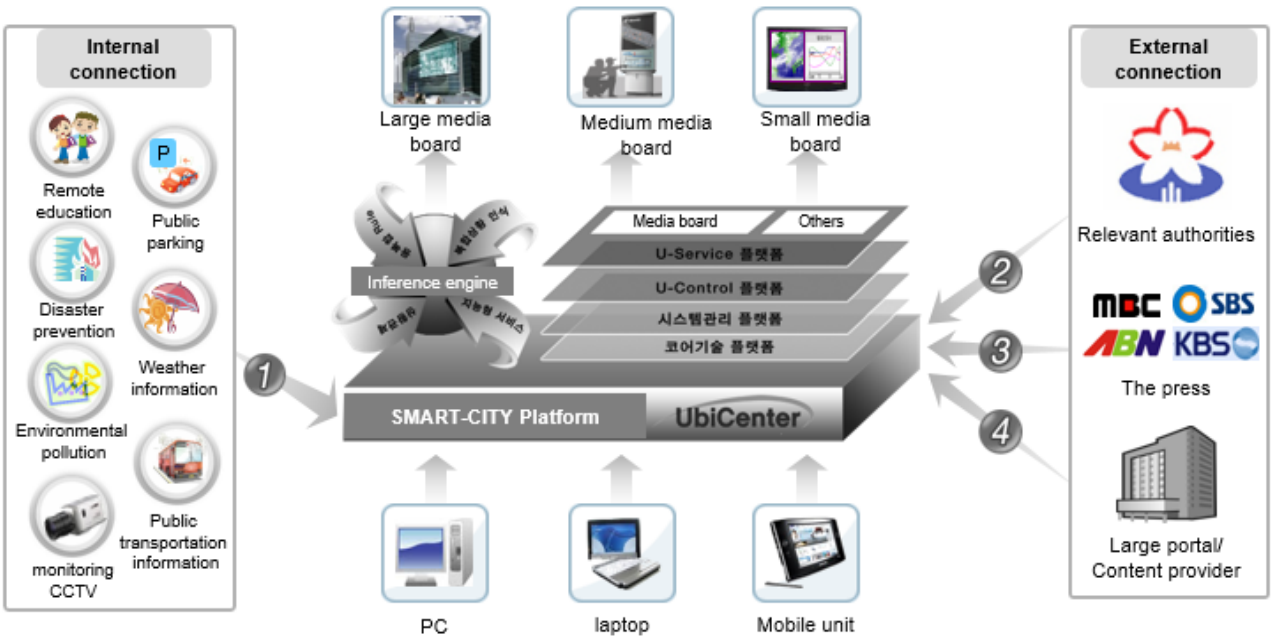

Figure 30 Media board service system diagram

3.7.6. Unified facility management

A. Water leakage management service

Link with water supply system to monitor flow meter, water-pressure gauge, water quality gauge and prevent disaster by early detection of water leakage and increase efficiency of water supply management.

By analyzing the collected information in real time, water supply leak can be predicted and relay the information to Seongnam City Water Supply and Drainage Office to swiftly restore to previous state. Also, data will be provided for restoration with link to water supply leak prevention and water supply cost DB.

Function	Detail
Flow/Water Pressure/Water quality information collection	Collect measurement data of flow-meter/water pressure/water quality information
Analyze water supply leak information	Detect leak location and analyze rate of discharge and pressure
Provide water supply leak information	Provide water supply leak information to water supply and drainage office
Provide statistics	Provide present facility status, leak history, maintenance history

Table 18 Water supply leak management service function

Figure 31 Water supply leak management service system diagram

B. Public utilities management service

Through management and monitoring of the 7 underground facilities (water and drainage, heating system, electricity, gas, communications, oil pipeline), it is important to ensure efficiency of underground facility maintenance and management through information exchange.

Unified DB is established through information link on floor plan, 3D location and construction schedule for new installations and maintenance work and exchange information with related organization and construction-site. Also, by monitoring, managing and field support for information such as underground pipeline retention by related organizations, the efficiency for information management and overlapping resources can be prevented.

Function	Detail
Pipeline management	Link information of water and drainage system, heating, electricity, gas, communications and gas pipeline
Construction information management	Link information of 7 underground facility
Support on-site tasks	Provide information for on-site tasks such as pipeline and location
Unified monitoring	Real-time information exchange within information center

Table 19 Public utilities management service function

Figure 32 Public utilities management service system diagram

C. Streetlight control service

By controlling and managing streetlights through automatic detection of malfunctions, resident's inconvenience may be limited and prevent waste of resources.

Specifically, through dispatching on-site personnel and managing street light history, complaint processing period may be shortened and maintenance cost reduced through prior decision to replace faulty stabilizer/lamp.

Active restoration and unified data management leads to minimal inconvenience of residents and some convenience for the relevant person in charge.

Function	Detail
Streetlight management	Remote control flickering and manage resources through replacement
Detect malfunction	Real-time detection of short circuit/power outage, management by resource type, center notification
On-site dispatch	Notification of designated person in charge of restoration, resource, location, floor plan, etc

Table 20 Streetlight control service function

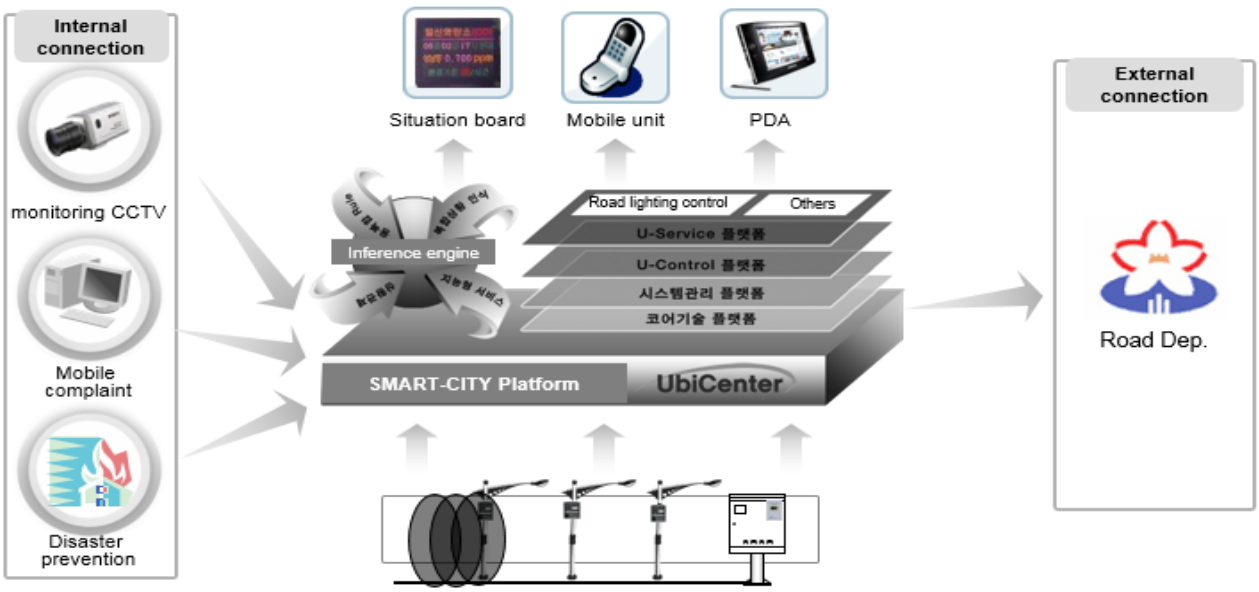

Figure 33 Streetlight control service system diagram

3.8. Knowledge Generation

Pangyo U-City aims to limit operations cost and has designed customized Pangyo profit model to gain sustainable and stable profit for self-reliance of U-City operations. By referring to previous profit model and discovering new profit model, a profit model pool including information sale type, advertisement fee type, commission type and usage fee type has been composed. Therefore, the method will be mining of profit model accommodating appropriate profit model and value assessment.

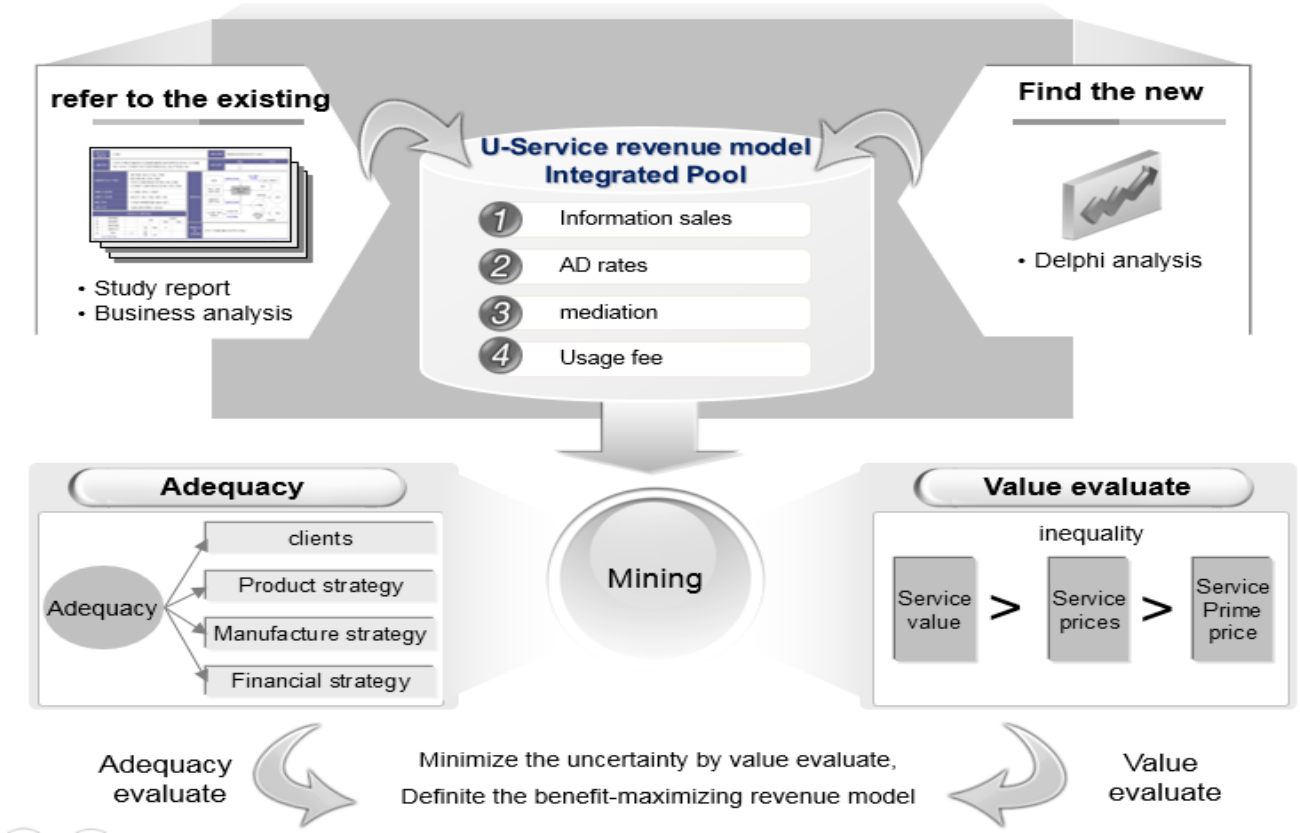

Figure 34 Pangyo U-City profit creation mining concept note

Information sale type includes the sale of collection information of U-City. The information are public transportation information, real-time traffic information and etc.

Advertisement type is creating profit from advertising fee through posting advertisement on the installed medium. For example, there are advertisements on media board and culture event fundraising advertisement service, etc.

Mediation type is value delivery method through matching which connects information or service and creates profit through a fee. For example, there is remote detection service of electricity or gas.

Usage type is utilization of contents or education material by paying a specific amount of money which creates profit. For example, the best case is continuing education or U-Learning services.

4. Organizational Structure

In other governments within Korea, it is commonplace for traffic related department to operate a unified city operations center. However, Pangyo U-City unified city operations center operates under the supervision of Information Policy Division, Administration and Planning Bureau. Actually, the Life Information team under the division operates the center. This is due to the closeness of the resident's daily lives with most of the service provided by the Pangyo U-City unified operations center.

Table 21 is a detailed list of the team, number of personnel and delegated tasks of the Information Policy division in charge of the unified operations center. Within the unified operations center, U-City situation room is operated by the city and crime prevention situation room is operated by the police agency. The city and police officers take 3 shifts for 24 hours to operate unified operations center without suspension.

Team Name	No. of personnel	Task	Note
Director of Information Policy	1	In charge of all division tasks	
Information Planning Team	4	• Operate city webpage and mobile • Accounting, security, information education of public servants and operate information related tournament, IT assistive device • General affairs, common software management, information education	
Administration Information Team	4	• Common base1, unified storage, unified backup, prior agreement on software, EA • Common base2, administration, operate administration portal system • Operate On-Nara System, operate and manage administrative electronic signature • Operate unified control system of data room	
Big Data Team	3	• Establish base for big data sharing • Disclose public data and coordinate and plan utilization • Utilize big data • Disclose public data	
Information Protection Team	3	• Personal information processing system • Introduction of administration and public network security equipment and operations management • Operate output and stored media management system • Manage malignant code and virus • Manage and operate code and encryption device • Detect wiretapping/surveillance within province	
Network Operations Team	4	• Manage public network • Manage and operate information and communications network(administration network, public network, library network) • Examine information and communications construction before design review • Administrative call exchange network, unified communication (UC) system, establish and operate public Wi-Fi, unified message (UMS)	
Life and Information Team	3	• Operate U-City unified center, U-City tasks • Manage U-Care sector projects, U-Control(City facilities) sector projects, U-Life(IPTV, etc.) sector projects, U-Park safety management service, U-Tancheon service	
Imagery Information Team	5	• Living safety(crime prevention) CCTV • Establish and operate children safety CCTV • Establish children protection zone CCTV, Operate overall U-service network • View and obtain living safety CCTV imagery	

Table 21 Pangyo U-City unified operations center organization

5. Lessons Learned

Generally, it is common for the same company to carry out design and construction of U-City project. However, in the case of Pangyo U-City, a method has been followed to allow for the design to be preceded and construction afterwards. Following this reason, there were some difficulties with project implementation as the designer and head of project construction were different. For aspiring U-City project developers, it would be favorable to have the same person overseeing the design and construction.

Also, there were changes to the construction with the request of residents as some time gap occurred during the initial design and construction stages. This caused a lack of construction time as well. Due to changes in the on-site conditions, there were various modifications to the initial design. Furthermore, ample time was needed for an agreement among concerned parties as there were many project implementers including Seongnam City, Gyeonggi Province and Korea Land Corporation.

Part of the service and standardization issue of system had been a main concern. Previously, a link between the systems already in place by the past Seongnam City was required. In the process, there were worries of the new technology becoming depended on the old technology. A need to break away from a specific supplying company's product and solution was needed through standardization.

After U-City establishment, there arise a problem with covering operations cost. In the past, after the city development implementer finishes establishing the system and hands it over to the local government, the operations cost had carried over to the city development implementer. In the case of Pangyo U-City, Seongnam City and Korea Land Corporation agreed to apply the benefit principle and wisely solved the issue.

Finally, a bold move to introduce Biz-model, which aims for a global service, would be needed to take on a leading role if another U-City project is currently being planned. Public service on the whole is conservative and aims to be universal. Therefore, it would be wise to break away to develop a new model through fusion methods such as private commercial service and continue to introduce service that satisfy citizens such as remote medical treatment and remote education.

6. Conclusion

As a successful case of smart city system implementation in new city, Pangyo provides various implications. Pangyo planned the smart city initiative from the new city development stage which enabled the systematic allocation of development gain into the smart city implementation. The city also divides the smart city system into five areas and is providing fifteen services to enhance the citizen convenience. The city has created direct interface with citizen by installing information kiosks at main points within the city with largest pedestrian flow, and has installed services in the environmental sector such as water leakage management system which differentiates it from other smart cities in Korea. One of the most challenging factors during the smart city implementation in Pangyo was securing the compatibility and standardization between the system under operation in the existing city of Sungnam and the newly installed system in Pangyo during the new city construction. Another area that Pangyo strives is to develop private services to raise system operation and maintenance fee to lessen the city's financial burden. Pangyo can especially be a reference when implementing smart city initiative in a new city context and is expected to continue to provide useful ideas in the future.

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Interviewed stakeholders

1. Representatives from the Seongnam Pangyo u-city department, Seongnam City


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